TELE·TECH

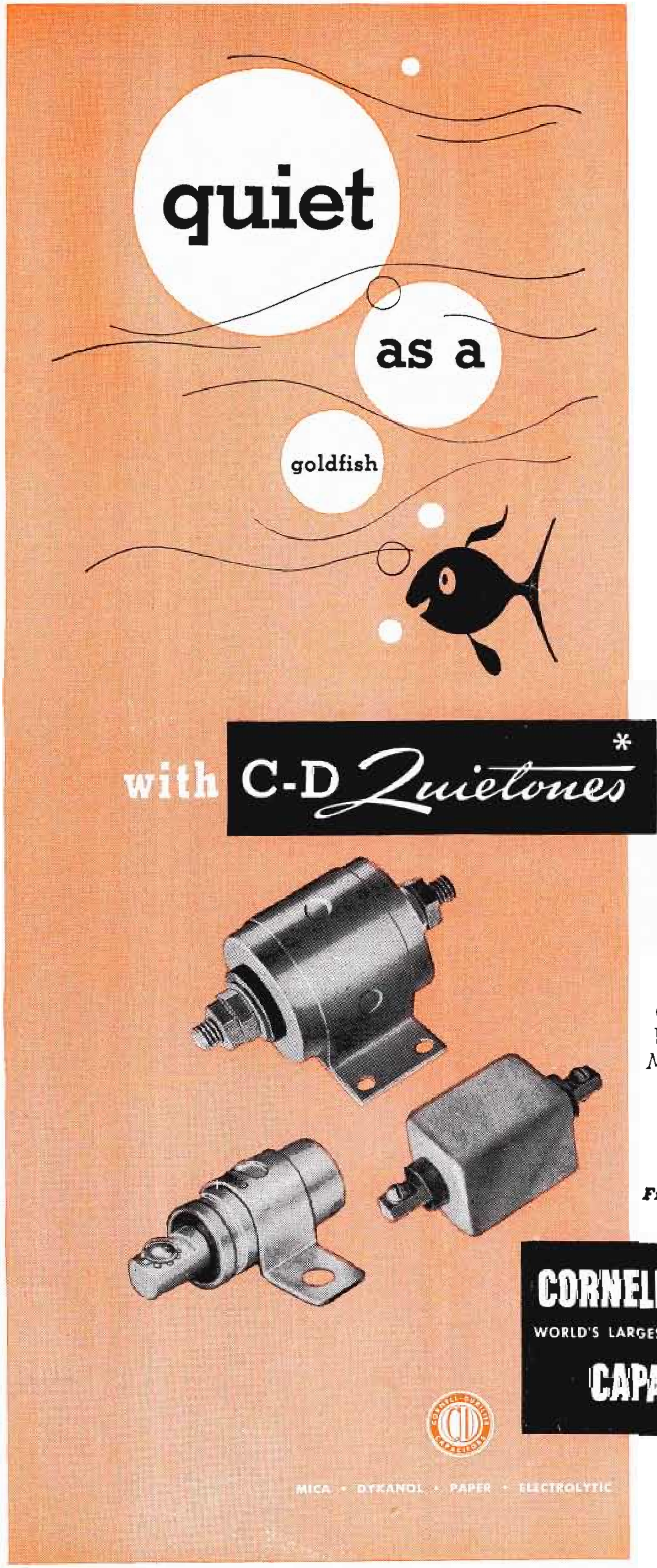
Formerly the TELE-communications TECH-nical Section of

ELECTRONIC INDUSTRIES

**DESIGN AND OPERATION OF RADIO · FM · TELEVISION
RADAR AND ALL COMMUNICATIONS EQUIPMENT**

January 1948

AUDIO COMPENSATING NETWORKS — In This Issue



A lot of ***electronic and electrical equipment is going to sea these days. But it won't stay there long—in fact, it won't even stay sold—unless it is Noise-Proofed against radio interference.***

To you—the manufacturer—this means that your product should include C-D Quietones in its basic design. With safety at sea—as well as listening pleasure—at stake, your marine customers demand the kind of interference-free equipment operation C-D Quietones are designed to give. Of the hundreds of Quietone types available, there may be one which will fit your needs to a "T"; if not, our sleeves are rolled up and we're ready in our modern and complete Radio Noise-Proofing Laboratory—to design the specific filter you need. C-D Quietones will solve your radio noise and spark suppression problems speedily, permanently and effectively. Your inquiry is invited. Cornell-Dubilier Electric Corporation, Dept. J1 , South Plainfield, New Jersey. Other large plants in New Bedford, Worcester, and Brookline, Massachusetts, and Providence, R. I.

Make Your Products More Saleable with C-D Quietone Radio Noise Filters and Spark Suppressors.

CORNELL-DUBILIER
WORLD'S LARGEST MANUFACTURER OF
CAPACITORS

* Reg. U.S. Pat. Off.

TELE-TECH

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ELECTRONIC INDUSTRIES

Editorial Contents

JANUARY, 1948

CALDWELL-CLEMENTS, INC., Publication Office, Orange, Conn., Editorial and Executive Offices 480 Lexington Avenue, New York 17, N. Y., Tel. Plaza 3-1340

BRANCH OFFICES — Chicago 6, R. Y. Fitzpatrick, 201 N. Wells St., RAN 9225; Los Angeles 5, The Robert W. Walker Co., 684 So. Lafayette Park Pl., Drexel 4388; San Francisco 4, 68 Post St., Sutter 5568.

MODEL 260
VOLT-OHM-MILLIAMMETER

20,000 Ohms per Volt D.C.
1,000 Ohms per Volt A.C.

Volts, A.C. and D.C.: 2.5, 10, 50, 250, 1000, 5000.

Milliamperes, D.C.: 10, 100, 500.

Microamperes, D.C.: 100.

Amperes, D.C.: 10.

Decibels (5 ranges): —10 to 52 D.B.

Ohms: 0-2000 (12 ohms center). 0-200,000 (1200 ohms center). 0-20 megohms (120,000 ohms center).

Model 260—Size 5¼" x 7" x 3⅛" **$38.95**

Model 260 in Roll Top Safety Case —Size 5⅜" x 9" x 4¾". **$43.75**

*Both complete with test leads and 32-page Operator's Manual**

ASK YOUR JOBBER

WORTH MORE...
...COSTS NO MORE!

For what it buys in sensitivity, precision, and useful ranges, the price of Model 260 has always purchased value far beyond that of even remotely similar test instruments. Today this famous volt-ohm-milliammeter is a finer instrument than ever, with added ranges and with a new sub-assembly construction unmatched anywhere in strength and functional design. The price is the same. That means, of course, that your investment today buys even more in utility and the *staying* accuracy that distinguish this most popular high-sensitivity set tester in the world.

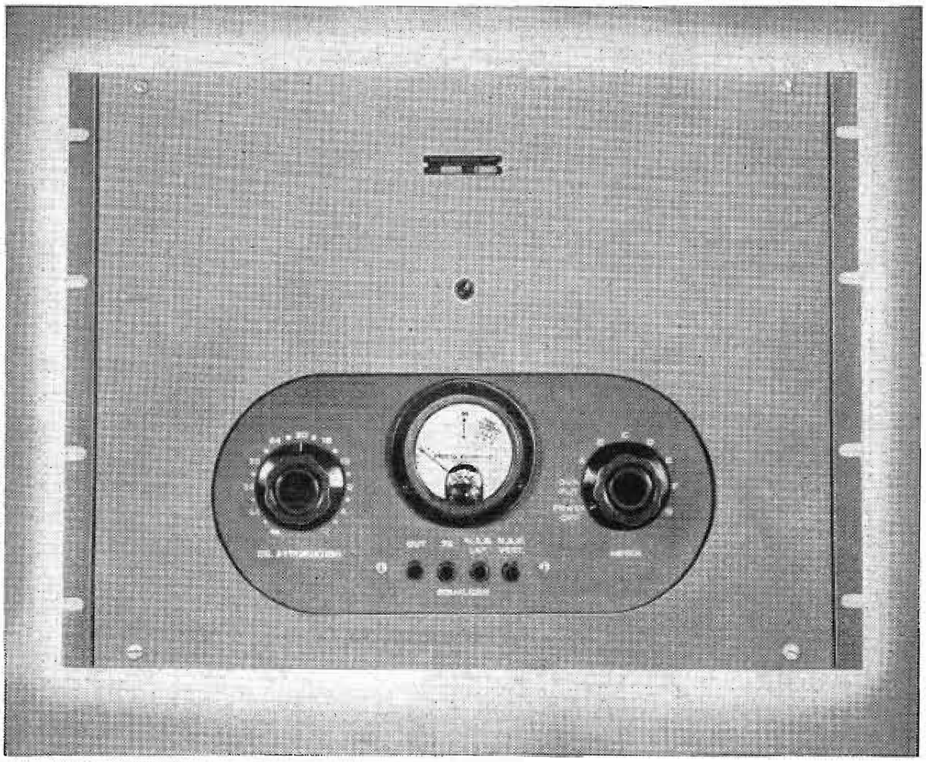
*No other maker of test instruments provides anything to approach the completeness of the pocket-size 32-page Operator's Manual that accompanies Simpson Model 260. Illustrated with 12 circuit and schematic diagrams. Printed on tough map paper to withstand constant usage.

Simpson
INSTRUMENTS THAT STAY ACCURATE

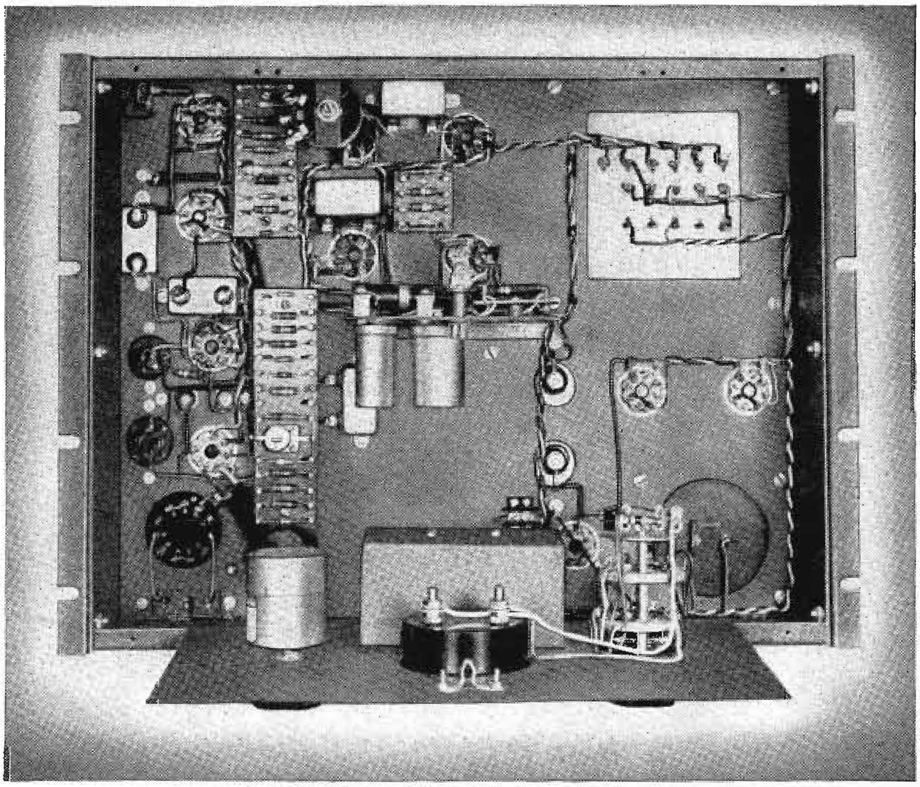
SIMPSON ELECTRIC COMPANY • 5200-5218 W. Kinzie Street, Chicago 44, Ill.
In Canada, Bach-Simpson Ltd., London, Ont.

Tele-Tech*, January 1948, Vol. 7, No. 1. Regular price per copy 25 cents. Published Monthly by Caldwell-Clements, Inc., Publication Office Orange, Conn., Editorial, Advertising and Executive Offices 480 Lexington Ave., New York 17, N. Y. Direct all subscription inquiries to Orange, Conn., or to 480 Lexington Avenue, New York 17, N. Y. M. Clements, President; Orestes H. Caldwell, Treasurer. Subscription rates: United States and possessions, $3.00 for two years. Canada (Canadian Funds Accepted) $4.00 for two years. Pan American Countries $5.00 for two years. All other countries $7.50 for two years. Entered as second class matter June 9, 1947, at the Post Office at Orange, Conn., under the act of March 3, 1879. Copyright by Caldwell-Clements, Inc., 1948. Printed in U.S.A. *Reg. U.S. Pat. Off.

Presto Presents Something New in Recording Amplifiers...



The new Presto 92-A is a 50-watt amplifier designed specifically for recording work. It answers the need for an amplifier of exceptional quality and performance, and includes a number of outstanding features thoroughly proved in operation:



1 Selector switch and meter provide both output level indicator (not for "riding gain") and plate current readings for all tubes.

2 Chassis is vertically mounted. Removal of the front panel gives access to all circuits without removing amplifier from rack.

3 The output stage has four 807's in push-pull parallel with an unusual amount of feedback. This produces ample peak power with low distortion and an extremely low internal output impedance for best performance from magnetic cutting heads.

Push buttons select any of these recording characteristics: flat, 20-17,000 cps, 78 rpm, standard NAB lateral, NAB vertical—all within an accuracy of ±1 db. Distortion is only 1½% at full output.

PRESTO

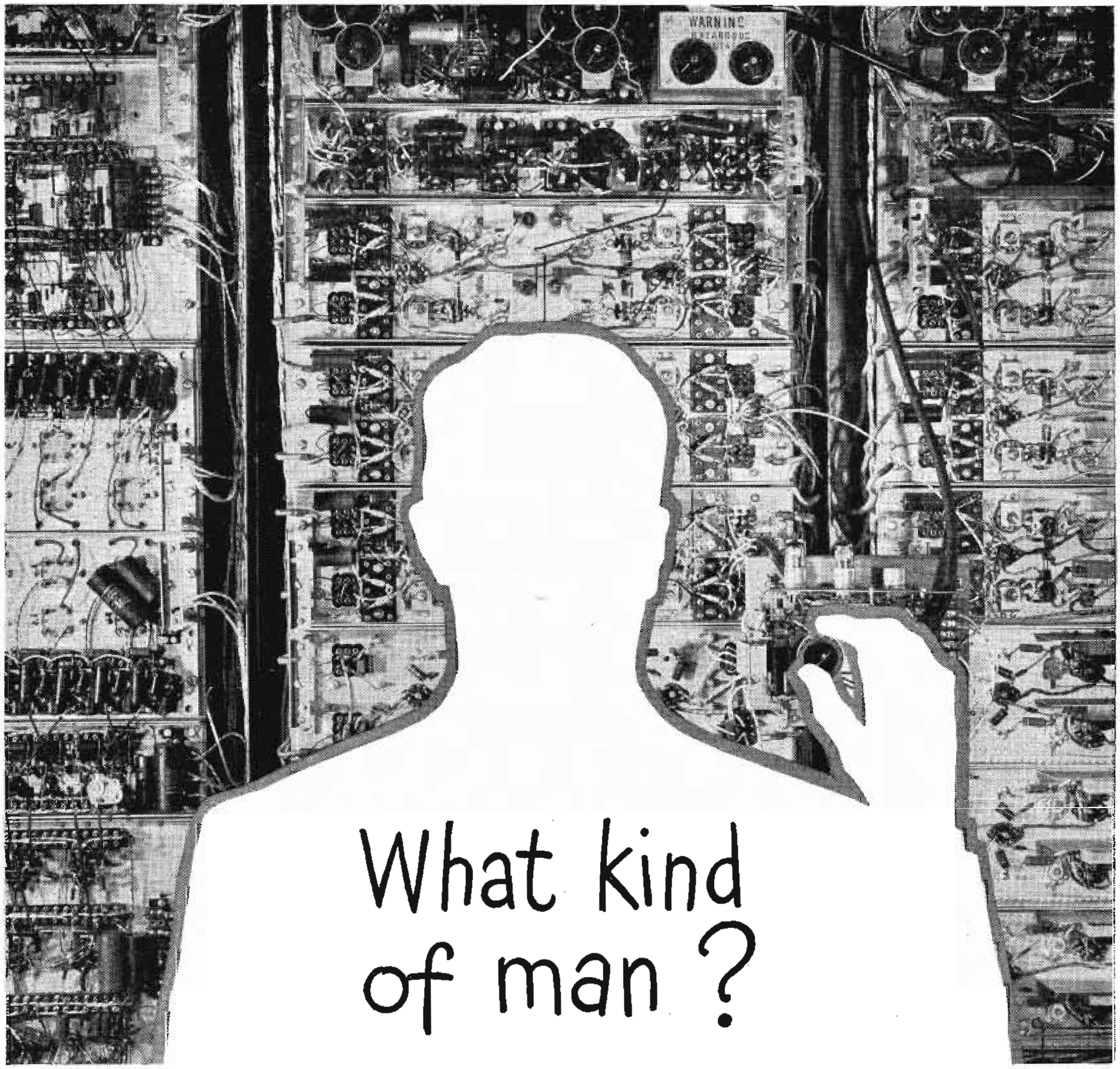
RECORDING CORPORATION

246 WEST 55TH STREET, NEW YORK 19, N. Y.

Walter P. Downs, Ltd., in Canada

FREE! Presto will send you free of charge a complete bibliography of all technical and engineering articles on disc recording published since 1921. Send us a post card today.

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT & DISCS



WHAT KIND of men are the 2,300 scientists and engineers of Bell Telephone Laboratories?

Men of many types, working in different fields of research, may contribute to each development.

But all have certain characteristics in common: Good minds as a foundation, many years of learning in the fundamentals of their science and the methods of research, and a co-operative attitude — for without co-operation of individuals these products of research could never be produced.

Above all else, however, they have "the spirit to adventure, the wit to question, and the wisdom to accept and use."

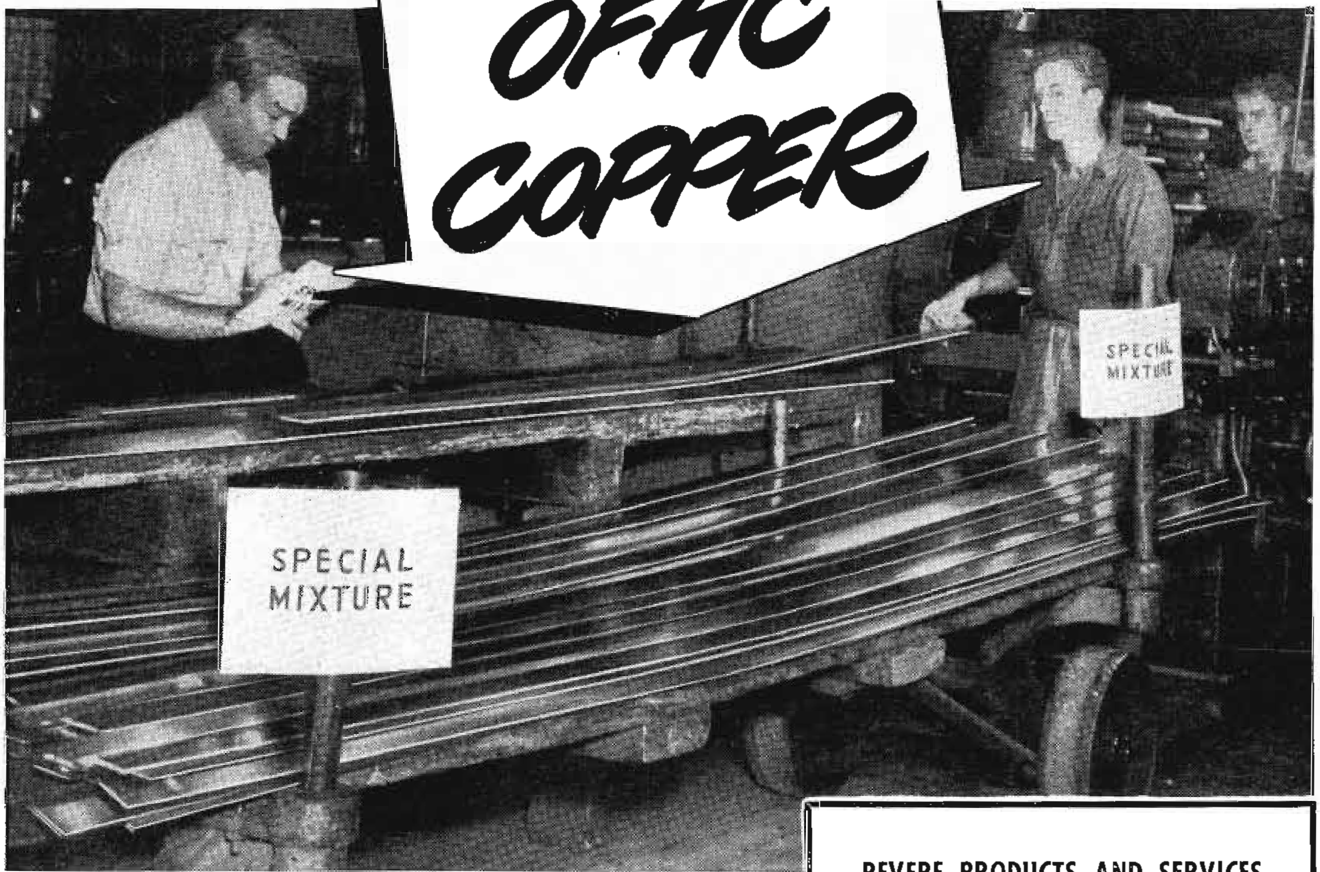
That kind of men can produce the finest telephone equipment in the world — and have done so.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

PERSONALLY CONDUCTED THROUGH THE REVERE MILLS

OFHC COPPER



BECAUSE OFHC Copper looks like any other copper, Revere takes great pains to identify it throughout processing, to see it is not lost track of or mixed up with other types. The obvious thing is to mark each piece, which is done, but markings are obliterated by operations such as rolling, and so Revere goes to the length of assigning special personnel to follow each lot of OFHC Copper from one operation to another, watching carefully to be sure each load is kept intact.

In addition, Revere takes full cognizance of the fact that OFHC Copper for radio purposes must have special qualities. In making anodes, it must be deep drawn, and for the feather-edge seal, it must be capable of being rolled or machined down to .002″/.010″. By carefully controlling mill processing, grain size is kept at or below permissible limits. Freedom from oxygen, and from voids, is guaranteed by the method of casting the bars from which we roll the forms required. In addition, there is an operation which results in Revere OFHC Copper being not just commercially free but *nearly absolutely free* of internal and external defects. This great care in producing copper for radio and radar purposes probably accounts for the fact that Revere is a preferred source of supply.

REVERE PRODUCTS AND SERVICES

All Revere Metals are processed with the care and attention required to assure that they meet all metallurgical and physical specifications. Revere supplies mill products in non-ferrous metals and alloys, and also electric welded and lockseam steel tube. An important part of our service to industry is the Revere Technical Advisory Service, which will gladly collaborate with you on specifications and fabrication methods.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

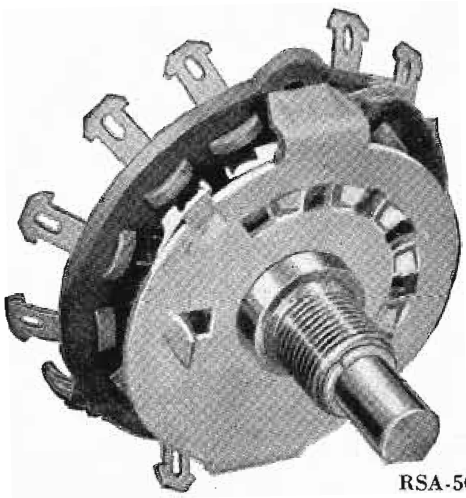
230 Park Avenue, New York 17, New York

• • •

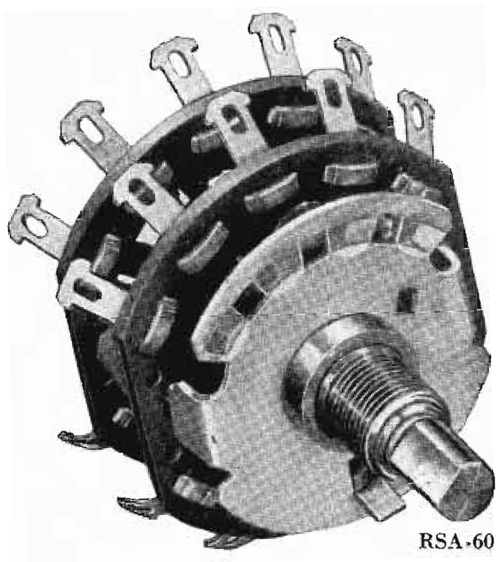
Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.

Sales Offices in Principal Cities, Distributors Everywhere

Two New Single or Double Section Switches . . .



RSA-50



RSA-60

. . . of Space Saving Design and Mallory Precision Quality

. . . *Yet They Cost No More!*

Where space is a factor—dependability essential—*low cost a prerequisite*—the Mallory RSA-50 and RSA-60 switches fill the bill!

These *new* circuit selector switches, with section and terminal design identical to that of the famous Mallory RS-50 and RS-60 switches, are designed for band and tone control switching in radio receivers and other electronic applications where medium and low torque indexing action is desired.

The index assembly is of durable design and constructed with a minimum of parts—affording dependable service life with low torque and positive indexing action.

Note these many features, inherent in all the Mallory RS series, which contribute to the dependability and quality of these two new additions to the line:

- **Insulation of high-grade, low-loss laminated phenolic.**
- **Terminals and contacts of special Mallory spring alloy, heavily silver-plated to insure long life at low contact resistance.**
- **Terminals held securely by exclusive Mallory two-point fastening — heavy staples prevent loosening or twisting.**
- **Double wiping action on contacts with an inherent flexing feature—insures good electrical contact with the rotor shoes throughout rotation.**
- **Six rotor supports on the stator—insure accurate alignment.**
- **Brass rotor shoes, heavily silver-plated—insure low contact resistance.**
- **All shoes held flat and securely to phenolic rotor by rivets—prevents stubbing—insures smooth rotation—*minimum of noise in critical circuits.***

The RSA-50 and RSA-60 are both available in one or two section construction. The RSA-50 accommodates up to twelve terminals on either side of the section and provides from 2 to 6 positions. The RSA-60 accommodates up to ten terminals on either side of the section and provides from 2 to 5 positions. The RSA-60 has the narrow section design—ideal for under chassis mounting, where space saving is paramount.

ENGINEERING DATA SHEET

Send for the Mallory Engineering Data Sheet on the RSA-50 and RSA-60. It contains complete specifications for available circuit combinations with respective terminal locations, dimensional drawings—everything the engineer needs to adapt the RSA-50 or RSA-60 switch to a particular circuit.

SPECIFICATION SHEETS

Specification sheets for the RSA-50 and RSA-60 switches have also been prepared. These sheets are printed on thin paper to permit blueprinting. The sectional drawings indicate standard and optional dimensions—make it easy for you to order production samples built to your requirements.

P. R. MALLORY & CO. Inc.

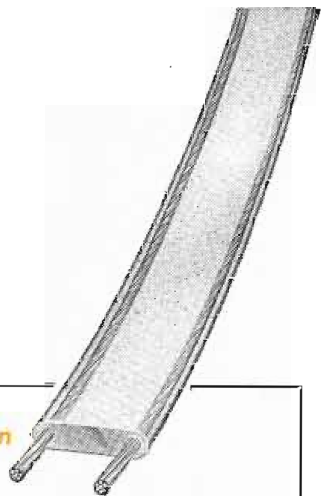
MALLORY SWITCHES

(ELECTRONIC, INDUSTRIAL and APPLIANCE)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

CONFUSING? OR AMUSING?

Lead-In Lines Play an Important Part in Television Reception



The effects of attenuation and impedance mismatch on FM and Television reception are minimized by Anaconda Type ATV* lead-in lines.

The satin-smooth polyethylene insulation of Type ATV line sheds water readily, thus avoiding subsequent impedance discontinuities. This material also has exceptionally high resistance to corrosion. Count on Anaconda to solve your high-frequency transmission problems—with anything from a new-type lead-in line to the latest development in coaxial cables. 47139

**An Anaconda Trade-Mark*

A Type ATV Lead-In for Every Need

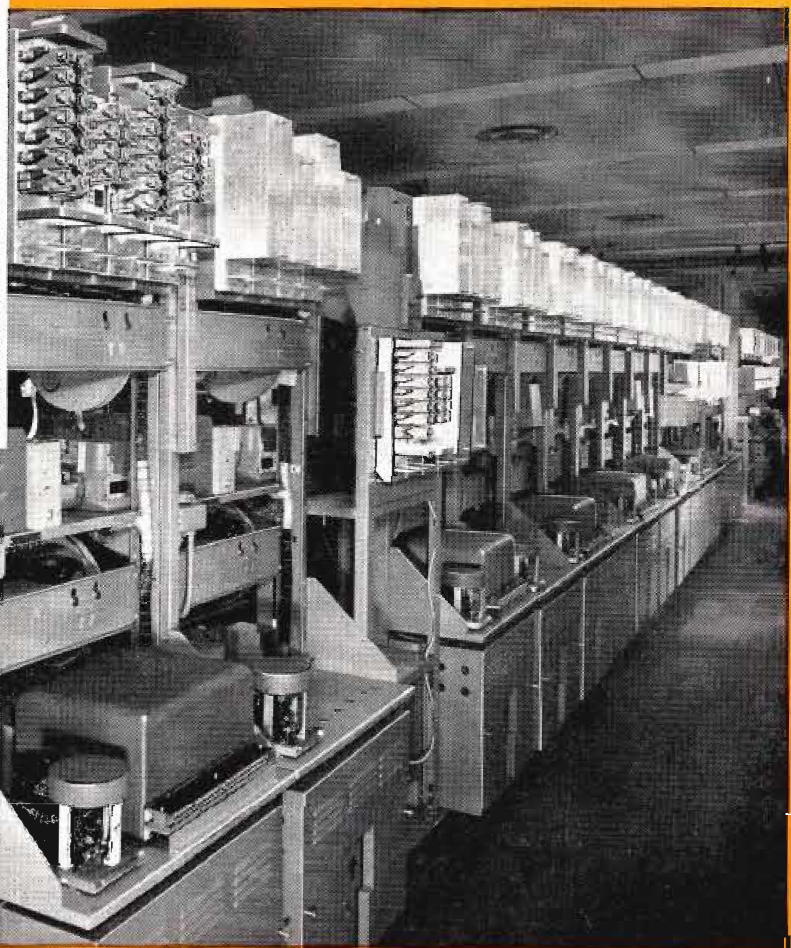
Anaconda offers a complete selection of Type ATV lead-in lines for 75, 125, 150 and 300 ohms impedance unshielded and 150 ohms shielded. For an electrical and physical characteristics bulletin, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.

ANACONDA from mine to consumer

ANACONDA WIRE AND CABLE COMPANY

WESTERN UNION

in Sensationally Rapid



Hundreds of Clare Relays are used in this Western Union Push-Button Switching installation. Covers are removed from first four banks at top to show location of Clare Relays, which play an important part in Western Union's new ultra-modern, high-speed communications program. Pictured is a rear view of positions on which the outgoing sides of the various circuits are terminated.

Picture in upper left shows the easily removable Clare mounting base used in this Western Union installation. The base slips readily into place on jack mountings . . . simplifies mounting, assembly, and maintenance.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical and Industrial Use

uses CLARE "Custom-Built" Relays

Push-Button Switching Systems

Revolutionary New Program Speeds up Service—Insures Accuracy —Provides Maximum Operating Convenience

Rapidly and on a vast scale . . . the Western Union Telegraph Company is revolutionizing telegraph operating methods.

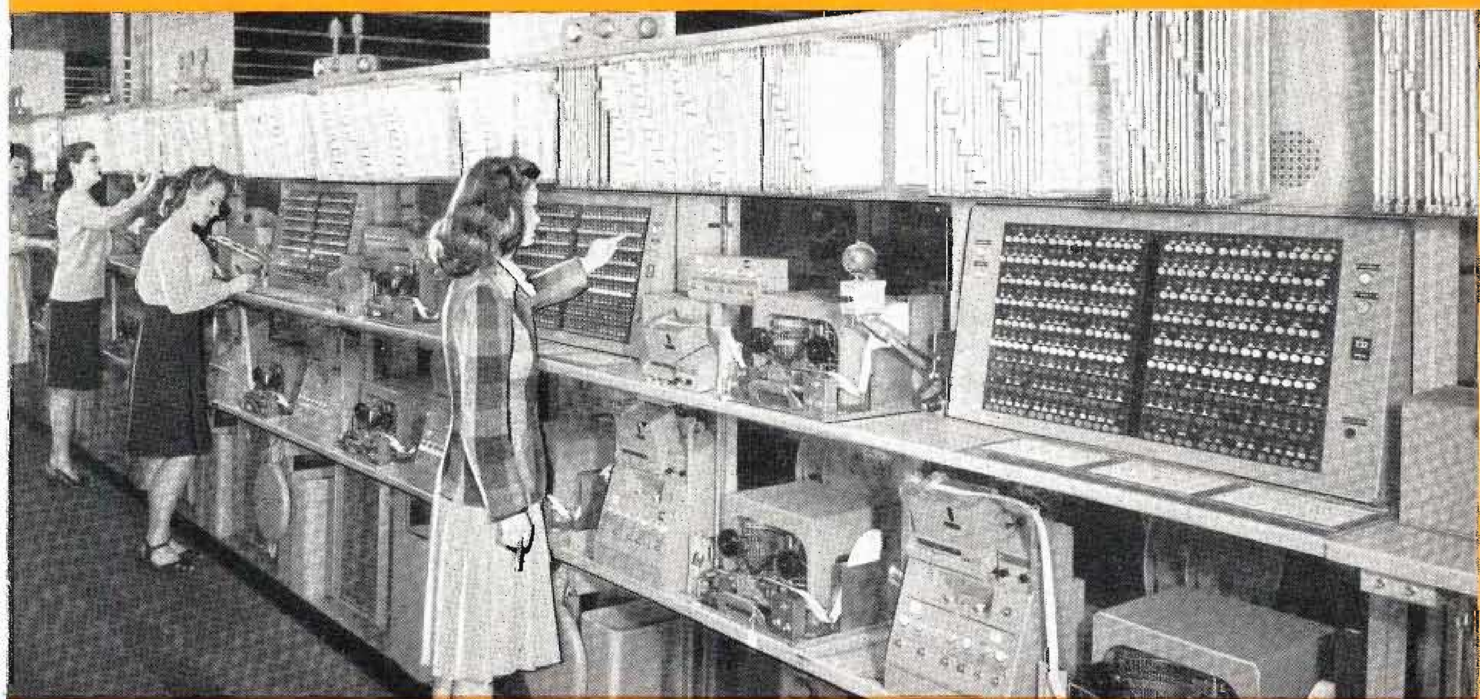
Western Union engineers have developed the Push-Button Switching System, which is being installed at strategic points throughout the country . . . to speed up the more than a half-million telegrams handled daily. With it, telegrams will be typed only once—at the point of origin.

Many thousands of Clare Relays, "custom-built" to the exacting specifications of Western Union's engineers, perform important functions in the Push-Button Switching System, which opens a new era in faster Western Union service.

Each incoming connection terminates in a printer-perforator which records the characters upon a tape and perforates the code combination for each character in the tape. All the operator is required to do is read the destination and, by pressing the proper push button in the switching turret, cause the message to be re-transmitted to the proper outgoing circuit.

Use of Clare Relays in this tremendously important Western Union program is a tribute to the ability of Clare's engineers to supply relays of maximum reliability for so exacting a requirement. Clare Relays are built for applications where precise performance, long life, and dependability are prime requisites.

Clare Sales engineers, trained in the Clare "custom-building" principle, are at your service . . . ready to show you how Clare "Custom-Built" Multiple Contact Relays are the effective answer to modern design problems. Look them up in your classified telephone directory or write: C. P. Clare & Company, 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable address: CLARELAY.



Receiving positions for the incoming lines where Western Union switching clerks push buttons on the switching turrets and, in a flash, telegrams are speeded onward to their destinations. This push-button telegraphy opens a new era of faster, finer Western Union service.

Aerovox Series 26 Bakelite-cased Tubular Capacitors Used Individually or Series-stacked Provide for . . .

VOLTAGES UNLIMITED!

● Name the voltage. These capacitors will handle it. The units shown are for a special high-voltage research project. They are rated at 125,000 volts for single units, 250,000 volts for two units in series. Yet they are *standard* Aerovox items—fully engineered; tried-tested-proven construction; ready to be built at any time—and in time!

Series-stacking builds up to any required voltage. Matched sections insure uniform voltage gradient throughout battery of series-connected capacitors. Plus, of course, Aerovox capacitor craftsmanship.

Originally designed for X-ray, impulse generators and other intermittent dc or continuous ac high-voltage applications such as indoor carrier current coupling, high-voltage test equipment and special high-voltage laboratory work, these *standard* units are now meeting the overnight call for atom-smashing equipment. Indeed, Aerovox is already in the forefront of this Atomic Age.

● ***Let us quote on your capacitance requirements—from the modest paper tubular or mica, to giant oil or mica capacitors. Engineering data on request.***

INTERESTING FEATURES . . .

Oil-impregnated and oil-filled with Aerovox Hyvol D, permitting smaller size and minimum weight.

Adequately insulated and matched sections of uniform capacitance, connected in series.

High-purity aluminum foil with generous number of tab connections. High conductivity. Lower inductive reactance.

Capacitor sections dried and impregnated under high vacuum. Closely-controlled long cycle. Eliminates voids. Higher insulation values. Lower losses.

Special laminated bakelite tubing container. Protected by high-resistance insulating varnish. High dielectric strength. Maximum safety from external flash-overs.

Design provides for low voltage gradient along case at maximum operating voltages.

Dependable operation assured at rated voltages and at ambient temperatures up to 65° C.

Three-piece cast aluminum end-cap terminals. Bakelite-treated cork gaskets locked in to provide hermetic seal.

Caps available with mounting feet for space-saving assemblies in series, parallel, or series-parallel arrangements. Or wih plain caps.

In 50,000, 75,000, 100,000 and 150,000 v. D.C. max. ratings per unit. Range from 14" to 32" high; 4⅜" to 13½" dia.

AEROVOX capacitors

FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A.

SALES OFFICES IN ALL PRINCIPAL CITIES • Export: 13 E. 40th ST., NEW YORK 16, N. Y.

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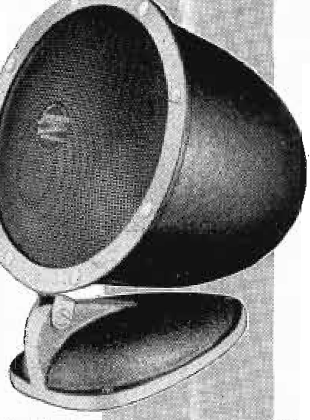
Listen! IT'S A Jensen SPEAKER

Jensen *Speech Master* REPRODUCERS NOW WITH *ALNICO 5* PM DESIGN

JENSEN Speech Master Reproducers have long been widely used in moderate-level intercom, paging and P. A. systems. Now, in *ALNICO 5* design, they are once more available for all applications where clear, crisp, intelligible speech and good "talk-back" performance are required. Ideal for amateur, commercial, police and aviation phone communication as separate units or integral equipment. In amateur CW they aid selectivity, help signals override QRM and QRN. The husky voice coil withstands keying transients.

JENSEN MANUFACTURING CO.
6625 S. LARAMIE AVE., CHICAGO 38, ILL.

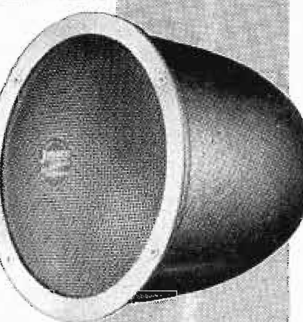
In Canada: Copper Wire Products, Ltd.
11 King Street W., Toronto 1



MODEL AP-10 SPEECH MASTER (Desk Type)

ALNICO 5 PM design. Complete with swivel base and tilt adjustment. Double dustproofed, fully enclosed and protected. Internal mounting bracket for ½ x ½" transformer. Power rating 5 watts. Height 6¾", depth 5⅛", diameter 5". Attractive hammered gray finish with satin chrome trim. 36" RC cord. Shipping weight 5¼ lbs.

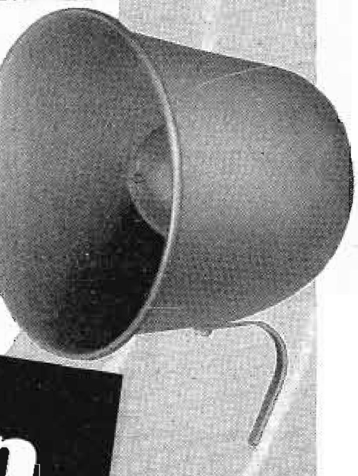
	List Price
AP-10 (ST-590) with 3-4 ohm voice coil	$13.90
AP-10 (ST-591) with 45-50 ohm voice coil	14.50



MODEL AP-11 SPEECH MASTER (Panel Type)

Similar to AP-10 but without swivel base. Clearance eyelets for mounting screws. Mounts in 4-27/64" cutout. Depth from front panel 4½". Power rating 5 watts. Screws and drilling template furnished. Shipping weight 3¼ lbs.

	List Price
AP-11 (ST-592) with 3-4 ohm voice coil	$11.30
AP-11 (ST-593) with 45-50 ohm voice coil	11.90



MODEL AR-10 REFLEX SPEECH MASTER REPRODUCER

Specially designed reflex horn increases efficiency in mid-range, giving added effectiveness and punch to speech quality when used for paging, intercom and call systems operated at moderate levels. Reflex construction prevents direct access of snow or rain to speaker diaphragm. Power rating 6 watts. Space within case provided for mounting ½ x ½" transformer. Over-all diameter 10", depth 8". Complete with bracket for wall or post mounting.

	List Price
AR-10 (ST-643) with 3-4 ohm voice coil	$20.00
AR-10 (ST-644) with 45-50 ohm voice coil	20.75

Jensen SPEAKERS WITH *ALNICO 5*

Designers and Manufacturers of Fine Acoustic Equipment

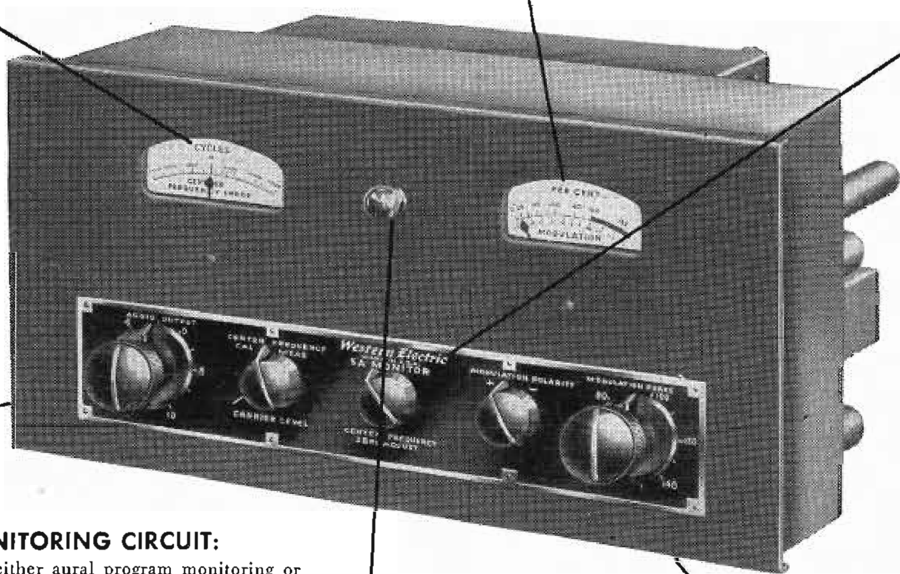
You get all these features ONLY in the

Western Electric 5A Monitor

for FM Broadcasting

CENTER FREQUENCY MONITOR:
Accuracy—better than ± 500 cycles. (± 200 cycles if occasionally adjusted to agree with a primary standard)
Meter Range—± 3,000 cycles
Terminals for connecting remote meter

MODULATION PERCENTAGE MONITOR:
Accuracy—better than 5% *for all readings*
Modulation Range Capability—up to 133% (± 100 kc)
Terminals for connecting remote meter

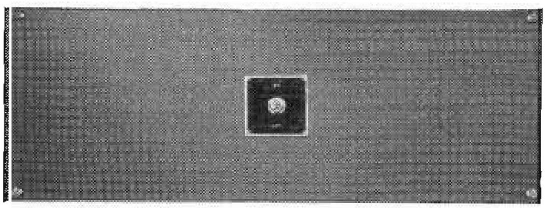


QUALITY DESIGN AND MANUFACTURE:
Designed by Bell Telephone Laboratories. Built by Western Electric, to Western Electric standards of quality.

PROGRAM MONITORING CIRCUIT:
Output suitable for either aural program monitoring or FM noise and distortion measurements
Frequency Response—± 0.25 db, 30 to 30,000 cycles, without de-emphasis; with de-emphasis, response is within ± 0.5 db of the standard 75 microsecond de-emphasis curve
Audio Output Power—output level adjustable up to + 12 dbm—permits direct switching of program monitor from transmitter input to 5A Monitor output
Harmonic Distortion—*less than 1/4 of 1%* from 30 to 15,000 cps
Output Noise—at least 75 db below signal at 100% modulation

MODULATION PEAK INDICATOR:
Indication Lamp — flashes when a selected level of modulation is exceeded
Peak Limit Range—continuously adjustable between 40% and 140% modulation

AM NOISE DETECTOR:
An exclusive feature in the 5A Monitor. The output of this detector—which may be read directly on an electronic voltmeter or noise meter — is automatically referred to 100% amplitude modulation, thus simplifying measurement of transmitter AM noise.



POWER SUPPLY: Newly designed 20C Rectifier (furnished as a part of the 5A Monitor) provides electronically regulated d-c *with less than 1 millivolt ripple* from 105-125 volts a-c 60 cycles. May be remotely located if desired.

The 5A Monitor includes numerous other valuable features such as: dual thermostats and dual heaters for each crystal—means for checking the inherent noise level of the monitor from its *input to output terminals*—requires only a low RF input level (1 watt) which can vary from 0.3 to 3.0 watts; i. e., a 10 to 1 variation *without affecting the performance of the monitor.* To get the complete story on this outstanding monitor value, call your Graybar Broadcast Representative or mail the coupon below.

Western Electric

Distributors: In the U. S. A.—Graybar Electric Company.
In Canada and Newfoundland—Northern Electric Company, Ltd.

Distributed by GraybaR — OFFICES IN 93 PRINCIPAL CITIES

—QUALITY COUNTS—

Graybar Electric Company T
420 Lexington Avenue, New York 17, N. Y.

Please send me Bulletin T-2437, including curves, schematics and block diagram of the 5A Monitor.

NAME________________
STATION________________
ADDRESS________________
CITY________ STATE________

ELECTRONICS

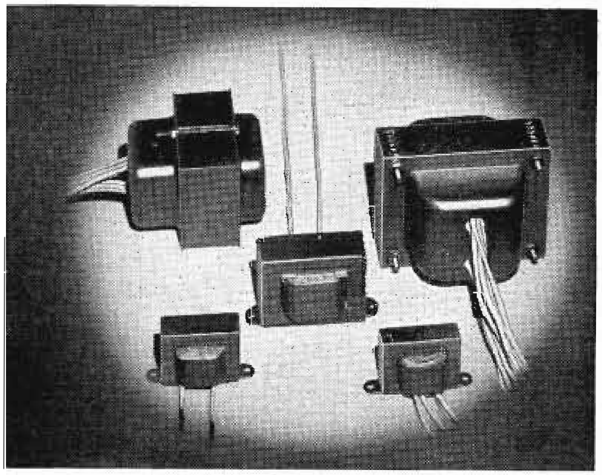
Designers

Television Transformers...tailored to your needs

1. Line supply voltage and frequency
2. High voltage d-c required
3. D-c milliamperes required
4. Filament volts and amperes
5. Sub-panel or above-panel mounting
6. Description of rectifier circuit
7. Winding insulation voltage required
8. Maximum ambient temperature

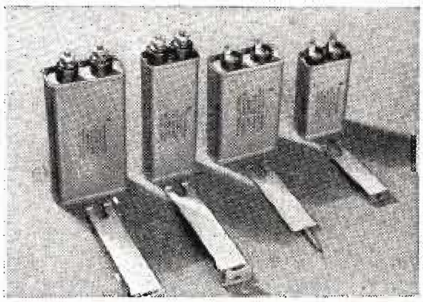
TELL US THESE

WE SHIP THESE



Whatever your transformer needs—power units like these, or special designs for deflection yokes, horizontal or vertical sweeps, or oscillators—General Electric can supply them . . . and quickly. G.E. offers its facilities and engineering "know-how" to television manufacturers in tailoring these transformers to their requirements. Just tell us your specifications and we will meet them to your complete satisfaction. Power-supply transformers are available now in core-and-coil and enclosed-case styles as standard units designed for television applications. Units for other uses are tailor-made from standard parts. Ask your G-E representative for more information; you'll be pleased with the prices and shipments he will offer you.

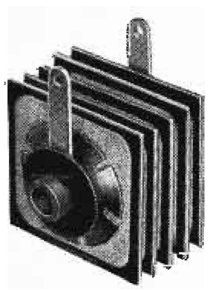
NEW PYRANOL CAPACITORS SAVE SPACE, WEIGHT, MONEY



If you have been using 600-volt d-c capacitors on circuits rated 400 volts or less, you're in for a substantial saving in weight, size and cost by specifying General Electric's new 400-volt Pyranol units. Compared with 600-volt ratings, these new, standard, 400-volt capacitors will save you from 24 to 51 per cent in volume, 23 to 33 per cent in weight, and approximately 10 per cent in cost. They are available in 2-, 4-, 6-, 8- and 10-muf ratings with solder-lug or screw-thread terminals optional on the four larger sizes; the 2-muf size comes with solder-lug terminals only.

New developments, such as silicones and new paper, are continually improving the quality of G-E capacitors. They also permit our engineers to handle your new requirements to your complete satisfaction. Write for quotation on any capacitor needs, or check Bulletin GEA-2621 for more information on the new d-c line described above.

NEW, SMALLER SELENIUM RECTIFIER



This new General Electric selenium rectifier, less than one inch long and one inch square, is available now for receiver and other elec-

GENERAL ELECTRIC

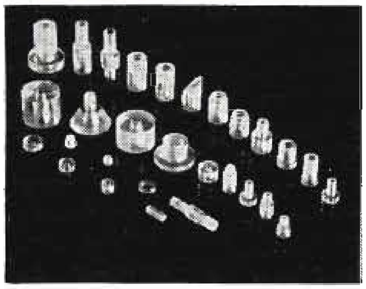
Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS

tronic applications. It costs little and mounts in places where a rectifier tube and socket won't fit. Tests prove that this new selenium rectifier will outlast several 117-volt rectifier tubes. Installation is easier too—only two soldering operations and a minimum of mounting hardware are required.

These rectifiers have an exceptionally high inverse-peak rating, and the inverse current is extremely low even with peak voltages up to 350 volts. At rated current output, the forward drop is five volts or less. Ratings are based on ambients of 50 to 60 C. Check Bulletin 21-127 for more information on this and other General Electric radio rectifiers.

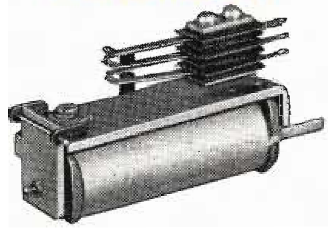
NEW MACHINABLE PLASTIC FOR UHF INSULATION



A new arrival in the plastics insulator field is G-E No. 1422, which offers characteristics of advantage in the manufacture of ultra-high-frequency equipment, television, FM, radar, and radio sets, and many other electronic applications. Possessing a dielectric constant of 2.5 to 2.6 with a power factor of .0006 to .0009 at 3000 mc, G-E No. 1422 exhibits unusual heat resistance and excellent machinability.

Indicative of its machinability is the industrial production of r-f connector beads from G-E No. 1422 on automatic and semi-automatic screw machines. As a low-loss dielectric in the hands of the electric-equipment designer, it affords an excellent low-cost means of producing experimental models and small production quantities through the use of standard machine shop tools. Check coupon for technical report.

HANDLES 12 CIRCUITS SIMULTANEOUSLY



This new telephone-type relay is capable of handling as many as 12 circuits in a wide variety of contact combinations. Designed for multipurpose use in industrial electronic apparatus, communications and signaling equipment, these devices have service lives measured in millions of operations. Working from five basic contact arrangements, combinations can be stacked to satisfy intricate circuit switching requirements. Silver, palladium, or tungsten contacts can be supplied; the choice depends on rating and life specifications.

More than 500 different coils are available, with ratings ranging from 1 to 250 volts, and 0.1 to 26,000 ohms. This varied selection of coil ratings makes it possible to match closely the coil voltage and resistance with the rating of the energizing circuits. Check Bulletin GEA-4859 for full details.

TO MEASURE TUBE LIFE

Now available for immediate delivery, General Electric Type KT time meters are ideal for inclusion in transmitters and other electronic equipment where knowledge of tube "on time" is important. They can record operating time in hours, tenths of hours, or minutes, and are built in four forms: round or square for panel mounting, portable with attached base, or for conduit mounting. Those designed for panel mounting are housed in small Textolite cases that harmonize with other panel devices.

Telechron motor drive assures an accurate record of tube operation over a long period of time. They can also be used on electronic production tools, such as resistance welders, to keep an accurate record of machine operating time. Researchers use them for measuring time intervals, verifying circuit operation, and life testing. Bulletins GEA-3299 and GEA-1574 have full details.

GENERAL ELECTRIC COMPANY, Section B642-16
Apparatus Department, Schenectady 5, N. Y.

Please send me:

- ☐ GEA-2621 400-v D-c Capacitors
- ☐ GEA-3299 } Type KT Time Meter
- ☐ GEA-1574 }
- ☐ 21-127 Selenium Rectifier
- ☐ GEA-4859 Telephone-type Relay
- ☐ Report on G-E No. 1422 Plastic

NOTE: More data available in Sweets' File for Product Designers.

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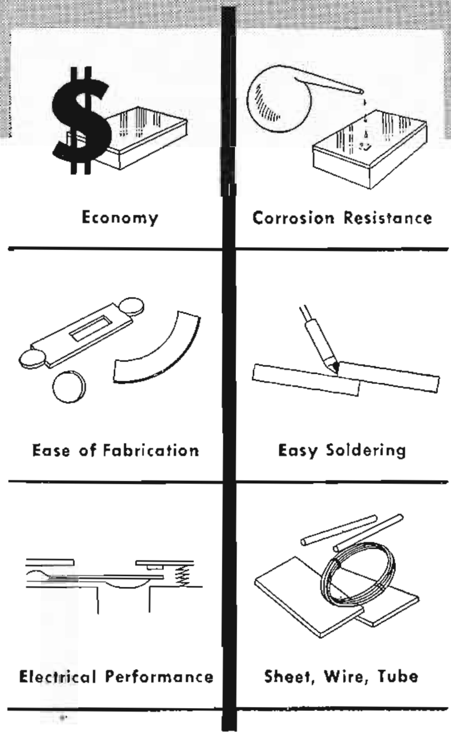

The versatility of General Plate Laminated Metals enables you to simplify designs, cut costs and maintain precious metal performance such as exceptional electrical conductivity, corrosion resistance and long operating life.

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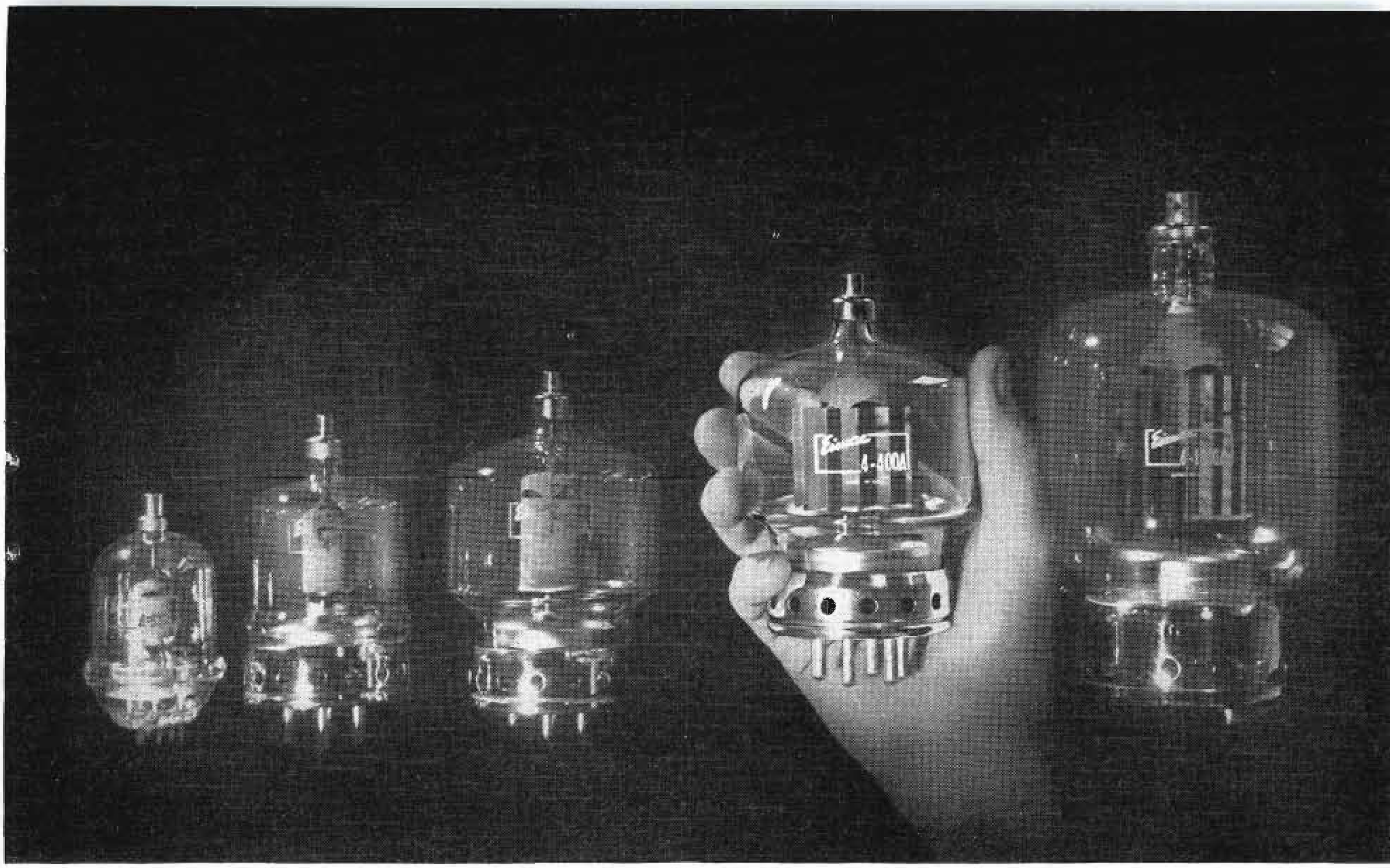


FOR 1 KW FM . . . A NEW RADIATION COOLED TETRODE

ANOTHER in the Eimac line of power tetrodes . . . Type 4-400A embodying stability, high performance, and economy characteristics familiar to all Eimac tetrodes.

PROVEN DESIGN

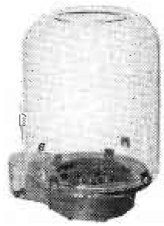
The 4-400A was created to fill the established need for a tetrode of the internal anode type capable of providing 1 kw FM-broadcast output per pair at low driving power, while operating well below maximum ratings. Type 4-400A inherits the Eimac know-how of tetrode design, it incorporates maximum shielding of the tube input—output circuits, processed non-emitting grids, low-inductance leads, thoriated tungsten filament and a rugged plate contributing to exceptionally long tube life.

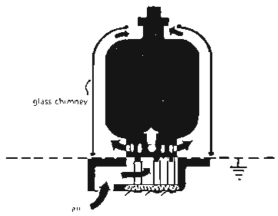
AMPLE POWER

In typical operation, at frequencies in the 88-108 Mc FM broadcast band, two 4-400A tetrodes provide over 1000 watts of useful power output, operating at 4000 plate volts, while the plate dissipation is considerably under the maximum rating of 400 watts per tube. Complete operational data and characteristics are available by writing direct.

UNIQUE FEATURE

To assure adequate cooling and extended tube life, the 4-400A must be used in the special Eimac socket and air control chimney. This unique socket makes maximum use of a small amount of air by directing it first on the terminals, around the base seals, through the socket, around the envelope, and then on the plate seal and lead. The socket housing is of cast aluminum and conveniently mounts below the chassis deck while spring clips on the deck support the pyrex chimney.





LOW COST

Type 4-400A tetrodes are priced at $50.00 each, an exceptionally low price considering their power performance capabilities.

DESIGN ASSISTANCE

Let Eimac engineers assist you in your vacuum tube application problems. A letter to the Application Engineering Department will bring you up-to-the-minute data and application suggestions on the 4-400A and other Eimac tube types.

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. . . the new Model "S"

Here is welcome news to manufacturers of radio-phonographs—Seeburg announces the addition of a new, single-post record changer—the Model "S".

This new Seeburg Changer has been designed and engineered to bring important competitive advantages to your table model and popularly priced consoles. For while the Model "S" is moderately priced, it is Seeburg quality throughout, possessing many of the features found only in more expensive changers.

Plan now to give desired appeal to your instruments with new Seeburg Model "S" Record Changers.

MODEL "S" FEATURES

- Sturdy, single-post changer
- Modern styling — smart, shield-shaped base
- Lightweight tone arm
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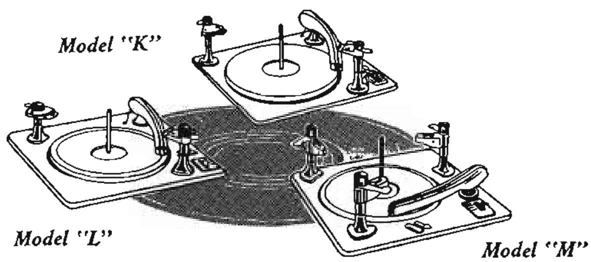


TELE-TECH

Formerly the TELE-communications TECH-nical Section of
ELECTRONIC INDUSTRIES

O. H. CALDWELL, EDITOR ★ M. CLEMENTS, PUBLISHER ★ 480 LEXINGTON AVE., NEW YORK (17), N. Y.

AUDIENCE RADAR—The radar principle will soon be used in audience-measuring technics, according to Frank Stanton, CBS president. For each home radio set equipped with a **respondor** attachment, four different kinds of information will be reported: (1) Set on or off; (2) Which program; (3) Family income; (4) Set location. The scheme sounds a lot like the IFF radar (Identification-Friend or Foe) used during the recent war. **Transpondors** emitting coded radar pulses triggered off respondors. Depending on the code received, the respondor answered the original interrogation with a specific piece of information. The new listener-checking system was developed by CBS and is to be known as Instantaneous Audience Measurement Service (IAMS).

RADIO PATENTS are now running about 12½% of all U. S. patents issued in all fields, if the output of the Patent Office for a single day (October 28) is a proper criterion to go by. That day a total of 424 patents emerged; 50 of them had to do directly with radio communications. A lot of these bright ideas never will dazzle with their brilliance; others undoubtedly are valued primarily for their "nuisance value." But a fair proportion represent worth-while contributions to the art, though it likely will be a long time before they reach the commercial stage. Meantime they point the way to today's thinking for tomorrow.

LINE-OF-SIGHT MAPS of cities, showing by tinted areas territories reached directly by each nearby television transmitter, would be useful to retail dealers, TV servicemen, home-owners, and real-estate offices having properties for sale to television-minded prospects. Preparation of such a map is not difficult, using contour map as basis. Such charts prepared by Dumont for New York suburban area are useful in judging reception from all metropolitan TV stations.

U. S. NAVY AIR STATIONS are installing photoelectric ceilometers to record the altitude of cloud ceilings up to 10,000 feet. A beam of light thrown against the cloud base is reflected back to a photoelectric detector, placed a known distance from the projector. Altitude is found by triangulation. The reading is recorded on a machine in the airport office. Used in the daytime, modulating the beam distinguishes it from daylight. The device was originally developed by the National Bureau of Standards and the Weather Bureau and is already in use at 140 Weather Bureau stations throughout the nation. Installation of a photoelectric ceilometer costs about $3500.

TELEVISION IN EVERY ROOM. Makers of television equipment remember well the impact of the first "radio-in-every room" campaign just about twelve years ago. Hotel management can now purchase hotel television systems from at least three manufacturers. More on this interesting development of television appears elsewhere in this issue.

NEW PRODUCTS, PARTS AND COMPONENTS that come on the market—latterly in quite a flood as is indicated by pages further back in this issue—are an indication of the progress of the art. In countless cases, the old wont do any more. New tasks impose new requirements, bring about re-design and the development of so many new things that engineers are hard put to it to keep abreast of progress. A close study of current periodicals of the profession is more than ever a must.

BC ENGINEERS' PAYCHECKS—35,000 persons are now employed in the business broadcasting, according to latest FCC survey. FCC began to take tabs in October of 1945 and saw broadcast employment increase at the rate of 1% per month for the subsequent 18 months! Here is a list which compares the average weekly earnings of broadcast personnel employed by seven major networks with their key stations and those employed in other stations.

Employe Classification	Big Stations	Little Stations
General Officers	$356	$156
Program Employees	$108	$ 56
Chief Engineers	$154	$ 86
Studio Engineers	$100	$ 73
Transmitter Engineers	$ 96	$ 60
Salesmen	$147	$ 92

The big stations naturally pay much higher salaries. However, in number they amount to only 1%, the smaller stations accounting for the other 99%.

The Design of Audio Compensation Networks

By WILLIAM A. SAVORY, Audio Engineer, Englewood Cliffs, N. J.

Application of the correct equalization for various commercial phonograph recordings has an important effect on character of reproduction

THIS is the first of three articles on the important subject of disc recording. Part 2 will deal with high-frequency compensation networks, and Part 3 covers low and high frequency network data in chart form, and describes a phono-preamp with a six-position low-frequency crossover and high-frequency correction equalizer.

• Due to the deliberate attenuation of the lower portion of the audio frequency spectrum in the recording of commercial phonograph records and transcriptions, proper reproduction (insofar as this phase of the problem is concerned) is contingent upon some form of compensation to overcome these original losses in the bass region. The magnitude of the bass compensation problem is increased by virtue of the fact that different "crossover"[2] points (i.e., points in the frequency spectrum at which progressive bass attenuation begins during recording) are encountered in recordings of differing manufacture. Phono recordings of any one of the major producers of this product are to be found with as many as two and even three different crossover points represented in their current catalogs.

This issue is further confused by unillustrated engineering descriptions of various recording characteristics in the 50 to 1000 cps region which fail to define whether a crossover point mentioned refers to an arbitrary "hinge" frequency that marks the immediate departure of the output response from a given reference level, or (more correctly) whether the stated crossover frequency establishes the half-power point at which, by definition, the output response is 3 db down from a given reference level.

Proper equalization of the lower frequency spectrum is to be considered first for the following reason: From a listening standpoint it is at once the most important and, paradoxically, the most neglected part of the subject of reproducer compensation. To illustrate, Fig. 1a represents the output vs. frequency response below 1 kc of a phono reproducer which has been equalized to compensate correctly for a recording loss of 9 db per octave below a "hinge" frequency of 300 cps. A record with a low frequency attenuation characteristic as shown in Fig. 1b is now reproduced on the system of Fig. 1a. Fig. 1c discloses the result: A considerable lack of response in the very region where most of the fundamental tones of orchestral music are concentrated.[1] Obviously, separate compensating networks are indicated, especially as these two crossover characteristics are quite commonly encountered. The design of two RC networks to afford proper compensation in this case will be considered.

Measuring Methods

At the outset it might be well to explain that LC configurations are not being considered for the following reasons:

(1) Difficulties attendant upon the procurement of exact design inductance values.

(2) Failure of measured LC network curves to match predicted design curves. This usually may be traced to the poor Q (WL/R) factor of most commercially available inductors. High Q coils are of course obtainable, but at correspondingly increased costs.

(3) Networks containing inductance that are operated in low-level circuits are rather sensitive to stray ac flux fields, and thus introduce noise problems and complicated structural arrangements due to the necessity of proper inductor orientation.

(4) Economic considerations: RC configurations may be constructed at but a fraction of the cost of those containing inductance. See (2), above.

(5) Many (naturally, not all) phono reproducer compensation problems can be successfully handled with proper RC networks.

In the following work the basic measuring instruments used were: the Columbia 10003-M and 10004-M frequency records for domestic 78 rpm phono recording characteristics; the HMV Gramaphone Test Recording D. B. 4037 for foreign 78 rpm phono characteristics; the Columbia YTNY 170 frequency record for 33.3 rpm lateral cut standard National Association of Broadcasters[2] transcription characteristics; an audio frequency vacuum-tube voltmeter; an accurate meter for resistance measurements; a variety of suitable potentiometers; a dual speed (33.3 and 78 rpm) turntable; and a disc stroboscope.

As a case in point, reproducer A will now be considered in connection with the bass frequency compensation problem illustrated in Fig. 1a

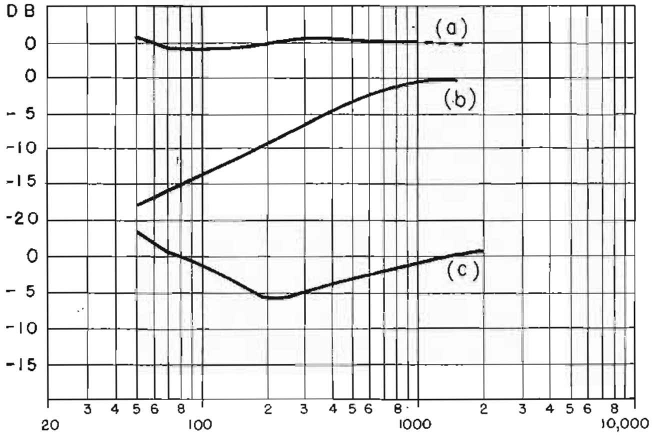


Fig. 1—If a record with low frequency attenuation as at b is reproduced with reproducer a, result will be as shown at c

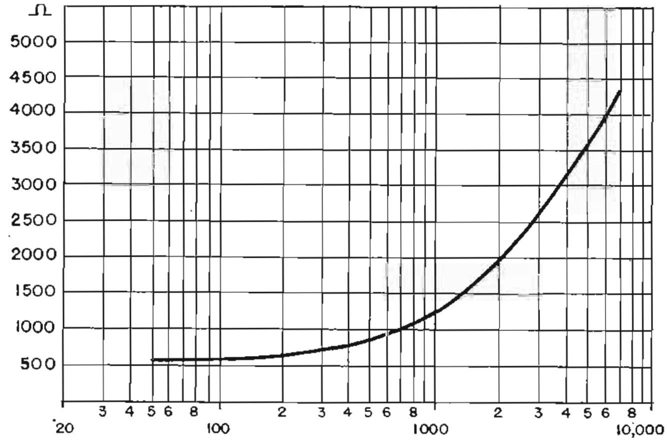
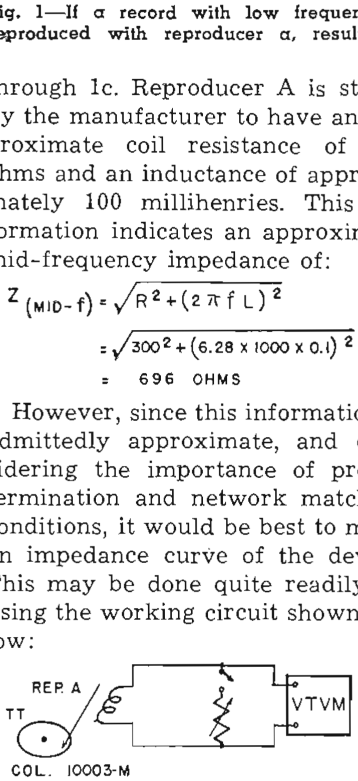


Fig. 2—Actual Z curve of reproducer a (left), which would require a load of 5000 ohms to represent a reasonable match

through 1c. Reproducer A is stated by the manufacturer to have an approximate coil resistance of 300 ohms and an inductance of approximately 100 millihenries. This information indicates an approximate mid-frequency impedance of:

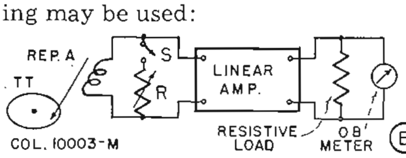
$$Z_{(MID-f)} = \sqrt{R^2+(2\pi f L)^2} = \sqrt{300^2+(6.28 \times 1000 \times 0.1)^2} = 696 \text{ OHMS} \quad (a)$$

However, since this information is admittedly approximate, and considering the importance of proper termination and network matching conditions, it would be best to make an impedance curve of the device. This may be done quite readily by using the working circuit shown below:



(A)

If a VTVM is not available, an alternate system such as the following may be used:



(B)

In either case the procedure is as follows:

(1) With turntable TT set at 78 rpm, check speed with disc stroboscope.

(2) Set R somewhere in the neighborhood of 600 ohms.

(3) With switch S open, place reproducer A on the 50-cycle band of the frequency record and note output voltage on meter. (Use needle pressure not in excess of that recommended by manufacturer.)

(4) Close switch S and again play the 50 cycle band. Vary R until a 6 db drop (or 2 to 1 voltage drop) from the switch open reading is obtained on the meter.

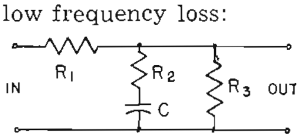
(5) Accurately measure the resistance of R. This is the impedance of reproducer A at 50 cycles.

(6) Repeat steps (1) through (5) on all frequencies of the record and plot the resulting impedance curve.

The actual Z curve of reproducer A is shown in Fig. 2. This information is quite important in the case of a compensation network designed to be inserted in series with the reproducer, as it must present a nominal load to the device at the mid- and high-frequencies in order to avoid excessive attenuation in this range. In the case of reproducer A, a load value of 5000 ohms presents a reasonable match.

Frequency Response

The next step is to determine the output vs. frequency response of reproducer A. The same measuring circuit of (A) or (B), above, will be used, with the switch S closed and R set at 5000 ohms. Play the Columbia 10003-M Frequency Record and note the response. The actual unequalized frequency run in the 50- to 1000-cycle region on reproducer A is shown in Fig. 3a. A 9 db per octave correction network of the following general configuration will now be designed to compensate for this low frequency loss:

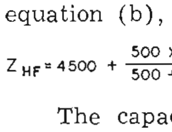


(C)

Since the maximum correction obtainable from a network of this type only approaches a 6 db per octave curve, the network will have to contain two sections: one having a 6 db per octave rise in output vs. frequency response below the "hinge" point at 300 cycles, and the other a 3 db rise below a frequency to be determined more accurately after the first section is completed and measured. The load impedance presented by such a network at mid- and high-frequencies (neglecting Xc which will be quite small in this region) is:

$$Z_{HF} = R_1 + \frac{R_2 \; R_3}{R_2 + R_3} \quad (b)$$

For a network having an output vs. frequency response approaching a 6 db per octave curve, R_1+R_2 will have a total value equal to the working impedance desired—in this case 5000 ohms:



$Z = R_1 + R_2 = 5000$ OHMS
$R_2 = Z \times .1 = 500$ OHMS
$R_1 = 4500$ OHMS (D)

R_3 should be made as large as is practicable. A nominal figure is 500,000 ohms. As a check on the mid- and high-frequency loading, these values may now be substituted in equation (b), above:

$$Z_{HF} = 4500 + \frac{500 \times 500{,}000}{500 + 500{,}000} = 4{,}999 \text{ OHMS} \quad (c)$$

The capacitor C may now be calculated. Inspection of Fig. 3a locates the halfpower point (3 db loss frequency) at 200 cycles. This point is the actual design frequency of the network, instead of the 300 cycle "hinge" point. At 200 cycles, then, the network response should be up 3 db over some remote high frequency, say, 2000 cycles. This is accomplished by making Xc numerically equal to R_2 at the half-power point, in this case 200 cycles:

$$X_C = \frac{10^6}{2\pi f C} = 500 \text{ OHMS}$$

$$C = \frac{10^6}{6.28 \times 200 \times 500} = 1.6 \text{ MFD.} \quad (d)$$

and the completed section of the network now contains the following values:

R_1 = 4500 OHMS
R_2 = 500 OHMS
R_3 = 500,000 OHMS
C = 1.6 MFD.

A frequency run of reproducer A with Section 1 of the network in the circuit is now made, and results in the response curve shown in Fig. 3b. This curve indicates that an additional 3 db per octave correction below a half-power loss frequency of 100 cycles is necessary. Section 2 of the network will now be constructed to take care of this additional loss. Where only 3 db per octave compensation is necessary, the following are the design values assigned:

$$Z = R_1 + R_2 = 5000 \text{ OHMS}$$

$$R_2 = Z \times 0.3 = 1500 \text{ OHMS}$$

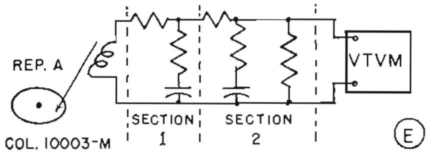
$$R_1 = 3500 \text{ OHMS}$$

R_3 again will take the value of 500,000 ohms and R_3 of Section 1 may now be eliminated, as Sections 1 and 2 will be connected in series. Section 2 is now complete except for capacitor C. As above, (Section 1) the reactance of C will have a value numerically equal to $2R_2$ at the half-power frequency, 100 cycles:

$$X_C = \frac{10^6}{2\pi f C} = 1500 \text{ OHMS} = R_2$$

$$C = \frac{10^6}{2\pi f 2 R_2} = \frac{10^6}{6.28 \times 100 \times 3000} = 0.525 \text{ MFD.} \quad (e)$$

This completes Section 2 of the network. Both sections are joined and a final frequency run is made as shown:



resulting in the curve of Fig. 3c. Reproducer A is now properly equalized to play phonograph records recorded with this bass frequency attenuation characteristic.

This procedure, starting with the unequalized reproducer, is now repeated with a frequency record described as having an "800 cycle crossover" frequency. However, an output vs. frequency response run using Reproducer A resistively terminated in 5000 ohms yields the curve shown in Fig. 4a. Examination of this curve discloses the "hinge" frequency point to be at 1500 cycles, and the half-power point to be at 500 cycles, with a recording loss of 7 db per octave below this point.

As previously pointed out, networks of this type cannot be expected to provide for more than 6 db per octave correction. However, in this case the "hinge" frequency (1500 cycles) is sufficiently removed from the half-power point (500 cycles), so that a compromise can be effected and a single section network made to suffice.

This is accomplished by arbitrarily advancing the half-power design point to 800 cycles, and selecting as small a value for R_2 as is practicable in order to give the maximum approach to a 6 db per octave curve. The importance of R_2 with respect to this question will be made clear by considering the output voltage of the network under discussion at low and high frequencies.

At mid and high frequencies the approximate output voltage (neglecting Xc which is quite small in this region) is:

$$E_0 = E_1 \frac{\left(\frac{R_2 R_3}{R_2 + R_3}\right)}{\left[R_1 + \left(\frac{R_2 R_3}{R_2 + R_3}\right)\right]} \quad (f)$$

In the case of reproducer A the stated output voltage is of the order of 11 millivolts. Using a design factor of $R_2 = .05Z$, a network having the following values will be analyzed for out voltage: $R_1 = 4750$ ohms, $R_2 = 250$ ohms, and $R_3 = 500,000$ ohms.

Substituting in (f) above: $E_o = 0.00053$ volt.

At extreme low frequencies $(R_2 + X_c)$ rises to a large value and consequently has but a slight shunting effect on R_3. Therefore, at very low frequencies the approximate output voltage is:

$$E_0 = E_1 \frac{R_3}{R_1 + R_3} = .011 \frac{500,000}{4750 + 500,000} = .01089 \text{ VOLT.} \quad (h)$$

The difference between these voltages over a wide frequency range is about 26 db. Inspection of equation (f) above, shows that as R_2 is made a larger part of $(R_1 + R_2)$ the attenuation in the higher frequency range becomes less, and the slope of the compensation curve is decreased.

Returning to the single section network decided upon for correction of this frequency record, we now have $R_1 = 4750$ ohms, $R_2 = 250$ ohms, $R_3 = 500,000$ ohms, and having selected 800 cycles as the design point:

$$X_C = \frac{10^6}{2\pi f C} = 250 \text{ OHMS}$$

$$C = \frac{10^6}{6.28 \times 800 \times 250} = 0.8 \text{ MFD.} \quad (i)$$

A frequency run of reproducer A

Fig. 3—Actual unequalized frequency run on reproducer a; with section 1 of network at b; with both sections at c

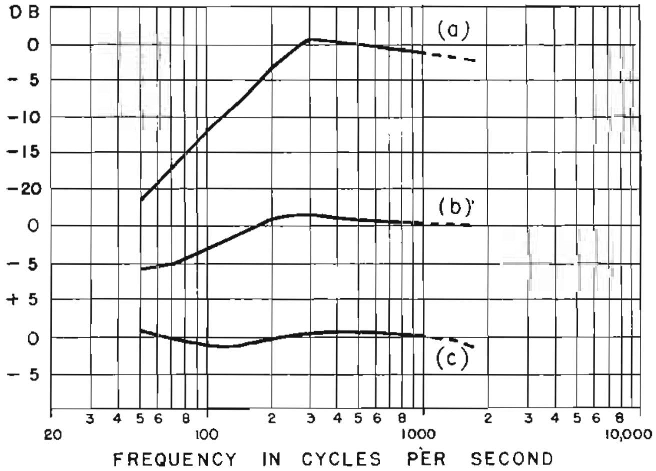
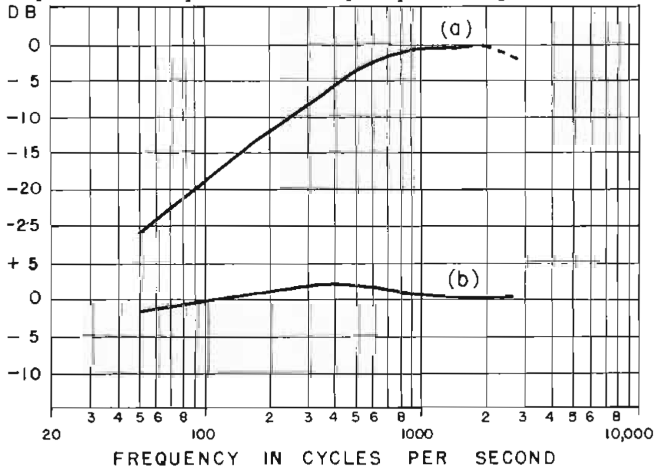


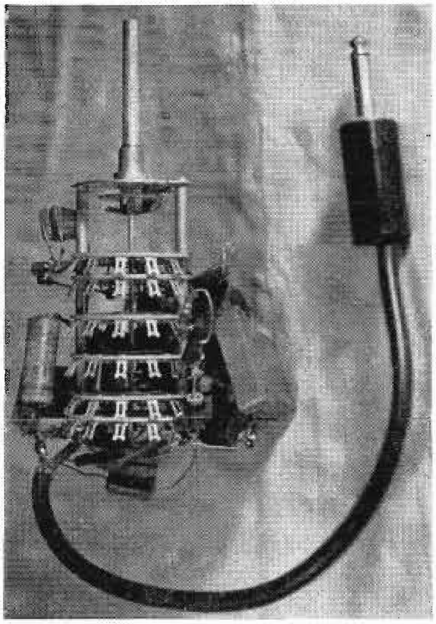
Fig. 4—Reproducer a properly compensated b to play properly two commonly used bass frequency recording characteristics



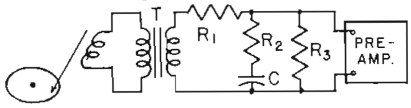
with this completed network in the circuit is shown in Fig. 4b. Reproducer A has now been compensated to play properly two commonly used bass frequency recording characteristics. The networks may be inserted individually by means of various switching arrangements.

For a network to compensate properly for the low frequency attenuation of a typical transcription recorded according to the NAB Lateral Standard,[2] the same procedure as outlined is used, i.e., using the Columbia YTNY 170 as the frequency record. Similarly, if it is desired to equalize for the bass frequency characteristics of typical foreign phonograph recordings, the HMV Test Recording D.B. 4037 is used.

The location of this type of network is of course not limited to directly following the reproducer. In fact, in the case of a reproducer in wide use in the broadcasting industry, the impedance of the device is so low that such a network location is impractical due to the large value that C would assume in such a low impedance line. In the case of this and similar types of low impedance reproducers, the following circuit arrangement is suggested:



Switch arrangement with its complement of resistors and capacitors for the audio compensation network



$R_1 + R_2 = Z$ (TRANS. SEC.)

$R_2 = Z \times 0.1$ (FOR 6 db PER OCTAVE CORRECTION)

$R_2 = Z \times 0.3$ (FOR 3 db PER OCTAVE CORRECTION)

$X_C = R_2$ AT 3 db DOWN CROSS-OVER FREQUENCY.

In the above case, R_3 should not exceed the stated grid-to-ground resistance given by the tube manufacturer, which in general seldom exceeds 500,000 ohms. If the transformer T has a reflected secondary impedance higher than this value, R_3 can be divided with the upper part in series and the 500,000 ohm portion put in shunt with the grid.

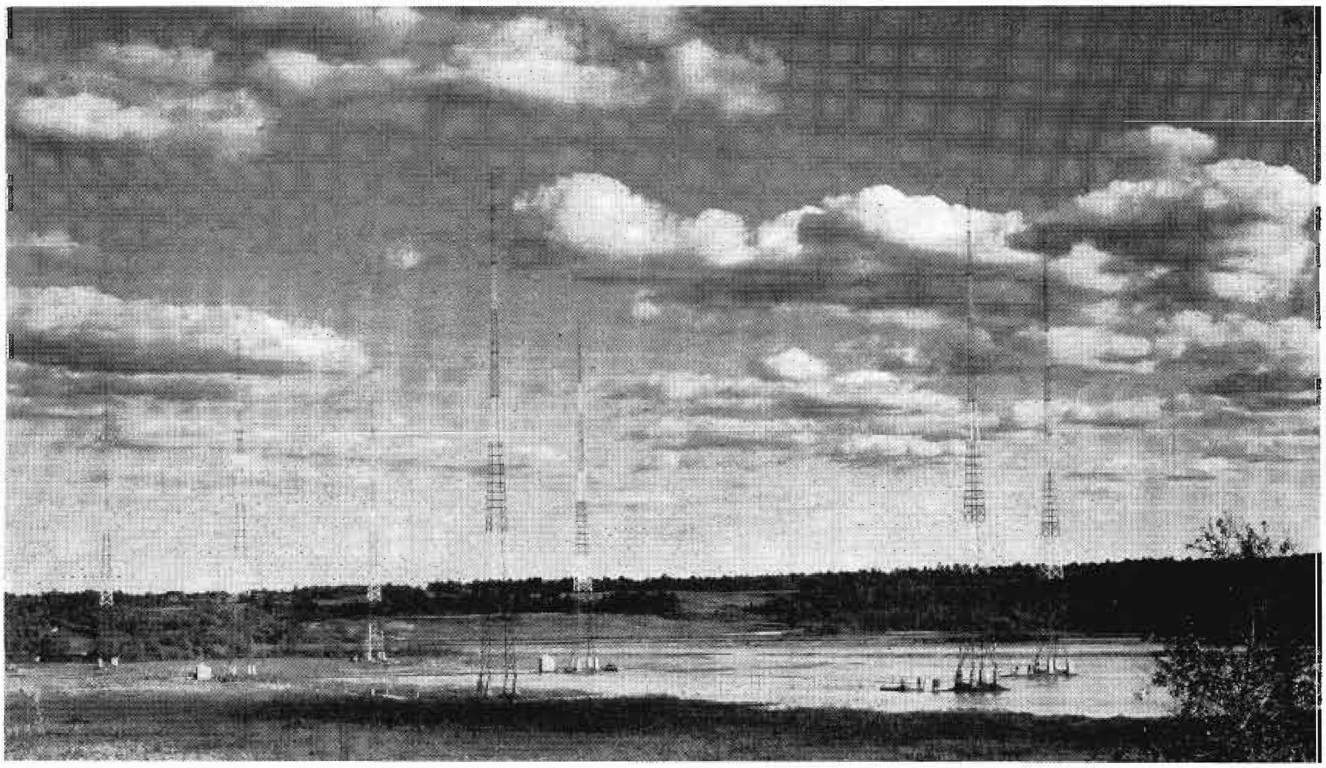
As previously pointed out, (Fig. 1a through 1c), this question of proper low frequency compensation is quite an important phase of phonograph reproducer equalization. Some form of standardization in the recording industry with respect to recording characteristics clearly would be of great help toward simplifying the problem of proper reproduction. However, it is felt that the millions of records extant in libraries, radio stations, and personal collections, underline the need for information on the subject of proper reproducing systems and networks.

REFERENCES

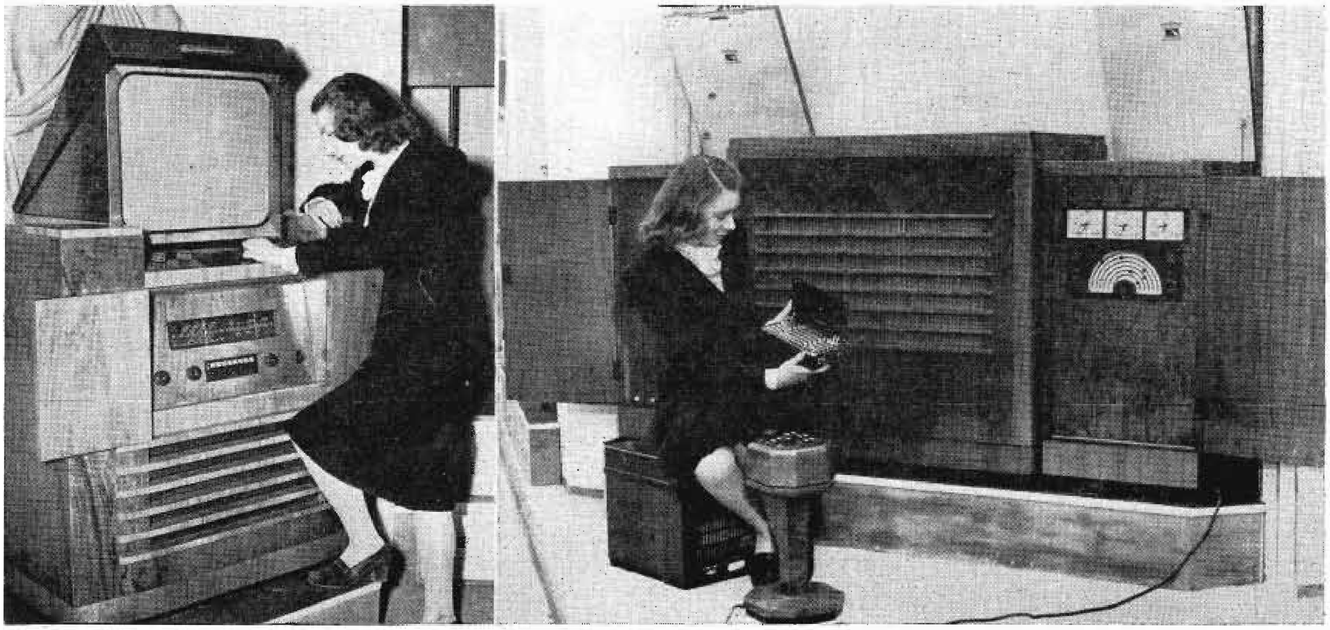
[1] Sivian, Dunn and White: "Absolute Amplitudes and Spectra of Certain Musical Instruments and Orchestras." Journal of the Acoustic Society of America, Volume 2, page 330, January, 1931.
[2] "Proposed Response-Frequency Characteristics for 33.3 RPM Lateral Cut Transcriptions." National Association of Broadcasters.

Next month part 2 of this phonograph reproducer series covers high-frequency compensation networks. Ed.

UNUSUAL SEVEN-TOWER DIRECTIONAL BROADCASTING ARRAY



Few broadcasting stations require such an extensive forest of towers as does WREX of the Lake Superior Broadcasting Co., Duluth, Minn. Six towers are used during the night and the seventh, with two night pattern towers, make up a three-element array to give day time coverage. The top 100 ft. of the 225 ft. tower is constructed of round members to reduce wind resistance



At left is shown one British version of a large-screen (16x20 in.) home projection television set which also incorporates an all-band AM receiver. Model at the right is a 43-tube remote-controlled console containing an all-band receiver as well as an automatic phonograph. Set will automatically switch itself on to any of three preselected programs at predetermined times. Girl is holding a personal portable which uses all miniature tubes

British Developing Projection TV

Olympia exhibit reveals that most receivers have 8x10 direct-view tubes; fixed tuning simplifies design and construction

• Television apparently stole the show at the Radiolympia exhibition in London in October, though, as might be expected, there was nothing startlingly new in the way of engineering for visitors to see. This was the first British exhibition since 1939, the fifteenth affair of its kind. The British Radio Industry Council, which represents all branches of the industry and stages the exhibition had divided exhibits broadly into four classes: broadcasting and communications generally, television, radar and navigational aids, and industrial applications of vacuum tubes.

Television receivers of some 29 different makers were displayed, most pretentious of the lot being a really immense console model which in addition to including a projection set (based on the familiar Schmidt system) with a screen measuring 16 x 20 in. also held an AM sound receiver covering 12 different bands in the spectrum with provisions for automatically switching itself on to any of three pre-selected programs at various pre-determined times. The set has 43 tubes, or valves as the British style them, and may be operated by remote control. Manufacturer is the Gramophone Co.

In general the new British TV receivers show a tendency to return to the prewar picture size of approximately 8x10 in. though they never did get very far away from that size, at least insofar as anything like mass production is concerned. These are mostly table models, priced to sell below the American equivalent of $400. Many have provisions for all-wave sound reception of AM; there is no FM in England as yet. Among larger screen sets, Philco exhibited its projection model and Electrical Musical Industries (EMI) showed a projection model quite similar to the Philco and having a screen the same size. It includes a five-tube sound receiver and sells for $1762, including tax. Inasmuch as there is only one British television transmitter, fixed tuning for that station is almost universal.

Apparently the British go in for pre-selection of their radio programs to a greater extent than do their American cousins. Quite a number of the new British radio receivers provide for pre-selecting preferred programs and at least one manufacturer has come up with an attachable accessory with which pre-selection of up to 20

(*Continued on page* 75)

U. S. Radio Statistics, 1948

Radio-electronic output and complete home-set census. Production and use tabulated for industry's past 26 years

THE RADIO-ELECTRONIC INDUSTRY

Data Covers Year Ended December 31, 1947	Total Investment	Annual Gross Revenue	Number of Employes	Annual Payroll
Radio manufacturers (1100)	$60,000,000	$ 450,000,000	80,000	$110,000,000
Radio distributors, dealers, etc.	300,000,000	1,000,000,000	125,000	240,000,000
Broadcasting stations (1800) including talent costs	125,000,000	380,000,000	*20,000	70,000,000
Commercial communication stations	60,000,000	....	15,000	8,500,000
Listeners' sets in use (66,000,000)	3,000,000,000	....	......	†500,000,000

* Regular staff—not including part-time employes, artists, etc., who number at least 30,000 more.
† Annual operating expense for listeners' sets, for tube replacements, electricity, servicing, etc.

ANNUAL BILL OF U. S. FOR RADIO

Sales of time by broadcasters, 1947	$350,000,000
Talent costs	60,000,000
Electricity, batteries, etc., to operate 66,000,000 receivers	220,000,000
17,000,000 home radio receivers, at retail value	800,000,000
170,000 television receivers, at retail value	120,000,000
Phonograph records, 325,000,000	300,000,000
Radio repairs and supplies:	
66,000,000 replacement tubes	90,000,000
Radio parts, accessories, etc.	100,000,000
Labor	75,000,000
TOTAL	$2,115,000,000

RADIO SETS IN U. S.; WORLD

	January 1, 1948
United States homes with radios	37,000,000
Secondary sets in above homes	16,000,000
Sets in business places, institutions, etc.	4,000,000
Automobile radios	9,000,000
TOTAL sets in United States	66,000,000
Total radio sets in rest of world: North America, 4,500,000; South America, 5,000,000; Europe, 46,500,000; Asia, 6,500,000; Australia, 2,500,000; Africa, 1,000,000	66,000,000
TOTAL sets in world	132,000,000

PRODUCTION OF CIVILIAN RADIO EQUIPMENT — 1922 TO 1947

	Total Civilian Sets Manufactured		Total Civilian Tubes Manufactured		Automobile Sets Manufactured		Total Reception Equipment	Auto Sets in Use	Homes with Radio Sets	Total Radio Sets in Use in U. S.	At Close of
	Number	Retail Value	Number	Retail Value	Number	Retail Value	Value	Number	Number	Number	
1922	100,000	$ 5,000,000	1,000,000	$ 6,000,000	....	....	$60,000,000	....	260,000	400,000	1922
1923	550,000	30,000,000	4,500,000	12,000,000	....	....	151,000,000	....	1,000,000	1,100,000	1923
1924	1,500,000	100,000,000	12,000,000	36,000,000	....	....	358,000,000	....	2,500,000	3,000,000	1924
1925	2,000,000	165,000,000	20,000,000	48,000,000	....	....	430,000,000	....	3,500,000	4,000,000	1925
1926	1,750,000	200,000,000	30,000,000	58,000,000	....	....	506,000,000	....	5,000,000	5,700,000	1926
1927	1,350,000	168,000,000	41,200,000	67,300,000	....	....	425,600,000	....	6,500,000	7,000,000	1927
1928	3,281,000	400,000,000	50,200,000	110,250,000	....	....	690,550,000	....	7,500,000	8,500,000	1928
1929	4,428,000	600,000,000	69,000,000	172,500,000	....	....	842,548,000	....	9,000,000	10,500,000	1929
1930	3,827,800	300,000,000	52,000,000	119,600,000	34,000	$3,000,000	496,432,000	....	12,048,762	13,000,000	1930
1931	3,420,000	225,000,000	53,000,000	69,550,000	108,000	5,940,000	300,000,000	100,000	14,000,000	15,000,000	1931
1932	3,000,000	140,000,000	44,300,000	48,730,000	143,000	7,150,000	200,000,000	250,000	16,809,562	18,000,000	1932
1933	3,806,000	180,500,000	59,000,000	49,000,000	724,000	28,598,000	300,000,000	500,000	20,402,369	22,000,000	1933
1934	4,084,000	214,500,000	58,000,000	36,600,000	780,000	28,000,000	350,000,000	1,250,000	21,456,000	26,000,000	1934
1935	6,026,800	330,192,480	71,000,000	50,000,000	1,125,000	54,562,500	370,000,000	2,000,000	22,869,000	30,500,000	1935
1936	8,248,000	450,000,000	98,000,000	69,000,000	1,412,000	69,188,000	500,000,000	3,500,000	24,600,000	33,000,000	1936
1937	8,064,780	450,000,000	91,000,000	85,000,000	1,750,000	87,500,000	537,000,000	5,000,000	26,666,500	37,600,000	1937
1938	6,000,000	210,000,000	75,000,000	93,000,000	800,000	32,000,000	350,000,000	6,000,000	28,000,000	40,800,000	1938
1939	10,500,000	354,000,000	91,000,000	114,000,000	1,200,000	48,000,000	375,000,000	6,500,000	28,700,000	45,300,000	1939
1940	11,800,000	450,000,000	115,000,000	115,000,000	1,700,000	60,000,000	584,000,000	7,500,000	29,200,000	51,000,000	1940
1941	13,000,000	460,000,000	130,000,000	143,000,000	2,000,000	70,000,000	610,000,000	8,750,000	29,700,000	56,000,000	1941
1942	4,400,000	154,000,000	87,700,000	94,000,000	350,000	12,250,000	360,000,000	9,000,000	30,800,000	59,340,000	1942
1943	....	....	17,000,000	19,000,000	....	....	75,000,000	8,000,000	32,000,000	58,000,000	1943
1944	....	....	22,000,000	25,000,000	....	....	85,000,000	7,000,000	33,000,000	57,000,000	1944
1945	500,000	20,000,000	30,000,000	35,000,000	....	....	105,000,000	6,000,000	34,000,000	56,000,000	1945
1946	14,000,000	700,000,000	190,000,000	200,000,000	1,200,000	72,000,000	900,000,000	7,000,000	35,000,000	60,000,000	1946
1947	17,000,000	800,000,000	220,000,000	260,000,000	2,500,000	150,000,000	1,100,000,000	9,000,000	37,000,000	66,000,000	1947

Figures for sets give value with tubes in receivers. In normal years, replacement tubes have run 25% to 40% of total tube production. All figures are at retail values. (Statistics Copyrighted by Caldwell-Clements, Inc.)

Performance Characteristics of FM Detector Systems

By B. D. LOUGHLIN, Hazeltine Electronics Corp., Little Neck, N. Y.

An analysis of operating features of two classes of currently used detection methods for FM receivers—Advantages of each

• This paper is intended primarily to discuss the performance characteristics of various FM detector systems which may have a direct effect upon the design and manufacture of FM receivers. Such performance characteristics include:

1—AM rejection properties, which relate to noise rejection and reduction of distortion due to amplitude modulation from IF selectivity and multi-path transmission.

2—Variation of audio output with carrier level.

3—The tuning characteristics of a receiver using the detector under consideration.

In illustrating these properties for the various detector systems, certain representative over-all performance characteristics are shown. It should be appreciated that while some of their overall characteristics are similar, the several systems differ appreciably in their mode of operation, and consequently differ in structure and in other performance respects.

When sensitivity is considered in terms of audio output voltage vs. input carrier voltage for a given percentage of modulation and similar AM rejection capabilities, all of the various detector systems discussed herein have sensitivities of a similar order of magnitude. Also, by appropriate design, it is possible to obtain very satisfactory detection linearity from the various detector systems.

THIS article describes the general performance characteristics of some of the frequency modulation detector systems of current interest. A detector system using a diode as a dynamic limiter, and having a variable threshold level, is described. This is followed by a review of the characteristics of the better known frequency modulation detector systems, such as those using grid-bias limiters, locked oscillators and ratio detectors.

Most FM detector systems include the equivalent of the balancing action of a balanced discriminator. With a balanced discriminator the AM output is zero at center frequency and is proportional to the frequency deviation from balance, as illustrated by the detector characteristic of Fig. 1A, and shown by the solid curves of Fig. 1B. When an FM detector system exhibits some AM rejection properties, the AM output may be expected to vary similar to the dotted curve in Fig. 1B.

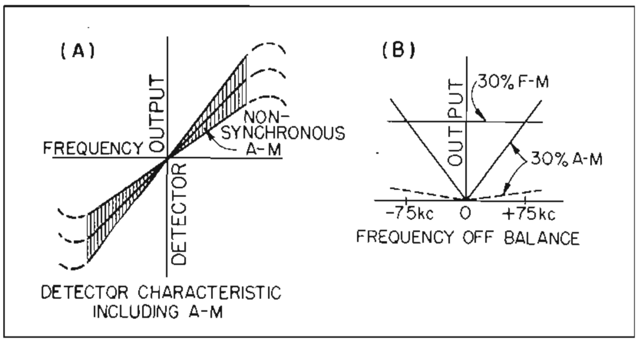
In this paper the term "AM reduction factor" refers to the ratio of the AM output of a detector system exhibiting AM rejection properties to the AM output of an ideal balanced discriminator. The AM reduction factor is generally substantially independent of frequency deviation, but in certain special cases when this is not true, it may be expressed as having different values for large and small amounts of FM. Also when perfect balance is not obtained, this is generally due to a different set of detector deficiencies which are best analyzed separately.

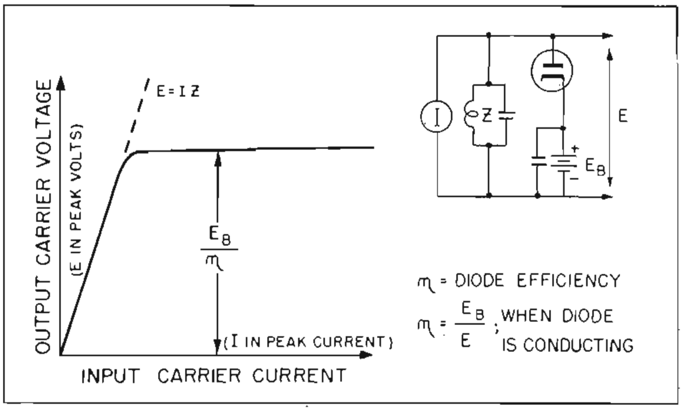
It is convenient to know two characteristics of the AM rejection action of a detector system:

1—The "AM Reduction Factor," which is the ratio of the percentage AM of the output to the percentage AM of the output to the per-

Fig. 1—Characteristics of a balanced discriminator

Fig. 2—Diode limiter as a fixed threshold limiter





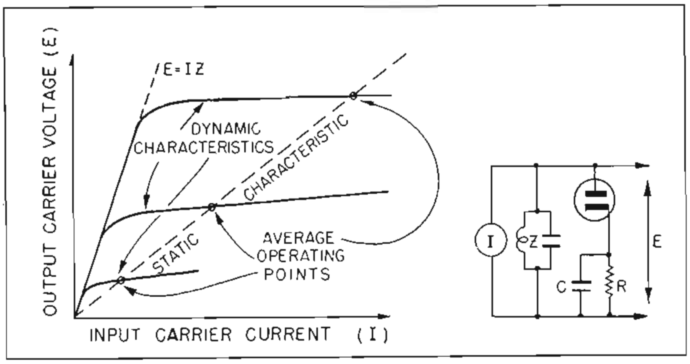


Fig. 3—Limiter characteristics for a dynamic limiter

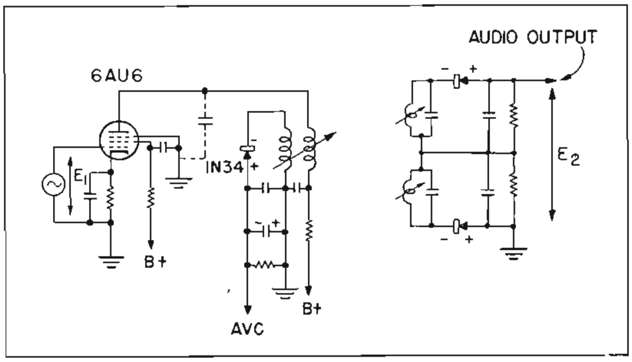


Fig. 4—FM detector using dynamic limiter with germanium diodes

centage AM of the input signal exclusive of the balanced discriminator action, for a small percentage of input AM. This relates to the rejection of such small AM as results from fluctuation noise at normal signal levels.

2—The "Downward AM Capability," which is the percentage of downward AM which produces a certain significant change in output signal amplitude, such as that due to the instantaneous signal level falling below the threshold. This relates in particular to the detector performance under conditions of large AM, such as may be due to multi-path transmission or to the IF selectivity. When a smooth or indistinct threshold exists, the downward AM capabilities are expressed, in this paper, in terms of the downward AM of the input signal which produces 25% AM of the output signal.

The Dynamic Limiter

An interesting type of FM detector system can be produced by using a diode for a limiter and following this by a balanced discriminator. An effective voltage limiter of the fixed threshold type can be produced by placing a biased high-conductance diode in shunt with a high impedance resonant circuit, as shown in Fig. 2.

As the applied signal current is increased, the output increases until the peak output voltage equals the diode bias voltage. As the input is increased beyond this threshold level the diode conducts, producing an increasing damping effect which regulates for approximately constant output. If the circuit Q is high, the damping is in effect integrated throughout the rf cycle so that a single diode, conducting on one peak, can be used. By using a high-conductance diode and a high-impedance tuned circuit the regulation is predominately in the tuned circuit impedance with only a small voltage drop resulting across the diode. This results in a fairly flat voltage limiting characteristic.

If the bias battery is replaced by a long time constant resistor-condenser network, as shown in Fig. 3, a variable threshold device results. The effective bias voltage is now proportional to the average carrier level, its exact value being determined by the resistor value relative to the tuned circuit impedance. However, for dynamic or sudden changes, the bias voltage is held constant by the large condenser, thus producing effective limiting for dynamic changes in the applied carrier signal, as illustrated in Fig. 3. It will be seen from this that the resulting output from the diode dynamic limiter is a carrier whose amplitude is proportional to the average value of the applied carrier current, but as a result of dynamic limiting is relatively free of audio frequency amplitude modulation of the applied carrier.

By following the dynamic limiter by a balanced discriminator, an FM detector system is produced which has a variable threshold level and an audio output which is proportional to the applied carrier level. A practical detector system can be made using a germanium crystal diode for the voltage limiter, this diode having a rather high conductance. Fig. 4 shows such a detector system which uses side-tuned circuits and crystal diodes for the balanced discriminator. It should be noted, however, that the conductance of the discriminator diodes is relatively unimportant as they can operate with rather high load resistors, and only the limiter diode need have high conductance.

Typical performance characteristics for this dynamic limiter detector circuit are shown in Fig. 5. The audio output and AVC voltages are approximately proportional to the input signal level. The AM rejection resulting from dynamic limiting varies smoothly with signal level, becoming better with increasing signal level because of increased diode efficiency. The resulting AM reduction factor, which for small percentages of AM is related to the slope or first derivative of the input-output characteristic of the limiter at the particular average carrier level, is shown in Fig. 5C. It should be noted that the AM reduction factor usually will not become negative in this device at any signal level.

Threshold Level

The downward AM capabilities, shown in Fig. 5D, tend to remain constant with changes in average signal level because of the variable threshold level. However, in this device, as in the ratio detector, the downward AM capabilities reduce at very low signal levels due to lack of AM rejection resulting from low diode efficiency. It is interesting to note that back conduction in a crystal diode used as a limiter merely supplements its limiting characteristics.

It is apparent from the above discussion that the dynamic limiter detector system has a variable threshold level, with a variable output and a downward AM capability which is relatively fixed. The effects of these characteristics upon the tuning characteristics of a complete receiver are interesting.

As the carrier is detuned, the audio output reduces due to a reduction in carrier level, at the detector, resulting from IF selectivity. This

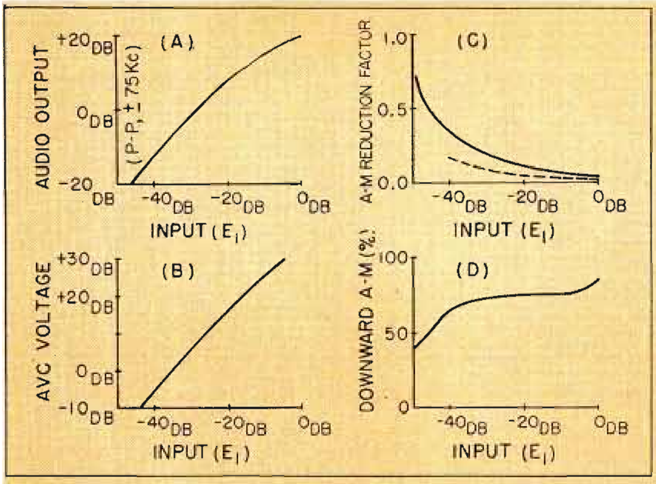


Fig. 5—Dynamic limiter characteristics

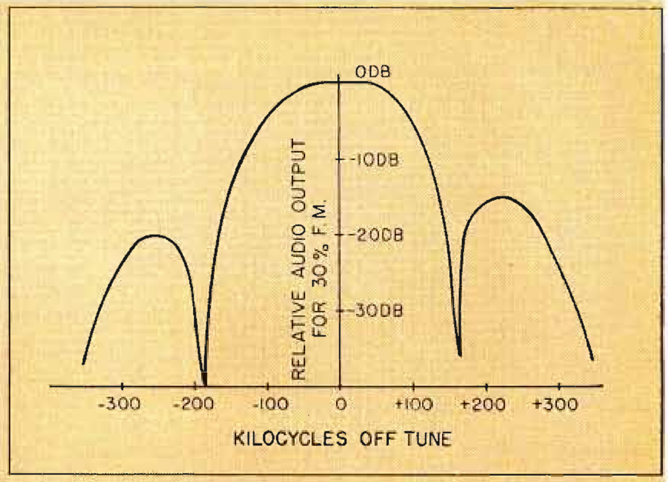


Fig. 6—Typical tuning characteristics for an FM receiver using a dynamic limiter

fact, in conjunction with the fact that the AM rejection reduces only gradually as the signal level is reduced, can result in a significant reduction in the side response amplitude and relatively little inter-station noise.

As an illustration, a typical tuning characteristic for a receiver using a dynamic limiter detector system is shown in Fig. 6. However, the amount of reduction of the side-responses, and of the inter-station noise, is determined by the AVC characteristics of the particular receiver. A receiver designed with a rounded top IF response and with a detector having wide peak separation permits the tuning characteristic to have a peak in audio output when the signal is on tune, and reduces the side responses.

Dual Diode Limiter

While a single limiter diode can produce significant limiting, the use of a dual diode as limiter can give improved results. In particular when the circuit Q is low, harmonic voltage may develop across the tuned circuit which will affect the limiting action. By using a dual diode limiter, which conducts on both positive and negative peaks, the even harmonic currents are substantially reduced, giving improved dynamic limiting action. An indication of the improved AM rejection which can result is shown by the dotted curve in Fig. 5C.

An interesting detector system can be produced which has cascade means for AM rejection, and has a variable threshold level, by following a dynamic limiter with a ratio detector. Since the resulting system has two means of giving AM rejection, the requirements upon each means are reduced.

This system uses a grid-bias limiter, for limiting amplitude modulation, with a subsequent balanced discriminator circuit for FM detection. The limiter circuit, as illustrated in Fig. 7A, operates by developing a self-rectified grid-bias which narrows the angle of plate current conduction with increasing signal amplitude. In a correctly designed circuit the result is a fundamental frequency output component which, above a certain critical signal level, is approximately independent of input signal amplitude, as shown in Fig. 7B.

When only grid-bias limiting is used, the output is approximately constant over a range of about 20 db of input signal level, but the output tends to again rise for higher input signal levels, as shown by the dotted curve of Fig. 7B. This effect can be reduced by using a low plate voltage to effect plate limiting, or by using a second cascade limiter. When using this double limiting action an input-output characteristic approximately as shown by the solid curve of Fig. 7B can be obtained.

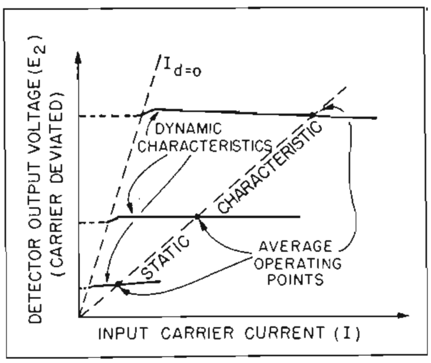


Fig. 10—Input-output characteristics for the ratio detector

The grid-bias limiter is usually designed to have a short time constant in its grid-bias circuit and to have plate and screen supply voltages of fairly good regulation. This produces a device whose input-output characteristic for rapid or dynamic signal level changes (at an audio frequency rate) is similar to that for slow or static changes in average signal level. Thus the knee in the input-output curve occurs at a unique input signal which is relatively unaffected by the applied average signal level, producing a device with a fixed threshold level.

Grid-Bias Limiter

Fig. 7C is the AM reduction factor vs. signal level for the grid-bias limiter, produced by limiting action. This shows that substantially no AM rejection exists below the threshold and that the AM rejection suddenly takes hold at the threshold level because of limiting. It should be noted that a slight over-compensation is common in the limiting region so that a small percentage of reverse polarity AM is frequently produced, as shown by the negative value.

The downward AM capability for the grid-bias limiter is shown in Fig. 7D and is seen to approach 100% modulation as a limit as the signal level is increased. From the above, the grid-bias limiter is seen to be a fixed threshold level device having a fixed output, a downward AM capability which increases with increasing signal level, and an AM

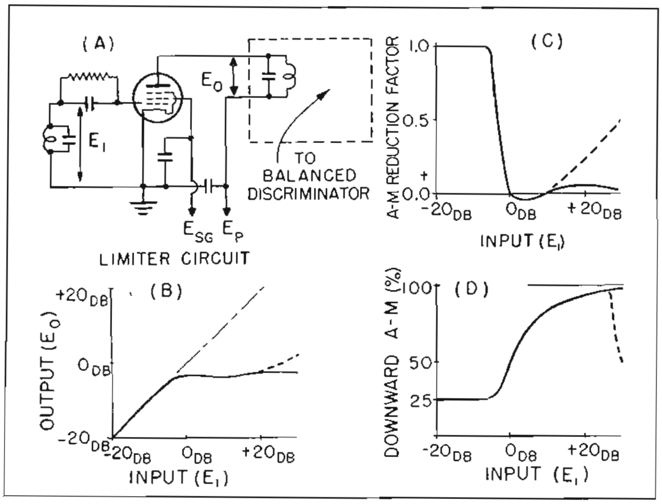


Fig. 7—Grid-bias limiter characteristics

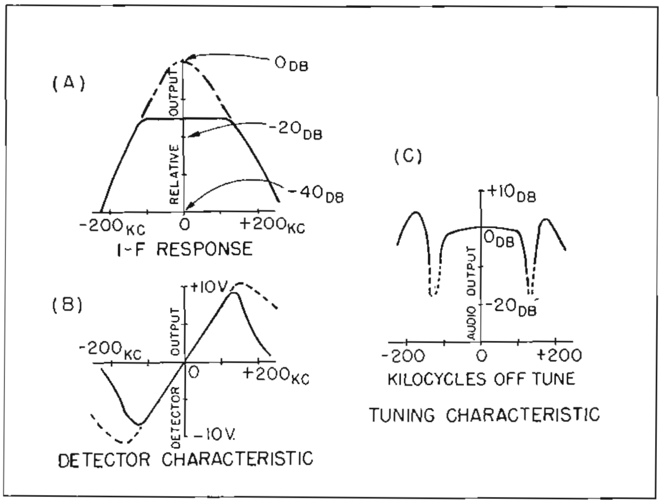


Fig. 8—Typical characteristics of an FM receiver using a grid-bias limiter

rejection by limiting which rapidly becomes effective when the input signal exceeds the threshold level.

The tuning characteristic of a receiver using a grid-bias limiter will next be considered. An IF response curve for a typical receiver is shown in Fig. 8A, the dot-dash curve being the response curve exclusive of limiting and the solid curve the effective response curve with limiting. A typical detector discriminator characteristic as measured with constant input to the limiter grid is shown in Fig. 8B by the dotted curve. When this detector characteristic is taken through the entire receiver, a curve such as the solid curve of Fig. 8B may result.

Audio Output

Here it is seen that as the signal is detuned, the IF selectivity causes the signal level at the limiter to fall below the fixed threshold level and then the IF selectivity curve skirts are effective in increasing the side-slopes of the overall detector characteristic. The audio output due to FM is proportional to the slope of the detector characteristic about the mean frequency of the applied signal. Thus, as the receiver is tuned through an applied signal, the audio output may be expected to vary as in Fig. 8C.

It is not uncommon for the resulting side-responses to be greater in amplitude than the desired response. These side-responses can be reduced in amplitude by reducing the IF selectivity; or, since they are due to the signal level passing below the threshold, they can be masked by noise by including enough gain in the receiver to make the threshold occur at the noise level.

An oscillator which is synchronized by an applied FM signal can be made to reproduce the FM of the applied signal and to be substantially non-responsive to AM. The signal from the locked oscillator can be fed to a conventional discriminator, or the discriminator action can be effectively included within the locked oscillator circuit, so that the combination forms an FM detector system which is non-responsive to AM.

The locked oscillators normally require at least a certain critical applied signal level to effect synchronization and below this level their output signal is relatively unaffected by the applied signal. Thus the input-output characteristic may have a discontinuity at the threshold level giving effectively zero output below this threshold level, at least as far as modulation components are concerned.

The locked oscillator FM detector systems thus have a fixed threshold level with fixed output, and a downward AM capability which increases with increasing signal level. It will be apparent from this that the locked oscillator detector systems have overall resultant characteristics similar to the typical characteristics shown for the grid-bias limiter except that an effective discontinuity may exist at the threshold. This discontinuity may produce a tuning characteristic having high distortion regions instead of side responses.

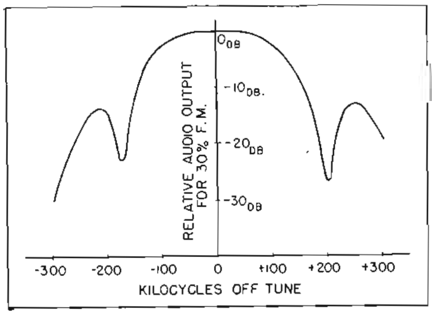


Fig. 12—Typical tuning characteristics for an FM receiver using a ratio detector

The Ratio Detector

The Ratio Detector is a relatively new, but already widely used FM detector system. A conventional form of this circuit is shown in Fig. 9.

This detector has the property that its dynamic and static characteristics are different. The effective input-output characteristics of this device may be measured by applying a statically deviated carrier and measuring the output voltage E_2 vs. the applied carriel level E_1. For slow or static changes in carrier level the output E_2 will vary approximately linearly with input E_1, as shown by the dotted curve of Fig. 10.

This type of detector has the desirable characteristic, however, that it is not responsive to dynamic or sudden changes in carrier level, such as audio frequency amplitude modulation, so that its output will be almost independent of the instantaneous amplitude of the input, as shown by the solid curves in Fig. 10, with the magnitude of the output determined by the average amplitude of the applied carrier.

This difference between dynamic and static characteristics results from the long time constant load circuit, across which the voltage E_B

is developed, this voltage E_B being proportional to the average carrier level and independent of audio frequency AM. The overall result is an output voltage which is proportional to the instantaneous carrier frequency and to the average carrier level but is relatively free of audio frequency AM of the applied carrier. The exact reasons why this detector circuit is non-responsive to AM is considered as being outside the scope of this paper.*

The range of the dynamic input-output characteristic has a limitation, for upon downward amplitude modulation the instantaneous carrier voltage applied to the diodes may be exceeded by the back biasing effect of voltage E_B, thus cutting off the diodes. While the resulting dynamic input-output characteristic may give an output voltage when the diodes are cut off, as shown dotted in Fig. 10, this output, however, is a static charge remaining on various condensers, and is no longer capable of being controlled by instantaneous frequency of the applied carrier.

Dynamic Threshold

Thus, there is in effect a sharp dynamic threshold occuring when the diode currents become zero. It should be noted, however, that as the average carrier level is varied, the bias voltage E_B varies and the threshold level for diode current cut-off also varies. The resulting variation in dynamic threshold in response to average carrier level variations tends to keep the downward AM capabilities of the detector system such that they vary only slightly with applied signal level.

Typical operating characteristics of a ratio detector are shown in Fig. 11. It will be noted that the audio output and AVC voltage vary almost directly with the applied signal level. As the average signal level is varied the slope of the dynamic input-output curve changes slowly. The resulting variation of AM reduction factor with average signal level is a smooth curve as illustrated in Fig. 11C which does not have a distinct threshold as far as *average* signal level variations are concerned. It is not uncommon for the slope of the dynamic input-output characteristic to reverse sign at high signal levels giving a small opposite polarity AM output. As indicated previously, the downward AM capabilities vary only slightly with average carrier level as shown in Fig. 11D.

It is apparent from the above discussion that the ratio detector is non-responsive to AM, has a variable threshold level, with a variable output and a downward AM capability which is relatively fixed, and it thus has quite different overall characteristics than the grid-bias limiter detector system. The effects of these differences in performance upon the tuning characteristics of a complete receiver are similar to those with the dynamic limiter detector system, and can result in a significant reduction in the side response amplitude and relatively little inter-station noise. A typical tuning characteristic for a receiver is shown in Fig. 12.

Based upon their overall resulting characteristics, the currently used FM detectors can be divided into two general classes. The first class having similar overall resultant characteristics includes the grid-bias limiter detector system and locked oscillator arrangements, particularly in that they have a fixed threshold level, a variable output, a down-AM capability which increases with increasing signal level, and an AM rejection which rapidly becomes effective when the input signal exceeds the threshold level.

AM Rejection

The second class, in regard to overall resultant characteristics, includes the ratio detector and the dynamic limiter detector system, in that they have a variable threshold level, a variabel output, a downward AM capability which is relatively fixed, and an AM rejection which varies gradually with variations of average signal level.

In general the input signal level required to produce significant AM rejection in one of the detector systems having a variable threshold level is smaller than that required for one of the systems having a fixed threshold level. However, the application and desired operating characteristics of a particular receiver will affect the class of FM detector which should be used. Besides the cost problem, such questions as the expected degree of multi-path interference, the amount of fading and the desired tuning characteristics should be considered for each application.

*For further details on the ratio detector, see Tele-Tech July, 1947 page 46 to 49.

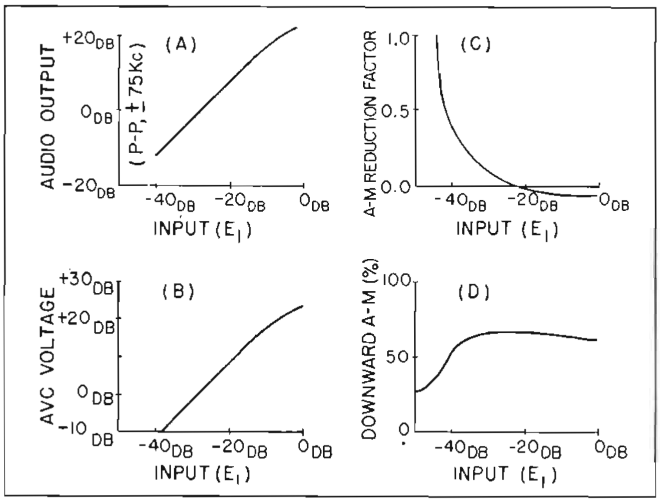


Fig. 11—Ratio detector characteristics

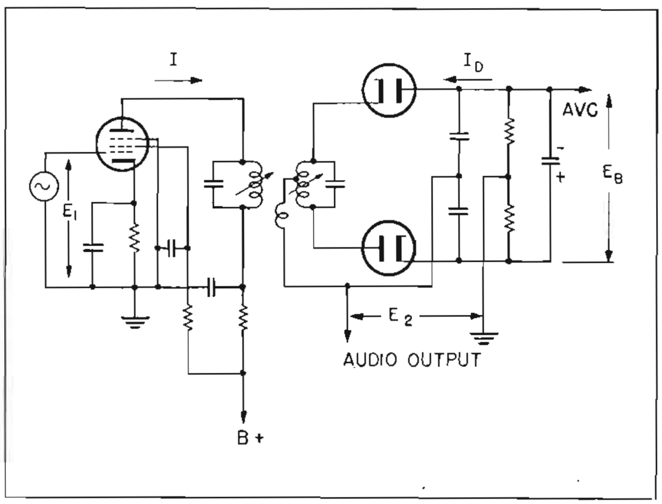


Fig. 9—Circuit diagram of ratio detector

Cavity Type Filters For Interference

By DANIEL E. NOBLE*

Systems and equipment designs for maximum spectrum utilization in the mobile radiotelephone services

Motorola Precision Selector, or anti-intermodulation cavity

• When radio channels were little used and vacant spaces in the spectrum provided guard channels for the active services, it was possible to design receiving and transmitting equipment with little attention to the problems of spurious radiation, spurious receiver responses, and the selectivity characteristics. Now the rise in the use of channels for all services, the introduction of FM broadcasting, television and mobile communications, the radiation of spurious energy, the design of receivers with spurious responses and poor image rejection, and the failure to recognize the problems of systems design as it may affect receiver desensitizing and intermodulation interference will contribute generally to a widespread condition of interference and chaos in the air.

FM stations will interfere with FM stations, FM stations will interfere with television stations, mobile stations will interfere with television and with FM, and television will be interfered with by everybody. Harmonic radiation, subharmonic radiation, cross beat or intermodulation radiation, receiver radiation, receiver selectivity, receiver spurious responses, and lack of proper modulation control will all tend to degrade the performance of all services.

We suggest a program for the mobile services which will minimize interference within the service and promote maximum channel loading and the most efficient use of the spectrum assigned to the mobile services. Our present standards are far too weak to permit the efficient use of the spectrum space assigned for mobile operation.

The original allocation was made by the Federal Communications Commission on the assumption that alternate channels would be used in the same area. The expectation is that, with the development of the art, adjacent channels will be used effectively in the same area without interference.

With the channel limitations facing us we have no choice in the matter, but we must design equipment for operation on adjacent channels and, unless we wish to waste valuable channel space, we must design such equipment at once and put it into immediate use. The placing of a large number of mobile communications units in use with standards which are inferior will develop an economic inertia, which may take ten years or more to overcome, and, in the meantime, it will be impracticable to operate equipment effectively in all of the channels assigned to the service.

To further clarify this problem, some factors are listed which influence the successful operation on adjacent and alternate channels in the same area. Such factors as spurious receiver responses, spurious transmitter radiation, receiver radiation, transmitter intermodulation and skip distance propagation are virtually independent of channel separation, but they are factors of great importance in determining the level of interference encountered.

A second group of factors, i.e., IF selectivity, modulation bandwidth, and stability, are inherently dependent upon channel separation and the systems designer must be guided accordingly. A third factor is the front end receiver selectivity, or carrier frequency selectivity of the receiver, and the relationship to intermodulation and desensitizing is affected by channel separation in some cases and independent under other conditions.

Spurious receiver responses can be controlled adequately by the use of shielding, the proper disposition of selective circuits, and by the use of multiple tuned circuit elements. The suppression of all spurious responses, including the image response, should be 85 db, or better. A suppression of 100 db is desirable and entirely practicable. The proposed RMA Standard called for 60 db suppression. Such a level seems inadequate.

Spurious transmitter radiation can be controlled by proper transmitter design and by the use of adequate shielding. While it may be possible to build a transmitter without use of double tuned circuits and still suppress sub-carriers, measurements indicate that sub-carriers will be present unless multiple tuned circuits are used in the transmitter interstage coupling to eliminate intermodulation of crystal harmonics. A figure of 60 db has been proposed as the reduction for all spurious radiation from transmitters. This figure is entirely possible and, in many cases, it may be a practicable value for transmitters below 50 watts of power. A better level would be 80 db, for transmitters exceeding 50 watts in power.

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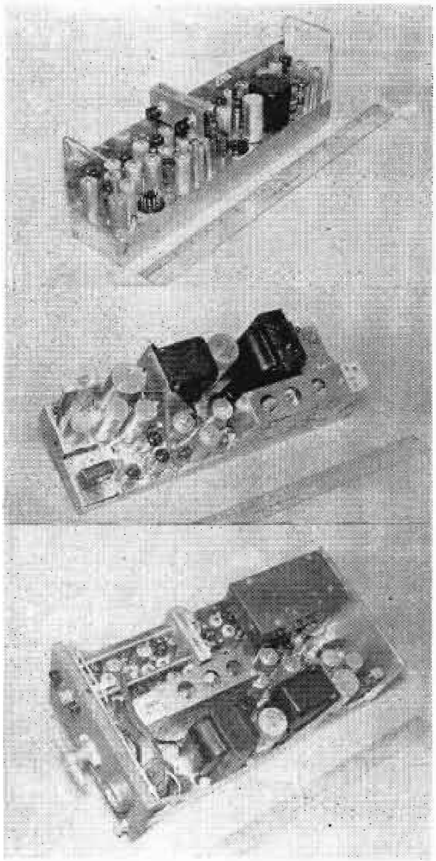
*Director of Research and Vice-President in charge of communications and electronic division, Motorola, Inc., Chicago.

Motorola experiments indicate that transmitter intermodulation is a secondary effect and usually not encountered unless an attempt is made to mount more than one transmitting antenna on a single support. Close spacing of antennas may result in voltage from one antenna inducing a sufficient voltage in the coupled antenna to produce intermodulation in the non-linear plate circuit of the transmitter. The radiation of the intermodulation products may introduce interference to operating systems.

Intermodulation Effects

The mixing of two or more signals in the non-linear rf amplifier or mixer circuits will produce intermodulation which may generate interfering products directly on the desired carrier frequency. Where such intermodulation exists, the only cure possible at the receiver point is the introduction of a sufficient degree of selectivity to reduce the signal level of the undesired carriers, so that intermodulation will not take place. Similarly, a strong, undesired signal may bias off the rf amplifier to a point where the weak, desired signal cannot be heard and the reduction of this desensitizing effect can be accomplished only by the introduction of carrier selectivity at the front end of the receiver.

While the modulation is not important within the present limits of equipment design where alternate channel operation is specified, the control of the bandwidth becomes extremely important when we contemplate adjacent channel operation in the same area. The adjustment of mobile units to a nominal degree of modulation based upon a fixed adjustment at the factory will be both practicable and satisfactory, but where the higher power land stations are considered with high and efficient radiators, some automatic form of modulation control must be introduced.



Top to bottom—Precision selectivity receiver as used in Motorola mobile FM "Dispatcher". 7-10 watt transmitter and power supply. Complete "Dispatcher" transmitter and receiver unit with "Quick-Call" selective calling unit case at rear left on chassis

The problem of maintaining stability is one of the extremely important factors which must be considered. Obviously, the channel width and channel separation will control the degree of stability required for successful operation. For precision selectivity in a 60 kc bandwidth at 150 mc, a stability of .002% over the temperature range may be adequate, but we might find that the stability requirements for a 10 kc bandwidth at 150 mc would be entirely impracticable where vibration and wide temperature ranges are encountered. Limiting factors introduced by stability and intermodulation suggest that the process of halving the bandwidth will not, in any case, double the number of channels available for use in a given area.

Wave Filter Design

It is well to devote some time to the discussion of IF selectivity and intermodulation as the two most important factors influencing the design of equipment for alternate and adjacent channel operation in the same area. The art of wave filter design is well advanced and there is no known reason why IF selectivity cannot be developed to almost any degree required. Even without the use of wave filters of specialized design, it becomes possible to use multiple tuned high-Q circuits effectively, to provide a remarkable degree of selectivity without introducing intolerable problems of maintenance of alignment.

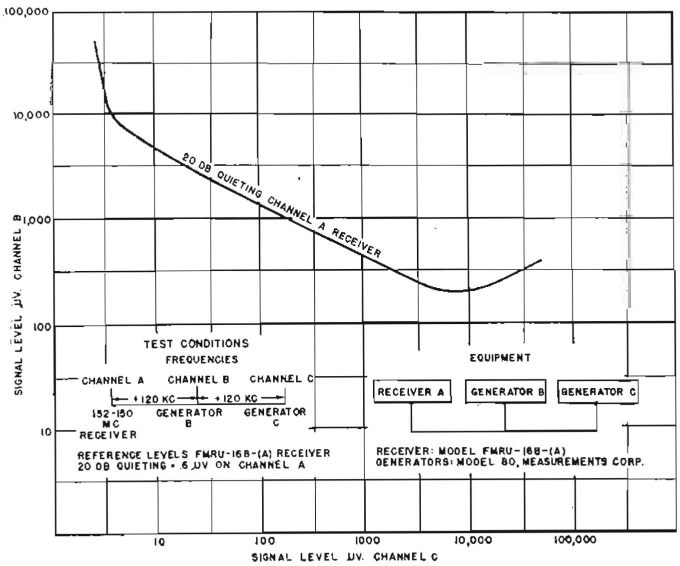
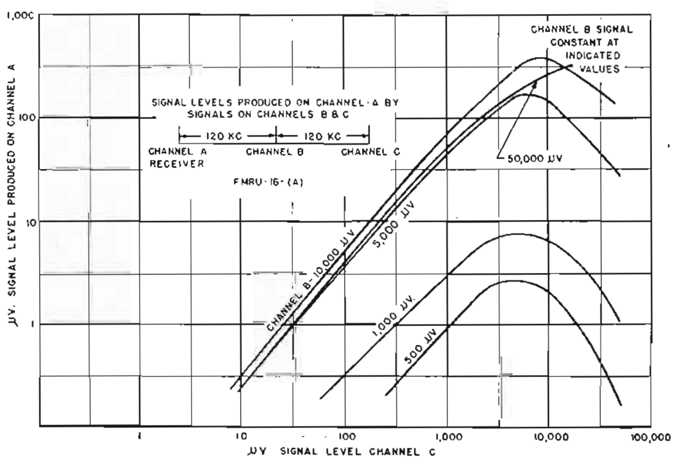
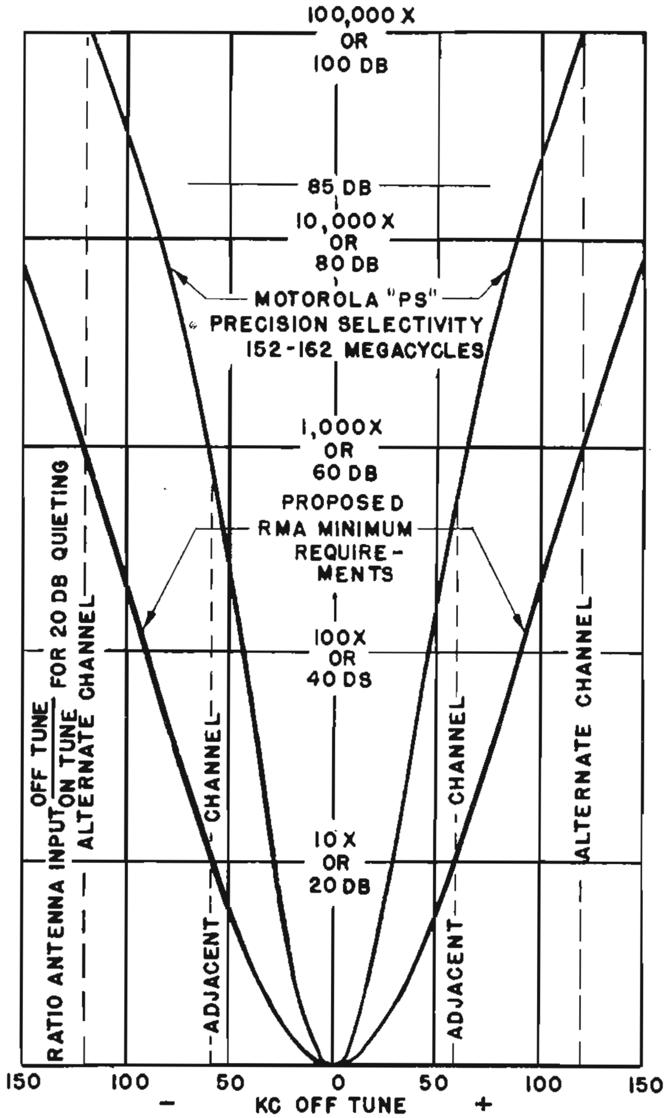


Fig. 2 (Left)—Relationship between level of two undesired signals, B and C, in producing an interfering signal on desired channel A. Fig. 3 (Right)—Various levels of interfering signals produced on channel A as a result of the products of intermodulation from B and C combining in non-linear receiver circuits





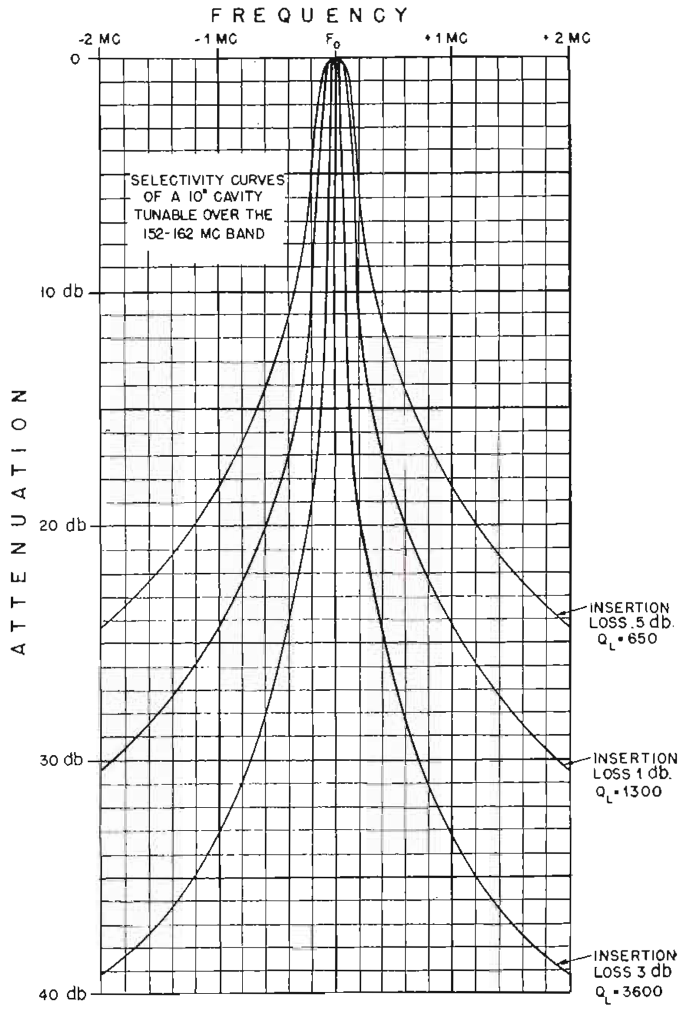


Fig. 1 (Left)—Proposed RMA minimum requirements for IF selectivity, 60 db down on alternate channels or 120 kc off resonance. Fig. 4 (Right)—Selectivity curves for Motorola anti-intermodulation cavity for various insertion losses

Fig. 1 shows the proposed RMA minimum requirements of IF selectivity, which calls for 60 db down on alternate channels, or 120 mc off resonance. The second curve shown is the Motorola precision selectivity curve with 100 db down on alternate channels, and between 55 and 60 db down on the adjacent channel. For this particular receiver, the spurious responses are also down between 90 and 100 db. On alternate channels, an undesired signal must have a magnitude of 100,000 microvolts before it will equal the effect of a 1 microvolt signal on the desired channel. For the adjacent channel, 60 kc off resonance, an undesired signal must be approximately 1,000 microvolts to interfere with a 1 microvolt signal.

In hundreds of direct comparison tests with this receiver compared to a receiver with the RMA minimum requirement curve, there was no difference of a significant nature in the range or the sensitivity performance of the two receivers. The trend was toward the superiority of the selective receiver over the wider band receiver. In an actual field test with two 250 watt transmitters feeding antennas at a 60 ft. elevation and operating on frequencies ±60 kc from the desired channel, a threshold signal was received successfully on the desired channel while the two 250 watt stations operated on the adjacent channels approximately one mile away. The test was repeated with the 250 watt stations operating at −60 kc and −120 mc.

Interference Elimination

The successful reception was achieved with the precision selectivity receivers accepting a threshold signal from a 30 watt station located approximately seven miles away. Since the desired station was a 30 watt unit working from a 40 ft. antenna approximately eight miles from the opposing 250 watt stations, and since the interference encountered was limited to a distance of one mile from the opposing 250 watt transmitters, it appears that interference-free service within a radius of seven miles from the desired station would be possible, even though all adjacent and alternate channels were occupied in the areas outside of the eight mile separation indicated. As the stations are brought close together, the desired signal will increase in level and tend to preserve the interference-free reception.

The most desirable systems design would provide for all transmitting stations feeding antennas at the same location with sufficient separation between antennas to eliminate the possibility of transmitters intermodulation. With such an arrangement, the desired to undesired signal ratios would always

(*Continued on page* 79)

Method for Determining Receiver Noise Figure

By MORRIS Allen, Cambridge Field Station, Army Air Forces

Practical means for making measurements that reveal limiting effect on sensitivity represented by shot effect and thermal agitation

• The receiver used for the experiment is taken from a radar system, composed of five conventional class A amplifier stages using 6AC7 pentodes, a 6H6 diode (one half used as a second detector, the other half as a dc restorer), a 6AC7 video amplifier and a 6L6 cathode follower: Fig. 1-2, 3.

The overall gain is about 120 db. The bandwidth centered at 30 mc, and taken at ½ power, (3 db down) is 0.9 mc. The noise figure in microvolts is 2.92. The theoretical noise figure in microvolts is 1.15.

In any pulse echo radar system there are two factors which limit the operating range of the radar set. The rf power striking the target is one factor and that is limited by the magnetron and the antenna design. The receiver system is the other factor. As in the case of any radar system, the smaller the target or the greater the distance, the smaller is the signal which comes back into the receiver. For a while we can meet this situation by increasing the amount of amplification in the receiver, but eventually we come to a place where extraneous disturbances get big enough to hide the signal even though we have eliminated all such sources of noise as bad power supplies, poor contacts, sparking commutators, ignition interference, etc. We find that there is still some left, and in fact this may be shown by thermodynamic arguments to be inevitable. There are two general sources of such noise: shot effect and Johnson noise, (Johnson noise is often called thermal agitation noise).

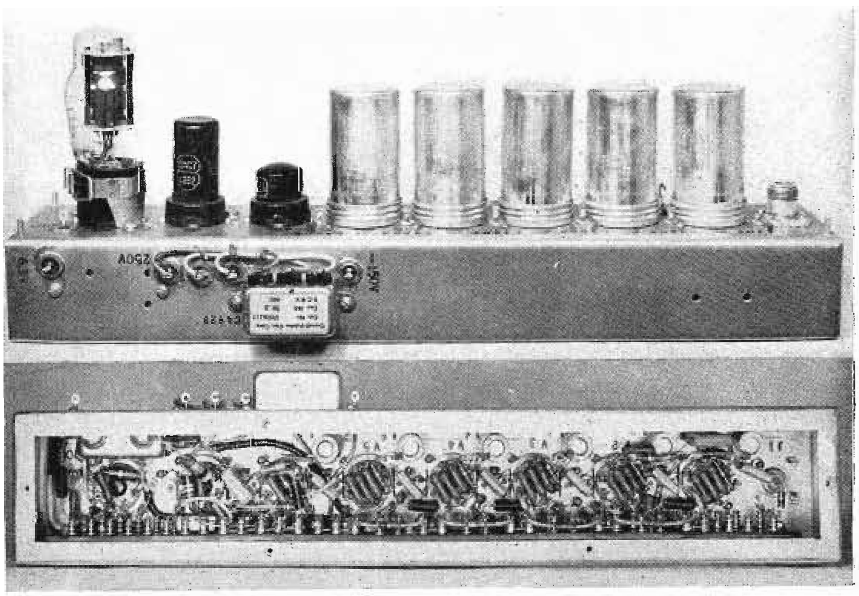
IN the design of a radar receiver one of the main factors to be considered is sensitivity. Sensitivity must be stated in terms of noise rather than of gain, because the gain of the receiver does not impose the limit on sensitivity. This noise quantity or noise figure "F" makes a comparison between the total noise present in the receiver, and the noise component of the antenna radiation resistance, since this represents a source of noise common to all receivers. This method of defining the sensitivity of a receiver has the advantage of being rigorous and independent of the psychology of the operator.

It is not the purpose of this paper to discuss Johnson noise or shot effect in any detail, except to state that it is this noise that limits the sensitivity of the receiver.

When a receiver is connected to an antenna, it receives and amplifies the noise and signal voltages of the antenna. When the noise level of a receiver is high, a weak signal is hardly distinguishable in the presence of a strong background of noise. Thus, the amount of noise that is present limits the minimum signal that can be distinguished. Even if the receiver were perfectly free from self-generation of noise, there is still a certain amount of noise in the antenna which passes through the receiver.

The thermal noise of the anten-

Fig. 1 (Above) and 2 (Below) Front and bottom views of the radar receiver used for the experiment



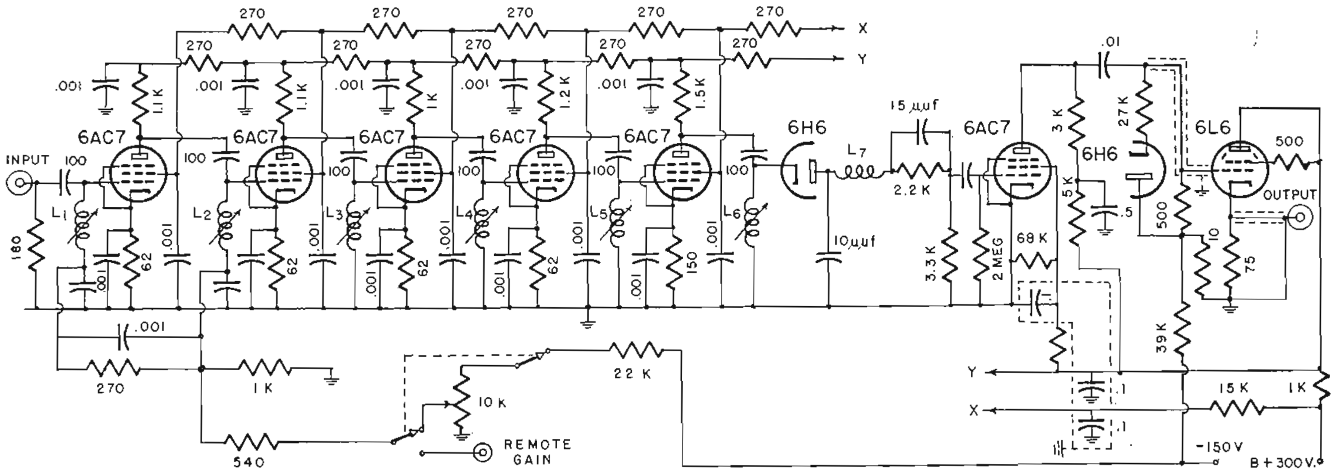


Fig. 3—Circuit diagram of the radar receiver composed of five conventional class A amplifier stages, a diode for second detector and dc restorer, video amplifier and cathode follower

na can be expressed in terms of the thermal noise that appears across a resistance equal to that of the antenna radiation resistance. The resistance can be regarded as a "dummy" antenna which generates thermal fluctuating noise given by the expression

$$E_N^2 = 4KTR_a(\Delta f)$$

where

K = Boltzman's constant (1.37 x 10^{-23} joules/degree)

T = Temperature of resistance in degrees Kelvin

Ra = Effective input resistance

Δf = Bandwidth under consideration

The numerical value at room temperature of 4KT is approximately 1.6 x 10^{-20} watt-seconds.

In Fig. 4, the noise-to-signal ratio for the "ideal" receiver for a signal input E_a is given by

$$\left(\frac{\text{Noise}}{\text{Signal}}\right)^2 = \frac{E_n^2}{E_a^2} = \frac{4KT\Delta fR_a}{E_a^2}$$

The noise-to-signal ratio for the actual receiver is then measured and compared with that in the "ideal" receiver. The noise factor (F) of the receiver is given by

$$F = \frac{\left(\frac{\text{Noise}}{\text{Signal}}\right)^2 \text{ of Receiver} = \text{Mean Square Noise of Receiver}}{\left(\frac{\text{Noise}}{\text{Signal}}\right)^2 \text{ of Ideal Rec.} = \text{Mean Square Noise of Ideal Rec.}}$$

Thus the ideal receiver has a factor of unity, while the actual receiver will be greater than unity.

The equipment used in the measurement of the Noise Factor "F" is a calibrated signal generator and a calibrated output meter. The impedance of the signal generator is matched to that of the receiver.

The output meter is used to indicate the signal and noise *power* at the IF output of the receiver. Since the output measurement is a power measurement, the meter should read or be calibrated to read in terms of mean-squared values.

The signal generator is matched to the receiver and the receiver is adjusted for maximum output. The readings of the signal generator and output meter are noted. The voltage of the signal generator will be called E_a and the power, as shown on the output meter, will be called P2. Next the signal generator is shut off (but is still connected to the receiver) and an output reading is taken

Fig. 4—Set-up for calculating noise-to-signal ratio in an ideal receiver

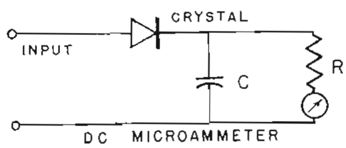


Fig. 5—Suggested output meter circuit

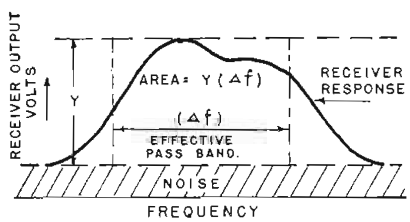


Fig. 6—Plot of receiver output and response as related to pass band

which indicates a power level that will be called P1. P1 represents the noise level. P2 represents the noise-plus-signal level. (P2 − P1) represents the signal level. When this level is compared with that already derived for the ideal receiver, it is seen that the noise-power level of the receiver is worse than that of an ideal receiver by a factor:

$$F = \frac{E_a^2}{4KT\Delta fR_A} \times \frac{P1}{(P2 - P1)}$$

As previously pointed out, the type of meter desired is one that will indicate the mean-squared voltage or current.

A thermocouple meter has this characteristic, but is not recommended because: (a) it may load the circuit, affecting receiver performance; and (b) it may be burned out during adjustments.

The output meter suggested is not a mean-squared type, but an average voltage reading meter, and consists of a crystal detector (to rectify the IF) and a dc microammeter (Fig. 5).

The use of an average voltage meter is permissible as long as the relation with a mean-squared meter is known, i.e., 1.12, or, in order to correct for the differences for mean-squared-to-average for the P1 and P2 measurements, the voltage measurement for P1 is multiplied by a factor of 1.12.

The amount of noise from the receiver depends upon the width of its effective frequency bandwidth. A simple way of measuring bandwidth, giving approximate results, consists of measuring the

(*Continued on page 77*)

Noise Neutralizing Detector Circuit

By D. L. HINGS and WILLIAM W. GARSTANG, International Electronic Corp., Indianapolis, affiliated with Electronic Laboratories of Canada, Ltd.

Static-free system of detection on entirely new principle for continuous wave and carrier shift transmissions

• The noise neutralizing detector circuit (NND) eliminates crash static of any amplitude by taking part of the noise energy and making it work to cancel its own damage. Advantage is taken of the fact that the amount of noise on the received carrier is much less than the noise on its sideband. This suggested a sideband acceptance circuit which was connected in the detector circuit in such a way as to modulate a second carrier (locally generated). The resultant circuit combines the incoming carrier, damaged by noise, and the local carrier, modulated by noise, in such a way as to reconstruct the incoming carrier to its original form, but without the noise.

HERE is a new approach to the problem of noise elimination in AM reception of voice-modulated waves. A second carrier is introduced to fill up holes (caused by noise impulses) in the original carrier and preserves information continuity. Conventional noise eliminators are limiting devices which have no provision for bridging voids in reception due to dead periods after each noise impulse. Airport control towers will find immediate use for this new circuit; with a little further development, the Noise Neutralizing Detector can be extended to home radios.

Interference caused by man-made static (ignition, constant impulse, switching) as well as atmospheric discharge, are eliminated. This action is in contrast to squelch circuits which desensitize a receiver during the time when impulse interference is at its worst, thus losing intelligence continuity.

The NND unit at the present writing costs about $300 ($265 in quantity). The audio frequency response is relatively flat from 100 to 1,000 cycles, and 50% down at 30 and 3,000 cycles. However, with further development and refinement, the flat characteristic could be extended considerably. The unit has many times the gain of the receiver to which it is connected, thus eliminating the need for full sensitivity of the receiver rf setting.

The NND principle is an extension of a noise-free detection system for reception of code signals which was described in a previous issue.* In the course of demonstration of the pulse detector units for code signals described in the aforementioned reference, the question, "when can this be done for voice?" outnumbered all others. For many years engineers have been trying to find a method for the elimination of static from AM broadcasting reception without impairing audio reproduction.

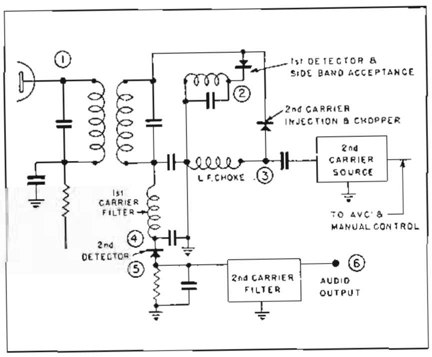


Fig. 3—Basic schematic of noise neutralizing detector circuit

In the development of the NND circuit, one of the first problems attacked was the analysis of avc. As presently used, most avc systems are actuated by interference energy. Receivers using these systems, retard the signal amplitude and decrease the receiver sensitivity when noise is present on the carrier. However, this noise varies greatly in amplitude and a circuit to eliminate these wide variations without harming the signal modulation, was difficult to design. For this reason initial development started on the basic requirement that all magnitudes of interference must be handled successfully. Present systems of audio limiting and squelching do not measure up to this strict specification.

The second detector is the logical point for the elimination of noise. One of the first essentials was to present a linear response of radio frequency and intermediate frequency at the second detector, regardless of whether the energy is generated by noise or signal. If distortion occurs in the amplifier prior to detection, then there is practically no way of neutralizing the shock due to noise impulses. This suggests the obvious; that long-time constants must be eliminated in the rf and the IF sections of the receiver.

One way of doing this is to apply avc control voltage to the screen grid of the amplifier tube instead of to the control grid. This permitted the grounding of the control grid return circuit and effectively eliminated RC components. The next step was to eliminate all cathode bias resistors which allowed the

*Tele-Tech page 55, January 1947.

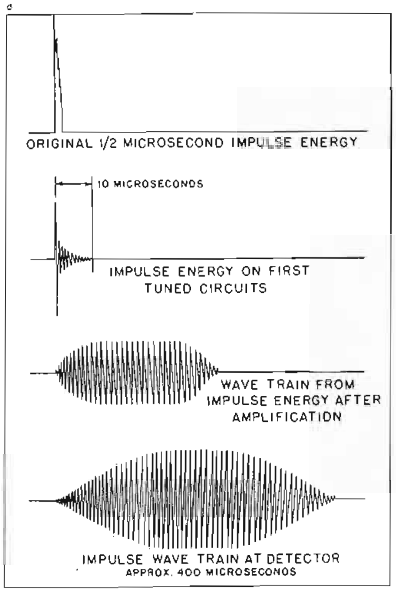
screen grid to control the impedance or the amplification factor of the tube. To accomplish this it was necessary to use twin-triode tubes with positive avc control voltage on the grids. This was found successful in reproducing a wave with very high peaks and without distortion or poor time-constant effects at the second detector.

The Q of the various circuits produced a time constant such that a half microsecond, high amplitude impulse at the antenna, reproduced at a much lower amplitude in the second detector and a ringing time of only 400 microseconds. During this 400 microsecond period, the carrier is completely swamped by the impulse noise on the second detector.

In conventional detector circuits, this same impulse produces a dead period of the order of 1250 microseconds. (Fig. 1). In this latter case, the intelligence on the carrier would be obliterated between three to four times as long as in the case of the NND circuit. A 1250 microsecond obliteration would be heard as a strong pop in the receiver output. Conventional limiting circuits designed to reduce noise would, indeed, reduce the amplitude of the pop, but the intelligence is nevertheless gone for that length of time. Further, if the noise impulse is occurring at frequent intervals, it is quite possible that the end of one pop may coincide with the beginning of the next and the whole system simply operates on noise.

This indicates that the percentage of modulation is very critical with respect to the amount of noise that can be permitted to be reproduced with the audio. Full 100% modulation will, of course, give a greater audio component and thus withstand more noise. But high levels of modulation cannot always be depended upon, and the next design step proceeded on the basis that noise had to be suppressed regardless of the percentage of modulation.

Since the amount of noise on the received carrier is much less than the noise on the sideband, this knowledge was used to evolve a system of noise elimination regardless of fading and signal-to-noise ratio. With this in mind, a circuit was set up whereby the incoming carrier from the last IF fed into a detector network. Unlike the conventional detector, this network permits diode detection to take place through a sideband acceptance circuit. The result is a sideband reaction in the same circuit which detects the carrier. The impedance of the sideband selector circuit is much higher at the frequency of the sideband than it is at the frequency of the carrier or IF. This allows the detector to rectify into its load at the carrier or IF frequency.



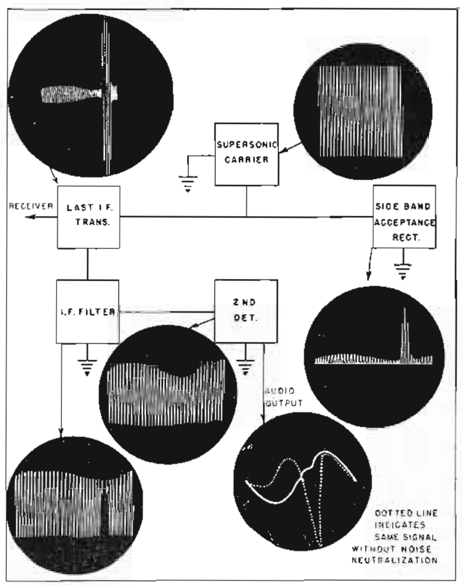


Fig. 1 (left)—Transient phenomena after reception of a half microsecond impulse. Fig. 2 (right)—Effect of 400 microsecond impulse on a 50% modulated carrier

Two problems remained: (1) Large variations in noise required some form of limiting; (2) The random phase relation between the noise and the carrier had to be corrected before detection. This is where the effectiveness of the second carrier comes in.

A locally generated carrier just above the audible frequencies is injected at the output of the last IF transformer. It is important to remember that the random amplitude of the noise taken from the sideband must be held within certain limits so that the proper reconstruction of the original carrier is possible. This is necessary because the carrier is of a certain amplitude and requires a specific amount of energy to be replaced in the hole cause by the noise impulse. Since the noise energy derived from the sidebands may exceed this value considerably, a form of limiting of the noise amplitude is necessary such that it will be proportional to the required energy to reconstruct the carrier.

This supersonic carrier is passed through a crystal detector and takes the form of a polarized impulse which continuously controls the limiting of the entire circuit from zero amplitude to a point of great enough amplitude to include the positive peaks of modulation of the signal carrier. This dictates that the signal and supersonic carriers must be controlled from an avc source which does not depend on noise energy. In other words, a peak of noise extending the first carrier will cause negative modulation in the second carrier.

When these two carrier modulations are recombined in the second detector load circuit, the supersonic carrier has just the right modulation and the right duration to exactly fill the hole in the signal carrier. Thus the signal carrier has been freed of the impulse shock component. The noise impulse has been neutralized and the modulation that still exists on the carrier is that of intelligence only. This is graphically shown in Fig. 2. Fig. 3 is a schematic of the heart of the NND circuit.

This carrier control detection unit has been developed primarily for commercial reception of radio and telephone signals. It is ideal where standby periods are required without a carrier and yet where the receiver is set for high sensitivity, as in the case of airport control towers. Due to the reconstruction of the carrier wave in the detector circuit, little distortion occurs on modulation even when very severe impulse noise exists.

Temperature Coefficient Effects of RF Coil Finishes—Part II

By CHESTER I. SOUCY, Chief Engineer, Electronics Div. Canadian Aviation Electronics, Ltd., St. Hubert Airport, Que.

Analyzing changes in inductance following the use of various products for dust and moisture protection and mechanical stability

THIS is Part II of an exhaustive investigation covering a great variety of products commonly in use as coil finishes. Results of the findings should prove of considerable value to design engineers.

• Incomplete penetration of wax into multi-layer coils can be achieved through flash dipping alone without using a preliminary coating of coil dope. The amount of penetration will then depend upon the winding, the characteristics of the wax, wax temperature, coil temperature, and the immersion time as well. Suitable processing can result in practical elimination of the radical change in temperature coefficient above room temperature that is characteristic of full impregnation. This is illustrated by curve No. 3 in Fig. 2 and curves 2 and 3 in Fig. 7 for Zophar No. 1553 hard wax (now coded No. 1584) and No. 1436 low-temperature wax dips. The coil tests represented in Fig. 7 are similar to the IF coils of Fig. 6, except that a special coil whose test is shown in curve No. 3 was wound on an Alsimag No. 196 ceramic form.

Incidentally, it may be noted that in the comparison of curves 1 and 4 of Fig. 7 for the plain coils on XXX bakelite and ceramic forms, respectively, it is apparent that the lower temperature coefficient of linear expansion of the ceramic tube (6.34 x $10^{-6}/°C$ as against possible 30 for the Bakelite) produced a reduction of about 2 to 1 in the temperature coefficient of the coil.

Besides the difficulty of controlling the wax penetration in a simple flash dip closely enough to obtain the desired temperature coefficient, there is another objection, namely, that the resultant coil assembly is frequently unstable. This was confirmed on a number of coils of different multi-layer types, and typical results are shown in curve No. 3 of Fig. 7, and in the lower curve of Fig. 8. Reduction of the instability by successive heat treatments is apparent from Fig. 7.

The larger coefficient obtained with the finishes corresponding to curves Nos. 1 and 2 in Fig. 6 may be desirable in practical circuit cases. For example, the writer found that the mica capacitors used to tune an IF trap coil had an average negative temperature coefficient of capacitance of 74 x $10^{-6}/°C$. By applying a double finish treatment consisting of a baked finish of Maas & Waldstein No. 1 clear acid-resistant varnish with an outer coat of Duco Household cement to the coil (a narrow universal winding of 53 turns of 6/42 litz on a XXX Bakelite form of ½-in. diameter) the temperature coefficient was raised from 33 to 80 x $10^{-6}/°C$. This compensated the capacitor characteristic closely, and also provided a smooth, non-dust-collecting finish on the coil. If the regular finish for the IF coils had been used, that is Q-Dope and No. 1436 wax dip, it

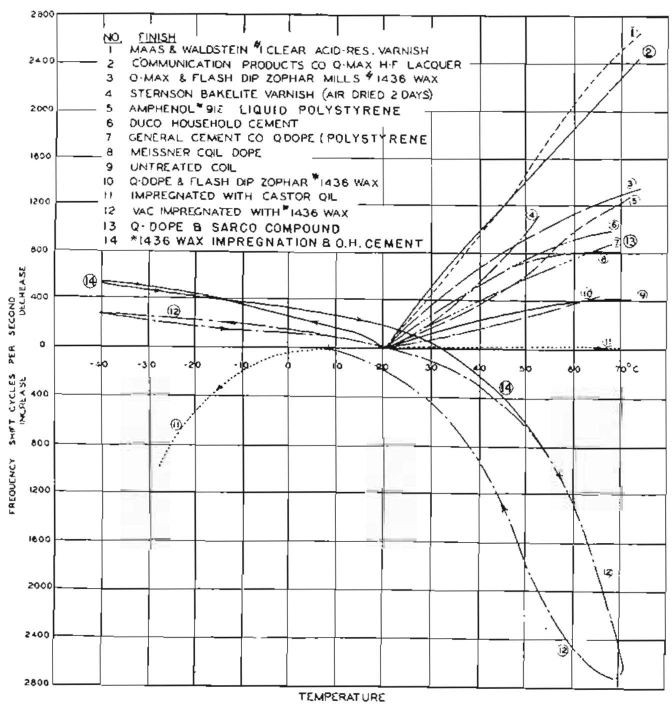


Fig. 6—Effect of various finishes on temperature coefficient of IF transformer coils. Test at 463 kc on 252-turn coil of 6/52 litz, ¼ in wide, on ½-in bakelite tube.

is evident from Fig. 8 that the temperature coefficient at the test frequency would have been 14 x $10^{-6}/°C$.

Vacuum Technics

Although the assumption was not verified during these tests, except in the case of wax, it is probable that vacuum impregnation with any suitable finishes would produce larger temperature coefficients than those resulting from dipped or brushed coatings. At the same time, the distributed capacitance and probably the rf losses would be increased with more thorough penetration to the inner layers. The differences between the results of wax impregnation, a flash dip, and lacquer coat plus flash wax dip, as shown by curve 12 of Fig. 6, curve 3 of Fig. 8, and curve 10 of Fig. 6, respectively, illustrate the effect of regulating penetration.

Only polyethylene, polystyrene, paraffin wax, and a few other insulating materials have a constant value of permittivity over the present wide radio frequency range. Most materials show a decrease with frequency and some vary irregularly, particularly at higher temperatures. It is not surprising, therefore, to find that the relative effects of the various finishes tested on an IF coil at 463 kc (as illustrated in Fig. 6) do not remain unchanged at higher frequencies. This is illustrated by the curves in Fig. 8 covering tests at 1.5 megacycles using a smaller universal-wound coil, 1/8-in. wide, also using 6/42 litz wire on the same 1/2-in diameter XXX Bakelite forms.

It will be noted that Duco Household cement causes no appreciable change in temperature coefficient (compared to its increased effect shown in Fig. 6), while Q-Dope plus wax dip gives a reduction of over 2 to 1 in temperature coefficient, and the M & W No. 1 C.A.R. varnish increases the coefficient only 2 to 1. The Duco cement coating over the No. 1 varnish adds an appreciable increase of coefficient, made use of, as noted above, to obtain a desired positive coefficient close to 75 parts per million.

Other Factors

The rf loss added by some finishes is usually taken into account by designers, and for many finishes commonly used the losses are negligible. This was found definitely true for some of the finishes tested such as Q-Dope, Q-Max, Zophar wax, and DuPont cement used on the IF and other low-frequency coils. Two other coil coating or impregnating compounds used to a considerable extent upon military equipment are Sarco Compound (supplied by Savereisen Cements Co., Pittsburgh) and Insl-X No. 67, the latter being a tough black bitumastic compound with good electrical and moisture insulating qualities, made by the Insl-X Co., Brooklyn, N. Y. The Sarco Compound causes no change in the Q of 463-kc IF coils, while Insl-X No. 67 produces a loss of about 15%.

Wax Deficiencies

The effects of these compounds upon temperature coefficients were not measured directly during these tests, but that for the Sarco compound is estimated to be fairly low, judging by the fact, observed from the identity of curves Nos. 7 and 13 in Fig. 6, that the Sarco coating applied over a Q-Dope finish does not produce any change in the temperature coefficient, in contrast with the effect of Duco Household cement applied over a varnish finish as observed by comparing curve No. 1 of Fig. 8 with curve No. 2.

It is difficult to obtain a wax type finish capable of meeting a wide range of ambient temperatures satisfactorily, since the hard waxes with high melting points become brittle at low temperatures and crack, while those that remain plastic at low temperatures become soft or melt at the higher operating temperatures. For the No. 1436 wax used the coating of cement served to preserve the mechanical stability of the coil and

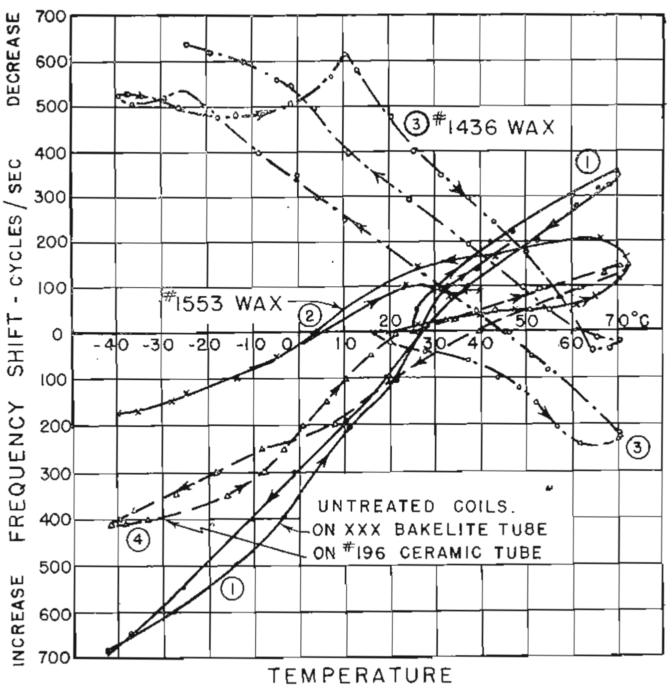
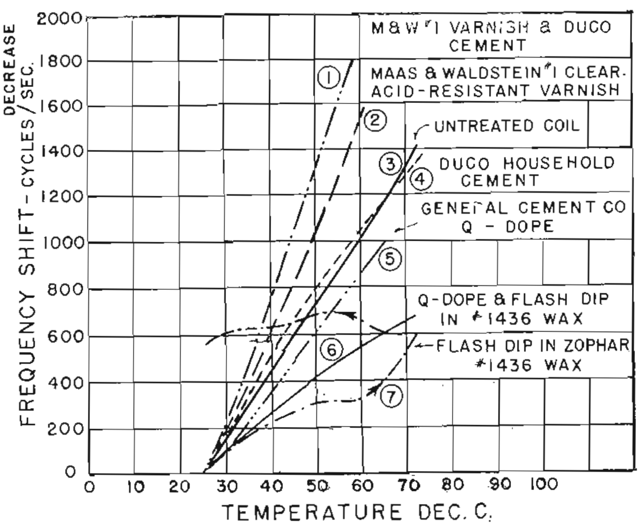


Fig. 7—Tests at 1.5 mc on a smaller coil show some changes from Fig. 6 in effects of finishes on temperature coefficient. Test coils are 52 turns of 6/42 litz in 1/8-in wide coil on 1/2-in Bakelite form.

Fig. 8—Effect of flash dips of Zophar No. 1553 and No. 1436 wax on same IF coils as in Fig. 6, except curve No. 4 for similar coil on Alsimag No. 196 ceramic tube.



to protect the soft wax when hot, and prevented down to about −40°C the embrittlement of the wax and impairment of its adhesion from causing cracking off as it would have done otherwise for this particular wax at temperatures lower than about −30°C.

Cement Coatings

When military requirements extended the low temperature requirements still lower to −55°C, the wax coating over the Q-Dope finish was replaced by Sarco Compound which is mechanically satisfactory at both high and low temperatures. As shown by curve No. 13 in Fig. 6, the resultant temperature coefficient is about 2.3 times greater (taking into account the temperature coefficient correction for the test chamber). Insl-X No. 67 is also satisfactory with regard to stability over similar temperature ranges, but its effects upon the temperature coefficient were not measured.

The need for a smooth cement-type coating over wax finish-multi-layer coils is usually less than in the case of single-layer hf coils. Moreover, while the addition of the cement over the wax coating on the hf coils did not affect the temperature coefficient, it was found that on the wax-impregnated IF coils with a coating of Duco Household cement, the cold-temperature drift was apparently doubled, with little change at temperatures above 25°C, as may be noted by comparing curves Nos. 12 and 14 of Fig. 6.

Ceraseal 15SX-2, a heat-polymerizing finish (manufactured by the Ceraseal Corp., Chicago), which melts at 240°F and has good moisture-resistant properties, has been used to a considerable extent on radar components. It requires careful processing. Non-wetting silicone varnishes, such as Dow-Corning 993 and 996 require baking temperatures of 450 to 500°F and 300°F respectively, and their DC-200 fluid recommended for glass and ceramic surfaces requires baking temperatures between 390 and 600°F, preventing application to non-ceramic coil forms.

Penetration Methods

In some cases complete penetration of the finish may be required, for example, in the windings of motors and dynamotors having stiff humidity cycling requirements. Impregnants show considerable variation in penetration qualities, and careful control of vacuum impregnation and temperatures during impregnation and baking is essentail.

For fine-wire coils, particularly, another important requirement is freedom from corrosive effects upon either conductors or their insulating coverings. Liberation of even minute quantities of substances serving as electrolytes in the presence of moisture proves serious in transformers and relays, etc. which carry direct current. In addition to critical requirements for finishes inter-layer material and fastening tapes must be chosen carefully, as shown in studies made of this problem[9,10] too detailed for inclusion here.

Thermal Aging

In other tests not included here it has been found that inter-layer insulating materials exercise an effect comparable to that of finishes upon the temperature coefficients of rf coils. This is an additional factor of importance in the case of oscillator coils having overwound primaries.

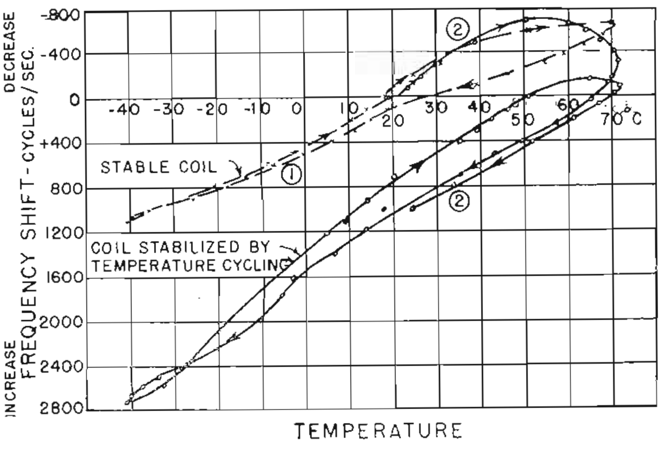
For coils whose critical use requirements demand a uniform temperature coefficient over a wide temperature range and high stability, considerable improvement can be derived from exposure to several hot-and-cold temperature cycles or even just heating cycles. This treatment will tend to equalize winding stresses and strains in the coil forms or mounting fixtures. If the elastic limits of the wire, coil forms, fastening pins, solder, etc. are exceeded in the cycle of normal temperature variations, thermal cycling can accomplish little improvement in stability, and redesign is called for.

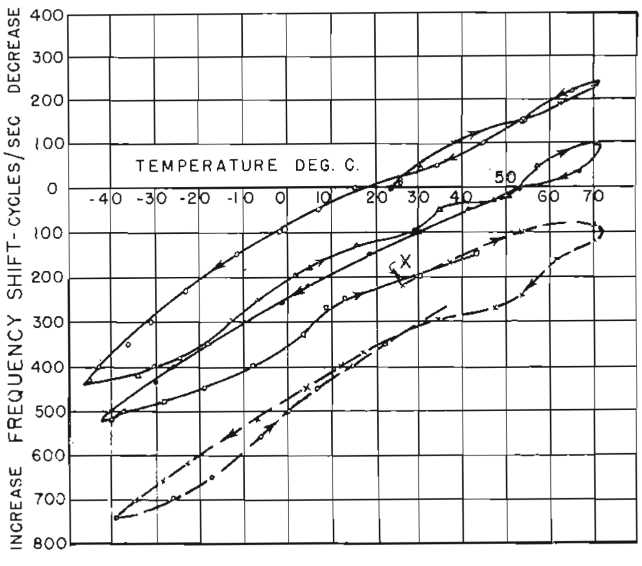
Curve No. 3 of Fig. 2 indicates the improved stability produced in a universal-wound coil of solid wire with a wax dip finish after one heating cycle. Fig. 9 in curve No. 2 discloses the effect of a hot-cold cycle on a universal-wound IF coil of litz wire finished with

(*Continued on page 78*)

Fig. 9—Curve No. 1 shows IF coil initially stable after drying of rf lacquer. Another similar coil shown by curve No. 2 requires temperature cycling for stabilization.

Fig. 10—Stabilizing effect of temperature cycling on large roller coil using No. 20 silvered invar conductor on Alsimag No. 202 grooved ceramic form. Test at 1.5 mc.





Tangential Electron Emission

Presence of space charge in front of cathode causes tangential electron emission velocity distribution to deviate from Maxwellian distribution

• A study of the electron optics of line-focus cathode systems for producing flat, strip-shaped electron beams revealed that under certain conditions individual electron pencils—separated out of the beam by an apertured diaphragm—split up into several elementary pencils. Soon, however, it was established that the appearance of these elementary pencils depends greatly upon the space-charge conditions near the cathode. Previous investigations were made with relatively small currents and therefore correspond to temperature-limited emission; they report no effects similar to the splitting up of the electron pencils into elementaries.

The cross-section of the pencils at the apertured diaphragm, Fig. 1, is determined, of course, by the size of the holes, while the spreading of the pencils measured by the angle α depends upon the tangential velocities of the electrons in each pencil. An investigation of the distribution of the tangential velocities of electrons emitted from cathode systems under space-charge conditions, therefore, appeared to be of interest.

For the experimental investigations, the conventional apertured diaphragm is replaced by a diaphragm with one very fine slot, (0.05 mm x 5 mm), extending at right angles to the cathode strip; the electrode distances in one set-up are 74 mm each. In the center of the fluorescent target is another very fine slot (0.1 mm x 2.7 mm) extending parallel to the slot in the diaphragm. A Faraday cage, not shown in the drawing, is arranged behind the target slot for current measurements. Any pattern produced on the fluorescent target can be observed by a suitable arrangement of mirrors and a microscope. The whole target, Faraday cage, microscope assembly can be shifted in the direction of the cathode extension so that the pencil can be explored over its complete width.

For the measurement of the tangential velocity distribution curve, the assembly is moved step by step across the width of the pencil, and for each position the current received by the Faraday cage is measured with a senstitive mirror galvanometer. Alternatively the electron density distribution may be studied by visual observation of the pattern on the fluorescent screen.

The spreading of an electron pencil results from a superposition of the tangential electron velocity components at the cathode over the normal velocity component acquired by the acceleration in the anode field. Therefore, assuming a Maxwellian distribution of the initial tangential electron velocities corresponding to the cathode temperature, a definite relative intensity distribution on the fluorescent target is to be expected for a given accelerating voltage.

Computations prove that the current distribution at the target is a complete representation of the initial tangential velocity distribution of the emitted electrons. This can be qualitatively appreciated by considering Fig. 1. Assume zero tangential velocities throughout the pencil. The fluorescent target will show a spot identical with the aperture in the diaphragm, while a wide spread of tangential velocities will result in a large spot on the target. The current intensity at the central point corresponds to the number of zero-tangential velocity electrons, while the intensity at an outlying point, identified by the spreading angle α, corresponds to the number of electrons with a definite tangential velocity.

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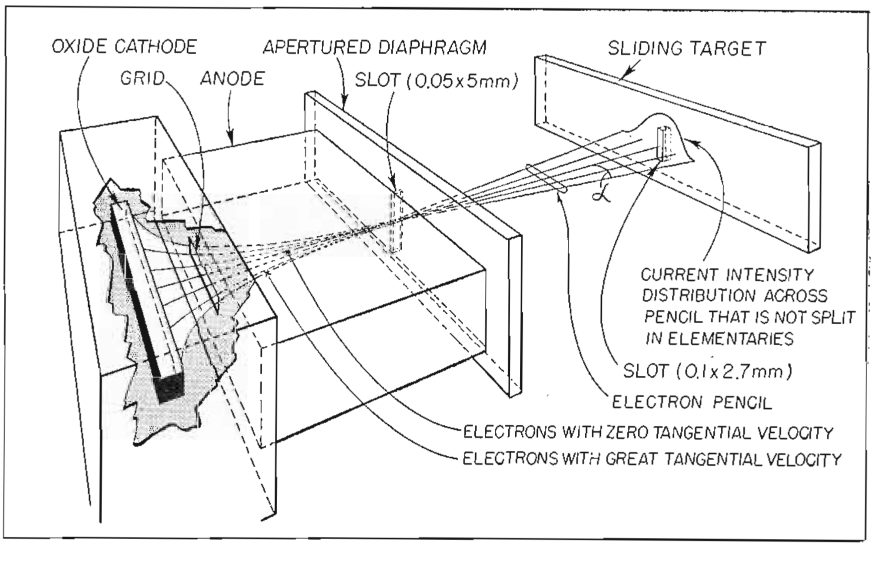
Fig. 1. Experimental arrangement for the observation and recording of electron density distributions over the width of electron pencils



**Summarized by Josepha Zentner, Ph. D., from an article by O. Klemperer, Ph. D., Senior Lecturer in Physics, Imperial College of Science and Technology, University of London, published in the Proceedings of the Royal Society.*

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Central Television Distribution System Engineering

Engineers tackle problems of providing multiple viewing outlets in a variety of ways—Some practical and projected methods described

• With the great and growing increase in television broadcasting facilities throughout the country there has come a heavy demand for multiple outlet systems which will accommodate large numbers of viewers in such public institutions as hotels, apartment houses, hospitals and the like. The problem is not too easy of solution, has required considerable engineering ingenuity. As was to be expected, there have been developed several different methods of approach.

In attacking the problem of providing picture units (not TV receivers) at many points, there are three main avenues of approach: (1) To provide a master receiver and individual distribution cable for each TV station; (2) To demodulate the video carriers, and remodulate new lower frequency carriers for distribution of a single cable system; (3) To have each slave unit connected to the master receiver by an individual line. To change stations the viewer telephones the operator requesting a new station. Of these the first is in use and the second is projected. Further technical details of the first two of these systems follow.

MULTIVIDEO TELEVISION USING "SLAVES"

System operates on a single coax network and distributes "pre-digested" video and audio signals from all local TV stations

• On paper now are plans by the Telicor Corp., New York, for an integrated distribution system for hotels which would use master control receivers and half-television units or slave sets in the various rooms. The big distinction between this plan and others is that only one distribution cable will be necessary to distribute as many as 6 to 8 television programs to the various slave units. Cabling is one of the highest cost factors in any of these systems. Some believe that it is economically feasible to install more elaborate television equipment if the cabling can be cut down. Any reduction in cabling is welcome because the cost mounts very quickly as each new cable is added for another single TV station.

The integrated system would use ghost-free antennas to pick up the TV transmitters and then "pre-digest" the signals in control receivers where the video and audio carriers are demodulated and placed on new carriers quite apart in the spectrum. In order to improve the selectivity of the slave units, the video signals would be placed on new carriers approximately 20 mc apart so there would be less susceptibility to interference or cross-modulation between television signals. The audio is demodulated and also placed on new carriers which are much farther apart than the frequencies of reception for the same reasons.

For example, if there were six television stations in a particular city, the video signals may be demodulated from their original carriers, then placed on 20, 40, 60, 80, 100 and 120 mc carriers. The audio, on the other hand, may appear on frequencies approximately 2 mc apart to give good selectivity. These carriers may be 5, 7, 9, 11, 13 and 15 mc. The cables would handle a bandwidth of less than 200 mc and the signals from the control receivers would be fed to this common cable at a fairly high level. At each of the slave units, the level would be high enough to operate into the audio and video detectors directly, thus eliminating any need for rf amplification at the slave units, and incidentally cutting the cost of manufacture.

With carriers below 200 mc, it is possible to use thin cable of lower initial cost than conventional cables now being used for the TV carrier frequencies. More important, however, is the fact that this cable requires less skilled technic in the installation, saving considerably on labor costs.

Each of the slave units would have only 2 switches, an audio volume control and a 6-position switch for selecting any one of the 6 television programs. For example, in the No. 3 position the slave unit may be tuned to the 40 mc video carrier and the 7 mc audio carrier. Both frequencies of which are far enough apart from their respective neighbors and from each other to preclude the possibility of intermodulation and other distortions.

The slave units would be permanently installed as there is rarely any need to take out a television unit once it is installed. The connection between main line and slave unit would be of the reactive type to prevent disturbances to other parts of the system. If for any reason a slave unit must be removed, a simple matching impedance will be substituted in its place to maintain the balance.

One of the cogent problems in any such wide scale distribution television system is the economic factor. Technical systems are well advanced, but the overall cost is contingent upon which technical solution requires inexpensive installation technics. For example, the cost of running a second cable as a supplement to the first, doubles the cost. Even this is already too high. To put in a third cable system for a third television station dictates that the rest of the equipment be severely inexpensive.

CENTRAL CONTROL TELEVISION FOR HOTELS

"Guest Television" system uses separate coax net for each channel—Additional audio channels provided for

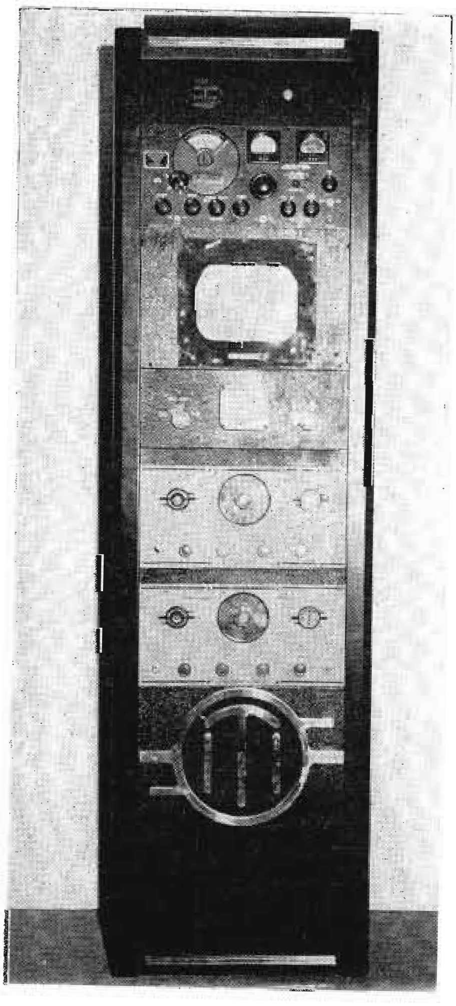
• The central system described in the following is a refinement of a remote control teleceiver design which has been marketed for public viewing in taverns, schools and clubs by Industrial Television, Inc., Clifton, N. J. Most of the circuits are straightforward and conventional.

Fig. 1 shows a three channel central control unit for the "Guest Television" system. Two video channels are employed and one FM channel. Starting at the top, the rack contains the power switching panel, FM receiver, monitor viewer, monitor selector and VU panel, two television tuners, the monitor speaker and distribution amplifier. Each of the television tuners can be tuned to any commercial television channel. Separate antennas are used for each although in high signal level areas one antenna with isolating pads may do. Careful attention has been given to the local oscillator design to minimize radiation.

Tunable traps are used in the antenna lines to eliminate any residual radiation which might interfere on other picture channels. The television tuners have low impedance unbalanced input systems with resistive input terminations. This insures good performance where the antenna lead-in run is long, as may be expected in hotel installations where the master control unit is placed in a basement service area. The bandpass of the television tuners is designed to fully utilize the television signal. The second detector of the television tuner feeds a cathode follower which has an output impedance of 75 ohms.

The cathode follower output of each tuner is coupled to a distribution amplifier located at the bottom of the rack. The distribution amplifier provides sufficient cathode follower outputs to take care of the required number of lines leaving the central control unit with signals for each channel. In most instances, a single line for each channel is required. In some cases, however, it is desirable to branch the distribution system at the Central Control and provide two or more independent lines all carrying the same channel signals.

Fig. 1—Main receiver rack with receiver units and distribution facilities as designed by the Industrial Television Corp.



The monitor selector panel enables the operator to monitor both the video and sound signal from any tuner. The sound is monitored for level by means of a standard VU meter; and, in addition, aural monitoring is provided by a high quality audio amplifier system. Sound is distributed on balanced low level lines. In the case of small installations where the advantages of balanced operation are not necessary, high level unbalanced lines are used.

The video signal is monitored for picture quality on a 10 in. magnetic tube monitor. The video level may be monitored by a switching arrangement which converts the VU meter to a peak reading vacuum tube voltmeter to measure the sync amplitude. The video output signals are maintained within the amplitude limits of the RMA standard for video distribution systems in television stations. All line signals are sync negative in 75 ohm coaxial cable.

An optional feature which is not incorporated in the central control unit illustrated is an automatic indicator circuit which supplies a dc control voltage at each viewer location when any one or more of the television stations for which the system is set up goes on the air. This circuit is actuated by the dc voltage developed at the video detector with special precautions being observed to prevent its actuation by noise. It is of considerable importance where some of the viewer units are to be coin operated. Through its use, viewing units suitably designed may be connected so that the television circuits cannot be energized by the local off-on control except when television is on the air. This leaves the audio system free for FM or AM use without ageing the television components.

In addition to the video and audio signal lines, a dc control line is run from the central control unit to actuate a relay control of the primary power on the repeater line amplifiers used in the distribution system.

Additional television or FM channels may be incorporated as required to meet particular local needs. A typical installation will have three video channels and two additional audio channels which might be either FM or AM.

The distribution network for the video signals is perhaps the most important part of this system. The use of a separate coaxial conductor for each channel together with an audio pair for the accompanying sound presents a considerable installation problem. By the use of specially designed multi-coaxial cable and individual coaxial conductors of as small cross-section as possible, the size of the cable required may be kept to practical dimensions for quite elaborate installations. Separate cables are used for the audio and video signals. A custom built video cable for use in a system with three television channels and providing one spare coax, is approximately ½ in. in diameter overall. The accompanying sound cable which includes audio pairs for three additional sound channels together with spares and control circuit lines is somewhat smaller in diameter.

The distribution system is installed in existing buildings by utilizing the power conduit or elevator shafts as risers between floors, and the wiring on each floor is done in surface conduit or "Wiremold." A distribution amplifier is required for each floor. This unit is usually installed in some service area such as a switch closet and is entirely automatic in operation. The floor distribution system from the floor distribution amplifier consists of one or more terminated lines with the viewers bridging the line in the various rooms. For the usual floor plan configuration and if not more than fifty viewers are required on a particular floor, no additional line amplifiers are needed. However, if excessively long runs are needed between one group of viewers and others on the same floor, or if the total number of viewers required is large, auxiliary distribution amplifiers may be necessary.

Each viewer location has a special cable outlet box and connector to the viewer. By careful design of

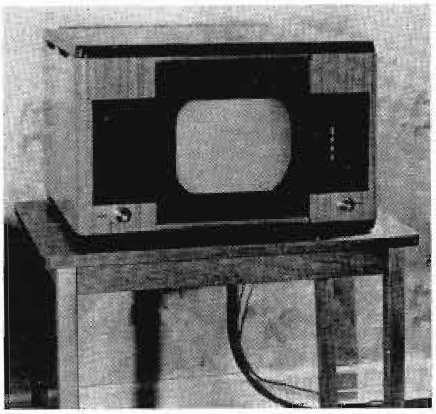


Fig. 2—One of the individual ITC "slave" viewing screens for guest rooms

the cable and switching system which connects the viewer to the several lines, a minimum of mismatch at the viewer location is introduced which will not degrade the picture quality if certain limitations of line length between successive distribution amplifiers and between distribution amplifiers and bridged viewers are observed. By placing cathode follower coupling tubes at the line where the viewer is to be located, more viewers may be operated between distribution amplifier points. However, the obvious disadvantages of having vacuum tubes incorporated in the outlet box at each viewer, which must be provided with filament and high voltage power, favors the use of the larger number of distribution amplifiers.

For public viewing, large screen direct view types utilizing the 15 in. and 20 in. cathode-ray tubes are intended. All types select the desired channel by means of push-button switching. Fig. 2 shows the 10 in. table model viewer intended for private rooms or suites. The unit shown is set up for a four-channel system with three television channels and one FM channel. The only operating controls are a

(*Continued on page 86*)

HOTELEVISION SOLVES "TV SET IN EVERY ROOM"

Master receivers feed demodulated video and audio signals to many slave picture units via coax nets

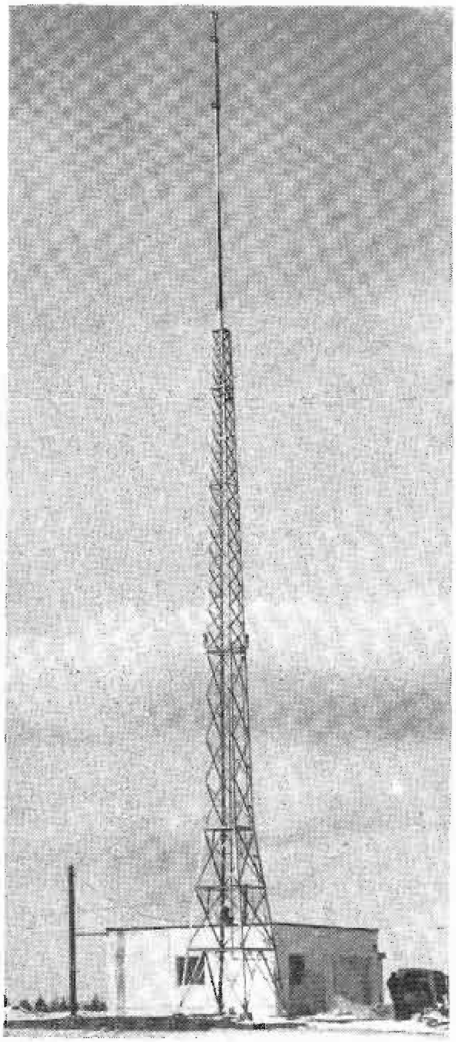
• The largest single installation of television picture units (not TV receivers) operating from master receivers is now in operation at the Hotel Roosevelt, New York, where 40 rooms are equipped to provide television service for guests at $3 per day extra. The installation requires three television receivers in the 19th floor control room which supplies three main coaxial trunks. Each picture unit is equipped with a 3-position switch to enable the patron to choose any one of the New York television stations now on the air.

The central control feature enables the system to operate from an inexpensive antenna system. Each control receiver is connected to its own specially-built and oriented antenna for adequate signal strength to keep monitoring down to a minimum. Audio and video signals (no carrier or IF) are run throughout the hotel on three independent networks using type RG-58U, 53-ohm cable.

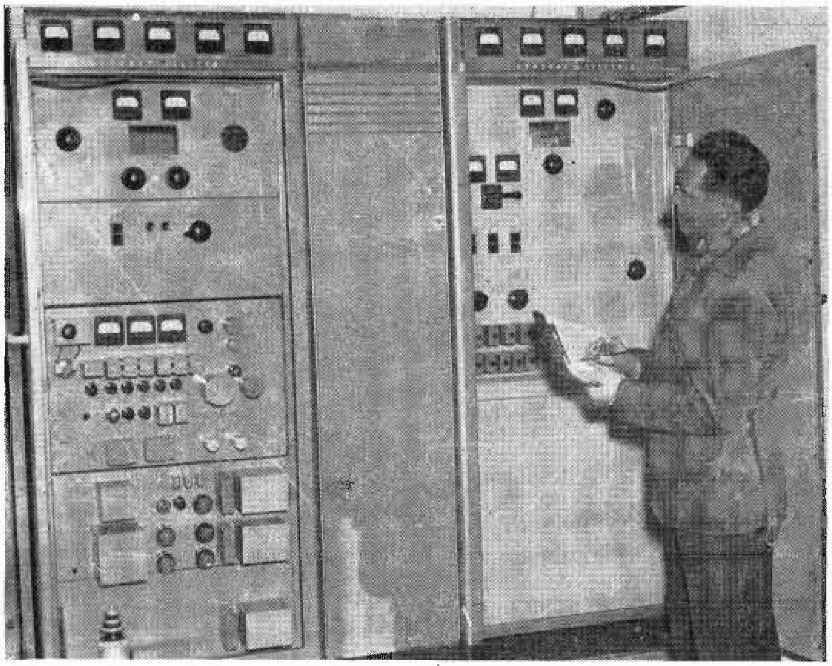
In order to make the system completely independent of failure of individual units, each slave is connected to the main line in such a way that no disturbances can be transmitted back to the main line. Thus, any slave unit may be disconnected from the system or changed to a different station without causing disturbances to any of the other units. In a pre-demonstration test, R. J. Langley, Olympic Radio chief engineer, connected a number of units to the main trunk line at various points. When a slave was attached, disconnected or changed from station-to-station at one point, no flicker was noticed on slave units at other points.

The project was financed by Hotelevision, Inc., and the units are being manufactured by the Olympic Radio & Television Co., Long Island City. The units are portable and can be plugged in or removed from any room wired for the system without costly or time consuming operations. The slave unit is 16 in. wide, 20 in. high and 20 in. deep. The picture screen is a 10 in. direct view cathode ray tube. Only two controls operate each slave unit, the volume and the station control for TV.

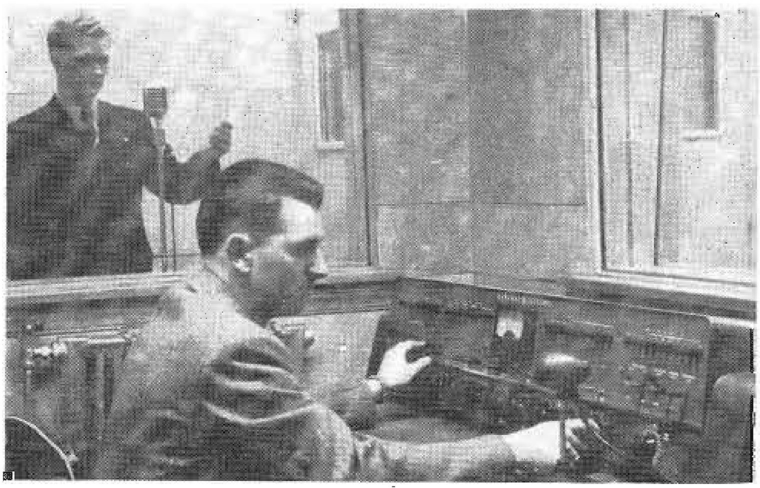
FM Station WWHG

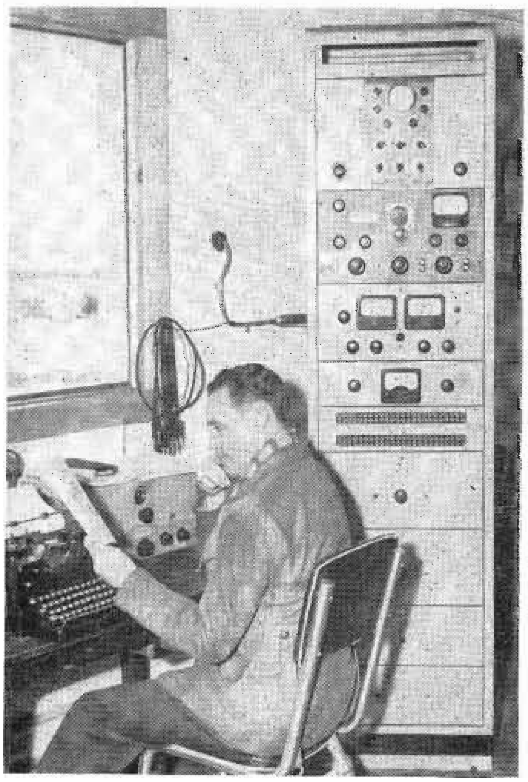


With its antenna at an altitude of 2,286 ft. Hornell, N. Y. station serves area of 12,250 sq. miles—Three studios



The antenna at WWHG, lately modified to give an effective radiated power of 10,000 watts, is located five miles from the studio building. Above right—Chief engineer N. W. Amidon checks operation of the General Electric transmitter. Below—General view of the main control room, centrally located for the three studios. Right below—Patch panel and monitoring equipment at transmitter





National Conference Urges Bigger Research Program

Chicago gathering, studying all phases of communication, emphasizes need for continuing development work — Television a major subject

• Approximately half of the extensive program of technical papers presented before the National Electronics Conference last month in Chicago was devoted to communication and closely allied subjects. And as was to be expected, the engineering aspects of television came in for more than a fair share of attention. All told, there were some 20 technical sessions concerned with 78 papers. The gathering drew an attendance of 2475 registrants, not counting 550 persons who were admitted to the exhibits alone.

As was to be expected the sessions devoted to television were always well attended. A paper by Prof. A. B. Bronwell described the "Chromoscope", a new form of color television viewing tube which is under development, featuring the use of separate fluorescent screens which fluoresce at the three primary colors. These screens are parallel and very close together so that the beam can traverse all three in tandem. They are transparent optically and electronically. In the latter case the electron transparencies are such that each beam intercepts about one third of the electron stream.

To prevent all screens from fluorescing at the same time, before each of them is a unipotential screen (also transparent to both light and electrons) which insures that electrons from the single electron gun are subject to the same influences. Selective excitation of the screens in sequence is obtained by adjusting their relative potentials: the potential on the screen whose color it is desired to excite is raised while that on the others is lowered.

ELECTRONIC RESEARCH

THE enduring need for a program of fundamental research was a highlight of the National Electronics Conference. Several speakers brought up the problem. In addition to the great amount of research under way looking to the development of new circuits and technics springing from military applications, many projects in entirely new fields are starting. Many engineers and scientists are entertaining concern relative to the necessity of utilizing to the fullest extent existing facilities of the country in research and of expanding such work by encouraging as many as possible to participate.

Experiments made so far with a two-color tube have indicated that this principle of operation is feasible. Thus at least one more path on the road which might lead to all electronic color television is marked.

Screens may be either fine wire grids or thin transparent plastics. In the first type wires are coated with fluorescent material, and oriented 45° with respect to one another in order to reduce stratification effects.

It is proposed to scan successive lines in the three colors sequentially, though this arrangement requires either a 523- or 527-line picture. Since color changes occur at end of each line this sequential color operation will eliminate color breakup and flicker effects. Use of interlaced color permits the use of longer persistence phosphors. This might lead to allow satisfactory color pictures on a bandwidth hardly greater than black and white, although only further experimentation on complete systems will tell.

A method was described by Edith B. Fehr for specifying the color characteristics of fluorescent screens for use on television screens. The method makes use of the tristimulus curves adopted by the International Commission on Illumination. A point in the vicinity of black body color at 6000° K is being proposed as a standard for white light.

The problems of monitoring a television broadcasting station, both picture and sound, were outlined by M. Silver (F. T. Labs) with a description of equipment which provides a constant check on the carrier frequency of the picture transmitter and both the center transmission frequency and the degree of modulation of the sound transmission. Also provision for the measurement of noise and distortion of the sound transmission is made.

The complete equipment is mounted in three chassis, the top section containing the sound-channel monitor, the middle unit the picture-channel equipment with its power supply, and the sound monitor is in the bottom section. The unit is suitable for operation on any of the 13 television channels.

A phase meter was described by E. O. Vandeven wherein the voltage on each phase is separately amplified, clipped and differentiated. The pulse outputs thereafter referred in time to the respective phase voltage, are then mixed and applied to the Z-axis amplifier of an oscilloscope. The vertical and horizontal amplifiers of this oscilloscope are supplied with voltages whose frequency is the same as that of the polyphase supply but separated in phase by 90 degrees. The Z-axis pulses intensity-modulate the resulting circular trace. The tube screen is calibrated radially in degrees so phase angles can be read by noting the angular spacing between the leading edges of the modulated portions of the trace.

Guided Missiles

The role of electronics in guided missile research was analyzed by W. N. Brown, Jr., (Haller, Raymond and Brown) and its past and present status discussed. He mentioned that an extreme degree of specialization among electronics and radio engineering personnel isolated this science from other fields of engineering and fostered unfamiliarity with electronics on the part of specialists in fields such as aerodynamics, ballistics, propulsion, etc.

Many of the guided missiles used were developed by specialists in the design of aircraft and bombs, most of them not fully aware of the possible application of electronic technics. A striking idea long surmised by those working in these developments was voiced: The military effectiveness of most missiles used would have been strikingly increased if contemporary electronic technics had been used for guidance and control of the missiles.

A survey was made of the problems confronting designers of equipment in the various categories of this field. Formerly hurdles often arose from electronic technic limitations but research men are now acquiring facility in development of new electronic technics and in application of known technics to non-electronic problems. Work in this program offers unparalleled opportunities. Project direction is now in the hands of scientists having a broad understanding of all the contributing fields of research, and detailed planning is being carried out jointly.

It is not possible to report many of the papers in these columns. Most of them will be published early next year in the Proceedings of this conference. Only a few typical papers on communication subjects have been mentioned here. At the first session Dr. Geo. D. Stoddard, President of the Univ. of Ill., presented a talk on "Science as a Guide to Education" in which the role of scientists in modern civilization was analyzed. In such matters science is neutral and cannot distinguish between virtue and evil. It is for other fields of activity to determine whether science and civilization or science and destruction get the upper hand.

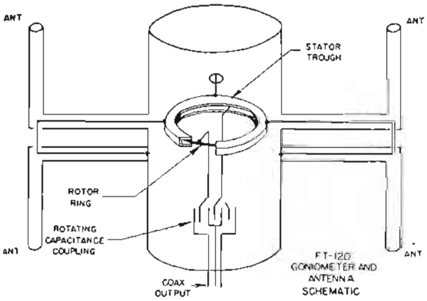
The advance of pure research, with no definite objective in mind, was championed by L. V. Berkner, Joint Research & Development Board, who showed that developments without this search soon lack perspective by not being able to call on the outer boundaries of knowledge for answers to the increasingly difficult problems coming up.

Walter Evans, (Westinghouse), proposed sweeping changes in national preparedness thinking under which science and industry would continually serve along with the military, in top-level planning councils. He suggested that American security be entrusted to a team of four departments:

1. A military high command to map plans and list requirements for defense.
2. A nationwide research organization to maintain laboratories continually seeking out new devices and technics.
3. Follow up by industry to convert the scientists' models to production - line equipments, and to establish manufacturing procedures for times of emergency.
4. An Army, Navy, and Air Force adequate to test equipment in the field and to train efficient operating and maintenance personnel.

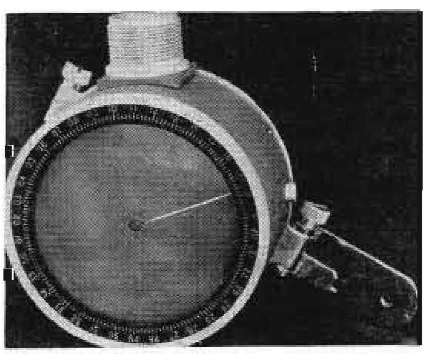
(Continued on page 76)

ROCHESTER MEET STUDIES MODERN TECHNICS



Federal instantaneous bearing indicator

Rotating coupler of unique design which connects signals from stationary dipoles to coax to give regular lobed DF patterns



• The recent Rochester Fall meeting of the IRE-RMA Engineering Dept. was as usual the attraction for a large assembly of engineers for three days of technical papers and shop talk. This meeting, the progenitor of the idea of local conferences of the time, has long since outgrown its local character and has a national reputation as a place to meet the men whose names are associated with progress. The papers were for the most part well selected and leisurely presented without the atmosphere of a three-ring circus.

The technical sessions started with a study of VHF direction finders by A. G. Richardson of Federal Tel. Labs., with particular attention to the recent improvements in automatic df systems with cathode ray presentation.

H. F. Wheeler (Wheeler Labs., Great Neck) described a simplified inductance meter which with simple settings gives direct readings of L. Two similar oscillators are tuned to the same frequency by zero-beat indications. Each contains a resonant circuit with fixed inductance L and fixed capacitance C. One oscillator also has a calibrated variable capacitor C connected in parallel with the tank circuit. The other has provisions for connecting the unknown inductance L in series with the fixed coil in the circuit. After tuning the two oscillators to resonance by a fine adjustment, the unknown L is inserted and the standard C is increased to restore zero-beat, from which readings simple relations were shown to give inductance values with an accuracy of 1% between 1 microhenry and 0.1 henry.

An impedance bridge for use in a range 20-140 mc, a new product of the General Radio Company, was also described by R. A. Soderman.

J. W. E. Griemsmann (Brooklyn Polytech.) described special design technics to obtain metallized film coaxial attenuators for use at centimeter wavelengths, featuring low reflection factors over wide bands. Typical fixed value attenuator units are possible with this technic.

A spirited talk was given by A. C. W. Saunders (Newton, Mass.) on the apparent lack of sympathy that many receiver design engineers have for the serviceman so that disassembly of many parts is now the rule to service (or even to test and check) many of the parts.

There were several television papers — a resume of progress trends by D. G. Fink, and a study of the transient response factor in transmitters and receivers with suggestions for further standardization by R. D. Kell and G. L. Fredendall (RCA). A paper "Spectral Response of Cathode Ray Phosphors" was presented by R. M. Bowie and A. E. Martin (Sylvania). The Philco projection television system, (previously described in these pages), was reviewed and demonstrated by W. E. Bradley.

In the field of receiver design, a paper on IF selectivity considerations for FM receivers and a paper on the relative performance of typical FM receiver systems, were presented respectively by R. B. Dome (GE) and by B. D. Loughlin and D. E. Foster (Hazeltine Electronics).

How Rigid is the Hartley Law?

Extension of famous law indicates bandwidth can be traded for signal-to-noise ratio or power. PCM system affords ideal exchange

• How rigid is the famous Hartley Law? It was first postulated in 1928 and states that the amount of information that can be transmitted in a given time by any system is proportional to the bandwidth of the circuit. In one of the largest turnouts for a New York Section IRE meeting, hundreds of engineers last November 12 listened to several theorists expound on the rigidity of this law.

The talks were laden with mathematical formulas and higher electrical theory, but the significant factor was the *signal-to-noise* ratio. With the advent of the new systems of modulation (FM, PTM, PFM, PCM), this S/N factor was found to bear specific relationships to these systems and led theorists to explore the completeness of the Hartley law which so far has not included this important factor.

In these various systems it is said that the factor S/N can be traded for bandwidth (BW) in varying degrees without losing any original information. How much noise can be tolerated before received information becomes unusable depends on the system used. A frequency modulation system can tolerate more noise than a conventional amplitude modulated system; and pulse-modulation systems can tolerate more than FM. The revised statement says that in the presence of thermal noise the maximum amount of information (measured in binary digits) that can be transmitted is $TW \log_2(1+S/N)$; where T is the time of transmission and W is the bandwidth. Thus the same information can be transmitted over a wide band with small signal power or over a narrow band with large power. Various of the newer systems of modulation such as FM, PTM, and PCM make use of this principle to obtain power saving at the cost of increased bandwidth. Of these, PCM comes closest to obtaining the ideal exchange of bandwidth for power.

ESSENTIALLY, Hartley's law states that "the total amount of information which may be transmitted . . . is proportional to the product of frequency range which is transmitted and the time which is available for the transmission." — Hartley, R. V. L.: "Transmission of Information" Bell System Technical Journal, 1928, Vol. 7, p. 535.

The point where noise overcomes signal and makes it unintelligible is called the *threshold*. In FM the threshold region is fairly well defined in comparison to AM, but in PCM the threshold region is even sharper. In the latter case, signal intelligence remains intact as the noise increases until the threshold point is reached, then the signal spoils rapidly. More significant, however, is PCM's invulnerability to cumulative noise over long circuits because it permits the regeneration of pulses to their original characteristics at each repeater point. The sharpness of this threshold phenomenon is apparent in television signals. When the human eye can distinguish light levels just above the noise, then the system receives all the information transmitted.

Signal-to-Noise Concepts

The signal-to-noise ratio has long been thought of by engineers as a factor which must be kept as large as possible, i.e., lots of signal with a minimum of noise. With new systems of modulation, this insistence for minimum noise was soon seen to be costly in spectrum space. The important point in any system is to recover at the receiver all the information that is put in at the transmitter. If the noise is allowed to increase to just below the threshold point, a corresponding economy in bandwidth is obtained.

One theorist said that if one can predict how much of the transmitted signal will be received, then S/N and BW both are being wasted. The implication is that there must be no correlation between the transmitted signal and the received signals; that the transmitted signal should approach random noise in character. Pulse-code-modulation, in which samples are taken from the original and complete information signal, is a system wherein the signal approaches a noise type. It was also implied that resort to quantum mechanics may be necessary to teach us more about the behavior of electromagnetic radiation and spurious noise contamination.

The subject matter is highly theoretical. To add further to confusion and ambiguity, descriptive word meanings are not held exactly the same by all theorists. For this reason TELE-TECH has asked A. G. Clavier of Federal Telecommunications and B. D. Loughlin of Hazletine Laboratories to present in brief the meaning of the Hartley law extension:

Says Clavier: In order to arrive at an evaluation of the amount of information contained in any type of transmission system, Hartley (B.S.T.S., July 1928, Vol. VII, pp. 535-553) started from the consideration of what would be called nowadays PAM (pulse amplitude modulation) telegraphic signals. Let n_o pulses be transmitted per second, each pulse being capable of s discrete signals.

The number of possible distinct sequences which can happen in a transmission time of t seconds is $s^{n_o t}$. The measure of the amount of information of which such a system is capable should be a function of this number of sequences. If it is considered as intuitive that, from the communication engineer's standpoint, this measure should be proportional to the time during which the transmission takes place, the suitable function to adopt is the logarithmic function. That is, the amount of information is measured by $H = K_o n_o t \log s$, in which K_o is a proportionality constant.

This kind of reasoning recently has been extended by various authors to the case when the message to be transmitted is a continuous curve of amplitude versus time. It is then found that the measure of the amount of information is proportional to the product of bandwidth by transmission time and by the logarithm of 1+S/N in which S/N is the signal to noise ratio (rms) over the transmission path.

Transmission Efficiency

The efficiency of any given transmission system therefore can be estimated as the ratio of the amount of information obtained in the reproduced message at the receiving end to the total amount of information which could have been transmitted over a line of the same bandwidth and signal-to-noise ratio as necessitated by the signals actually utilized.

This definition, applied to FM and PTM, shows that those two systems behave much in the same way, and that this efficiency decreases as the signal bandwidth increases. That is, the loss in bandwidth ratio is not compensated for by the gain in the ratio of signal to noise expressed in decibels. Pulse count modulation (PCM) shows a better transmission efficiency, equal to 0.33 approximately, irrespective of the number of digits in the code, provided it is larger than 3 or 4. Other systems, such as PAM or pulsed FM show an improvement when the number of channels, and consequently the bandwidth, increases, contrary to the way FM and PTM behave in this respect.

It should be emphasized, however, that transmission efficiency according to Hartley's law is just one factor among many involved in the choice of a communication system in a particular case. Prevalence of bandwidth over signal-to-noise ratio, or the contrary, simplicity and reliability of equipment, cost of manufacture and maintenance, all these intervene and cannot be included in an oversimplified factor of merit.

Bandwidth vs. Noise

Information transmission efficiency is nevertheless very useful as a criterion for the improvement brought in by a better adaptation of circuits, or for the detection of impossibilities when a new system is proposed.

Says Loughlin: The new relation shows that if the channel bandwidth is doubled and ideally utilized to transmit a message of given bandwidth, the message signal-to-noise ratio in *decibels* is approximately doubled, instead of getting merely a 6 *decibel* improvement as in FM and in most of the pulse modulation systems (except PCM).

This fact emphasizes that most of our presently used wideband systems for reducing noise are rather wasteful of frequency spectrum, and will surely lead to development of new systems which, like PCM, act more like the ideal. However, the economical practicality of the new systems will have to be carefully considered for each application.

The new relation implies that the channel bandwidth can be narrower than the audio bandwidth, at the expense of transmitter power, but the economical practicality of such a saving in frequency spectrum remains to be demonstrated.

The recently released formula relating the maximum information that can be transmitted in a channel signal-to-noise ratio represents a long needed and logical extension and clarification of Hartley's original work.

Graphical Aid for Frequency Selectivity Calculations

By ROBERT M. MAIDEN,
Naval Research Laboratory

Single nomograph can be used to solve problems in three separate categories for audio or radio frequencies

• Many problems in electronic engineering require the determination of one of the three parameters of the following equation when the other two have been given numerical values.

$$f = \frac{1}{2\pi RC}$$

In this equation f represents frequency in cycles per second, R represents resistance in ohms, and C represents capacitance in farads. The equation is the expression for:

(a) The 3 db bandwidth of a single-tuned circuit having parameters as shown in Fig. 1.

(b) The frequency at 3 db relative attenuation of the parallel RC low-pass network of Fig. 2.

(c) The frequency at 3 db relative transfer attenuation of the series RC high-pass network of Fig. 3.

It is the purpose of the following discussion to present a chart which facilitates calculations governed by this equation and to describe the application of this method to a few specific problems. The time required to solve the above equation using this chart is much less than if a slide rule were used, especially when many calculations of the same type must be made.

This nomograph is a timesaver for engineers concerned with problems involving the frequency response characteristics of audio or radio frequency bandpass, highpass or lowpass circuits. Fig. 4 illustrates how an RC coupled amplifier is first broken down to equivalent circuits for the high, medium and low audio frequencies. Each subcircuit is applied to the nomograph and the results are then integrated into an overall frequency response curve. Characteristics of IF stages can be similarly analyzed. Application of this formula has been made to the important study of the bandpass characteristics of video amplifiers in television equipment, as well as radar apparatus.

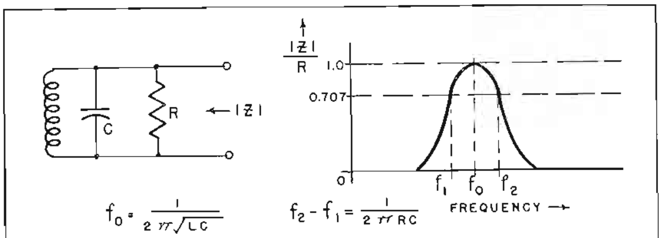


FIG. 1 CHARACTERISTICS OF A SINGLE TUNED CIRCUIT.

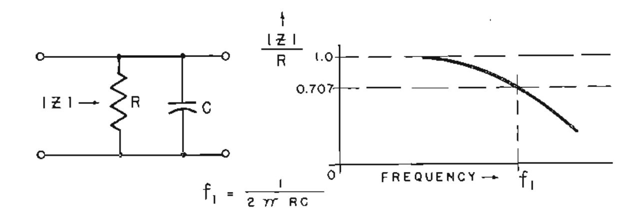


FIG. 2 CHARACTERISTICS OF A PARALLEL R C LOW PASS NETWORK

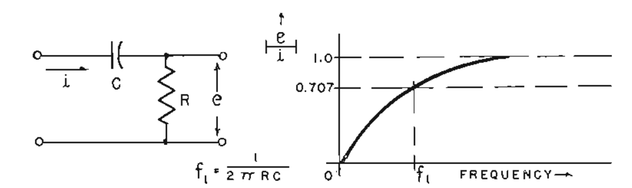


FIG. 3 TRANSFER CHARACTERISTICS OF AN R C HIGH PASS NETWORK

References: The circuit of Fig. 1 is described in "Stagger-Tuned IF Amplifiers" by Henry Wallman, Radiation Laboratory Report No. 524 dated January 28, 1944. The circuits of Fig. 2 and Fig. 3 are described in "Principles of Television Engineering" by D. G. Fink, McGraw-Hill Book Co., pp. 211-218.

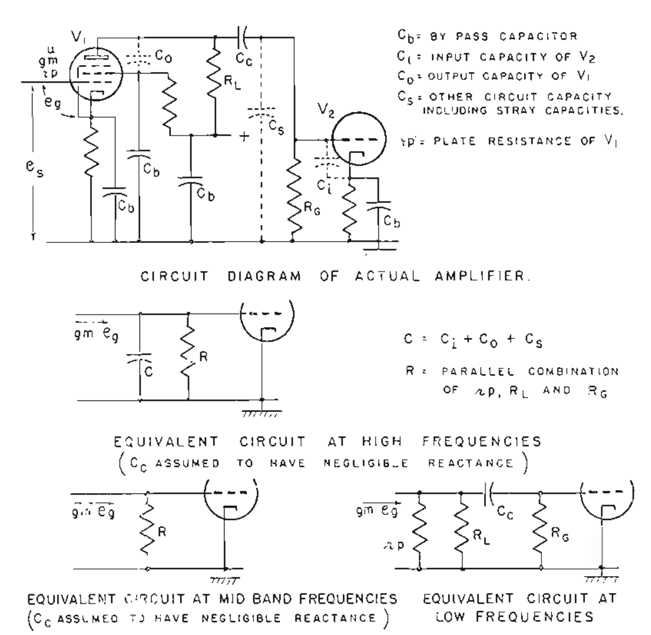
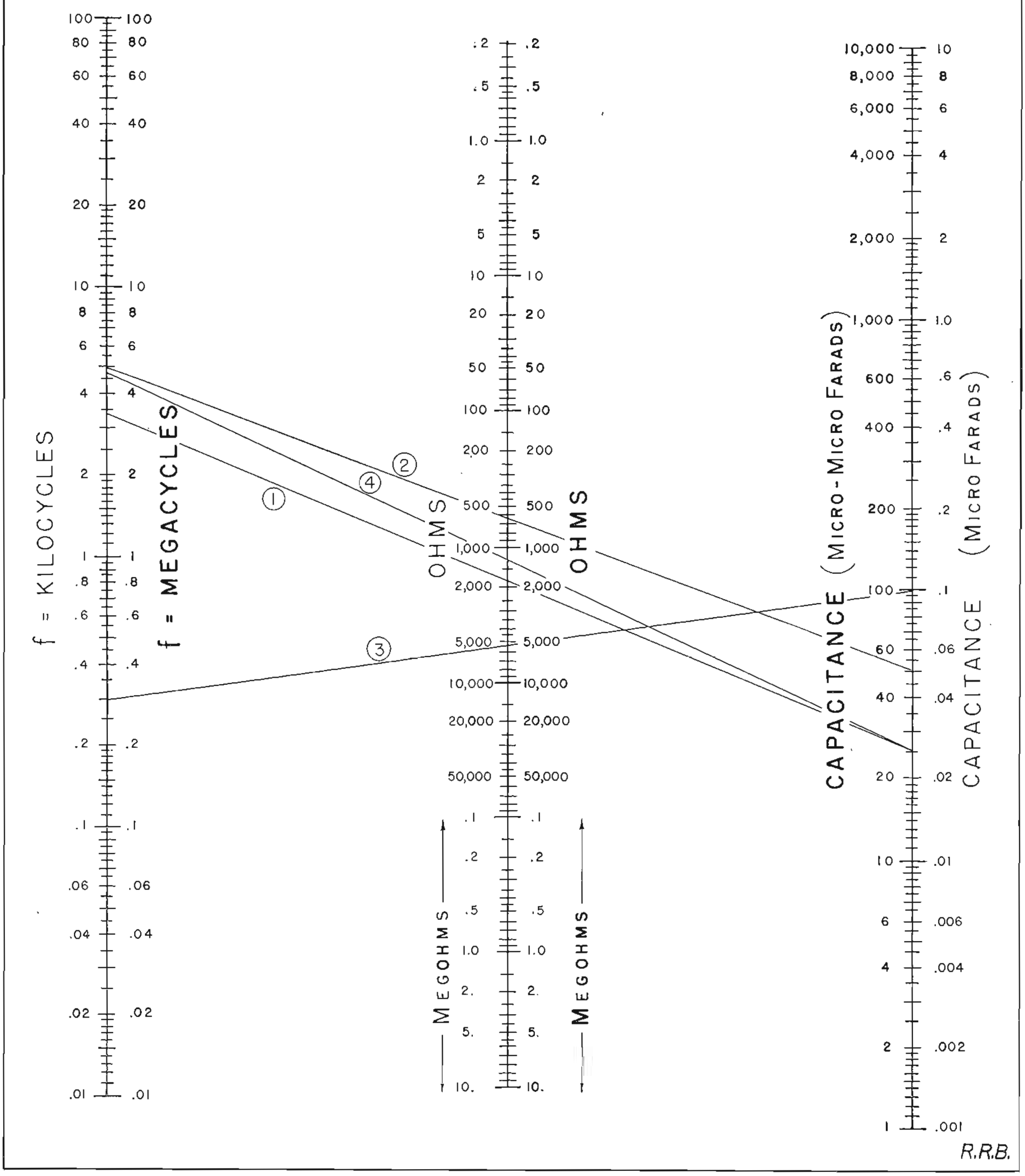


FIG. 4 AN RC COUPLED AMPLIFIER AND ITS EQUIVALENT CIRCUITS

NOMOGRAPH FOR SELECTIVITY CALCULATIONS



EXAMPLE 1. The circuit shown in Fig. 1 is to be used to couple two successive stages of an IF amplifier. It has been determined that the 3 db bandwidth of the circuit must be 3.4 mc, and that the equivalent shunt capacitance of the circuit is 25μμf. What equivalent resonant resistance must the circuit exhibit?

The problem is solved by reading the resistance scale when a ruler is set properly on the chart connecting 3.4 mc and 25μμf. It is seen that the equivalent resonant resistance is 1850 ohms. For this range of values only the heavier face figures on the scales are used. When solving a problem the heavier face scales *or* the light face scales are used.

EXAMPLE 2. Fig. 2 is a low-pass network. The specifications require that the output be 70% of the input at 5000 cycles, and drop off sharply beyond this frequency. A 0.05 μfd capacitor is available. What value of R will accomplish the desired results? For a problem in this range use only the light face scales on the nomograph. Draw a straight line from 0.05 μfd to 5000 cycles; read 620 ohms as the value for R.

EXAMPLE 3. Fig. 3 is an RC high-pass network. The specifications are that the circuit must attenuate rapidly below 300 cycles. For a 0.1 μfd capacitor, what value of R must be used? Use the light-face scales. Connect 0.1 μfd and 300 cycles. Read 5250 ohms on resistance scale.

EXAMPLE 4. Fig. 4 shows a resistance-capacitance coupled amplifier and its equivalent circuits. It is assumed that the reactance of the bypass condensers is negligible throughout the frequency range of the amplifier. If the equivalent circuit resistance R has a value of 1300 ohms and the equivalent circuit capacity C has a value of 25μμf, what is the frequency where the amplification is 0.707 of that in the mid-frequency range of the amplifier? As before, connect 25μμf and 1300 ohms. Extend the line and find 4.75 mc on the frequency scale. Thus the gain would be 3 db down at 4.75 mc.

Survey of World-Wide Reading

Electronic news in the world's press. Review of engineering, scientific and industrial journals, here and abroad

Exponential Transmission Line with Straight Conductors

W. N. Christiansen (Amalgamated Wireless of Australia, Technical Review, Ashfield, Australia, Vol. 7, No. 3, 1947).

An exponential transmission line is used at high frequencies for transforming impedances over a wide frequency band. To avoid the inconvenience of an exponential line structure, a balanced, four-wire transmission line made of straight conductors with tapering distances between the wires, (Fig. 1), was designed to approximate closely the characteristics of an exponential line. The mechanical construction of the line is greatly simplified if the wire radius, r, remains constant and if the wire spacings, b and c, can be arranged to vary linearly with the distance, D, along the line over an appreciable length of the line.

In the present instance, a balanced four-wire line with parallel connections between the wires of each adjacent pair connects the several antennas of an array to a transmitter; transformation from 600 ohms to 300 ohms is required.

In Fig. 2 the characteristic impedance of transmission lines is plotted on a logarithmic scale against the ratio c/r (horizontal wire spacing to wire radius) for a series of values of the ratio b/r (vertical wire spacing to wire radius). If the radius, r, is constant and the spacing c varies linearly with the distance D along the feeder, then a straight line drawn on the graph represents a linear change of the logarithm of the impedance with respect to the distance D along the wire; this is the requirement for an exponential transmission line. If, moreover, the curves representing equal intervals of b/r make equal intercepts on the straight line, the ratio b/r will be related linearly to c/r, and consequently the spacing b will also vary linearly along the line. A large number of such straight wire lines can be drawn over part of the impedance range from 300 to 600 ohms.

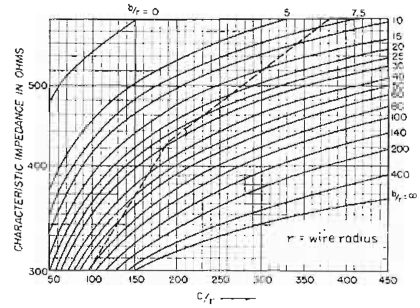


Fig. 2—Transmission-line characteristics

The straight lines drawn on the figure represent an example for such a line in two sections, the division being made at the geometric mean of the two terminal resistances (300 and 600 ohms), i.e., at 424 ohms. The actual transmission line is illustrated in Fig. 1 where the dimensions are given; it is designed for a frequency range of from 6 to 20 mc and extends over 40 meters. Tests proved it to be satisfactory, the maximum departure of the impedance level of this line from a true exponential line is only one per cent.—JZ

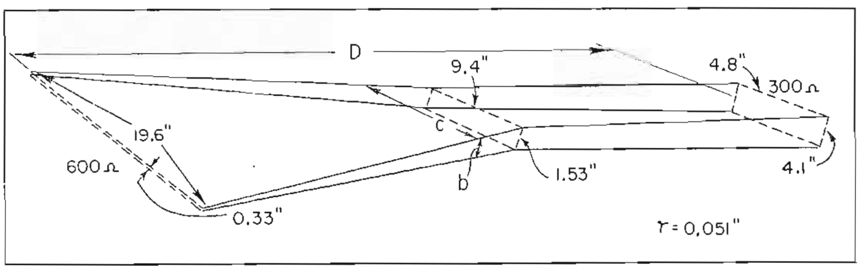


Fig. 1—Expcnental transmission line using straight conductors

Theory of Crystal Rectifiers

M. Leblanc (Bulletin de la Société Française des Electriciens, Paris, France, August, 1947, pp. 445-452).

The theory of semi-conductors and the effect of impurities and boundary layers is made the basis for an explanation of dry disk rectifiers, crystal detectors, the photographic image formation, and oxide cathodes. The energy levels and their variation with surface condition are studied.—JZ

Wheatstone Bridge in Computers

W. Krasny Ergen (The Review of Scientific Instruments, August 1947, pp. 564-567)

The value of an unknown quantity, $x = ab/c$, can be computed by making the resistors in three arms of a Wheatstone bridge proportional to a, b, and c, respectively, adjusting the bridge for balance either manually or by a servo-mechanism, and reading the value of the fourth resistor off a calibrated scale. The general problem of solving quadratic equations by means of a Wheatstone bridge is investigated. Each bridge arm may be made up of a series of separately adjustable resistors. It is established which specific group of quadratic equations can be solved by this type of bridge.

Extension to higher order equations requires parallel arrangement of resistors. One such bridge for the solution of an equation of the fourth order intended for a Shoran system is described.—JZ

Study of Thunderstorms

H. Norinder (Journal of the Franklin Institute, August, 1947, pp. 109-130 and September, 1947, pp. 167-207)

It is the main purpose of the Institute of High Voltage Research of the University of Uppsala to investigate the electrical character and effects of thunderstorms. The article is a comprehensive report on the results they obtained concerning the electromagnetic properties and behavior of lightning discharges. Variations of the electric and magnetic fields associated with lightning, current variations during the discharge, and a study of one particular stroke that was fatal to a workman are the main subjects. A large amount of radio receiver and of oscillographic recordings are included and discussed. Typical sequences in voltage and current variations are pointed out.—JZ

Time Sequence of Solar Noise at Different Frequencies

R. Payne-Scott, D. E. Yabsley, and J. G. Bolton (Nature, London, England, August 23, 1947, pp. 256-257).

Solar noise bursts do not necessarily coincide in time or shape when observed on different frequencies. Separate receiving systems for 200 mc, 75 mc, 60 mc, and 30 mc therefore were built and the time of arrival of solar noise at these frequencies was compared.

Low intensity noise at the different frequencies showed no correlation. Correlation between many of the larger bursts indicated that the highest frequency burst arrives first and is followed by the other bursts in the sequence of decreasing frequency with time delays of the order of 2 seconds. Exceptionally high intensity outburst showed long delay times of several minutes duration.—JZ

RF Spectroscopy

B. Bleaney (Physica, the Hague, Netherlands, Vol. XII, Nos. 9-10, pp. 595/605).

In spectroscopy it is of advantage that radio technic permits much more accurate frequency measurements than optical frequency determination, and that single frequency oscillations can be generated at large powers and detected in minute quantities. However, the energy exchange in a transition is very small.

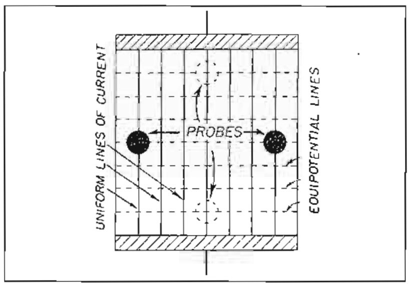
Emission and absorption measurements are feasible. Investigations of lines associated with the magnetic moment of the nucleus in the megacycle range are reviewed. Recently the region of spectroscopy has been extended to molecular spectra situated in the centimeter wave range.

The author reports his experiments with ammonia enclosed in a 1-meter waveguide section. The molecular absorption lines at different pressures were measured. In another series of experiments, a hollow waveguide was used to avoid very long paths.—JZ

Variable-Frequency, Two-Phase Sine-Wave Generator

T. H. Clark and V. F. Clifford (Electrical Communication, September, 1947, pp. 382-383).

A uniform flow of current in a plane resistive sheet generates a series of parallel equipotential lines at right angles to the current flow. If the resistive sheet is rotated around its center, a sinusoidal voltage will be generated between each pair of opposing probes; the two voltages will be 90 deg. out of phase if the probes are situated as illustrated.



Principle of 2-phase sine-wave generator

The resistive sheet consists of commutator segments punched from both conducting and insulating strips—coin silver and acetate tape, 0.005-in. thick—which are interleaved. The whole assembly of laminations mounted between two end bars is compressed between locking nuts. Care must be taken to assure plane surfaces so that the probe brushes can slide smoothly over the resistive sheet.

The commutator can be readily synchronized with any rotating shaft; it generates two-phase voltages of constant amplitude between zero frequency and 60 cycles, and operates for a period of 1000 hours without initial difficulties.—JZ

Evacuation of Electron Tubes

R. Wild and H. Penotet (Le Vide, Paris, France, pp. 252-266, two articles).

The first article is concerned with the properties of various getters, mostly barium alloys. Commercially available getters are listed and their chemical composition is given.

The second article first analyzes the different gases present in the electron tube originating in the glass walls, the metal parts, and the cathode. Vacuum pump mounting and their automatic operation in American and European factories is compared, and the effect of the simultaneous heating of the tube is discussed. Different metals and different getters are studied.

Plan for a Television Station

N. Q. Lawrence (Electronic Engineering, London, England, October, 1947, pp. 322-324).

In the course of a comprehensive program of research and development on television transmitting equipment, the importance and complexity of the operational side of television picture production and their close relation to the engineering features became apparent. Architectural considerations in television station lay-out were therefore studied. A detailed model of a television station was designed to meet the exacting and complex operational demands.

Microwave Telephone Link

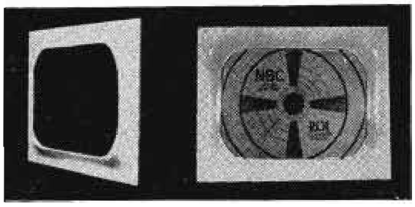
H. R. L. Lamont, R. G. Robertshaw and T. G. Hammerton (Wireless Engineer, London, England, November, 1947, pp. 323-332).

A 57-mile single-channel duplex radiotelephone operating on a wavelength of 3.2 cm has been installed over sea between Rhiv in North Wales and a site near Strumble Head in South Wales.

One parabolic mirror is used for transmitting and receiving signal focusing. The transmitted and received signals are perpendicularly polarized so that they can be separated by slotted diaphragms arranged in the two branches of a circular waveguide system which leads to the receiver and the transmitter, respectively.

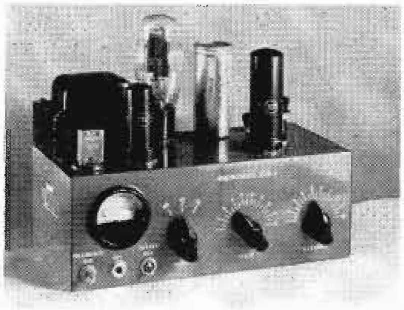
(Continued on page 76)

Parts for Design Engineers



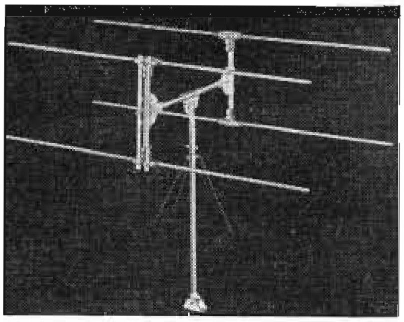
Picture Tube Mask

This combination picture tube mask and protective plate is optical plastic and plate follows the contour of the tube surface. It masks the image with opaque white (or other) finish. The unit permits the picture tube to be installed forward in the cabinet allowing for a wider viewing angle and simplifying cabinet construction. The units are available in sizes for all standard picture tubes.—**Telectro Components, 141 Belleview Ave., Belleview 9, N. J.**



CW Transmitter Kit

The XTR-1 transmitter kit is the first of a line of amateur radio equipment brought out by this company. The kit includes all parts necessary to assemble a CW transmitter, rated at 45 watts input to the final amplifier.—**Micamold Radio Corp., 1087-1095 Flushing Ave., Brooklyn 6, New York.**

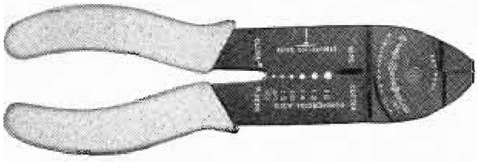


Television Antennas

Designed for broadband coverage of the television spectrum, Camco "Featherlite" antennas are supplied as folded or straight dipoles, with or without reflectors, and as arrays. The antenna-reflector array is designed to give 5 db gain with 15 db rejection of unwanted signals.—**Camburn, Inc., 32-40 57th Street, Woodside, N. Y.**

Cueing Attenuators

This new line of cueing attenuators, with a switch to transfer input to a pair of separate output terminals for cueing, facilitate program switching and fading without increasing the diameter of the control. Any standard Shallcross ladder, bridged T, straight T, or potentiometer may be equipped for cueing action, including units as small as 1¾ in. in diameter. All controls are available with mounting by means of a single-hole 3/8 in.-32 thread bushing or two screws. —**Shallcross Mfg. Co., Collingsdale, Pa.**

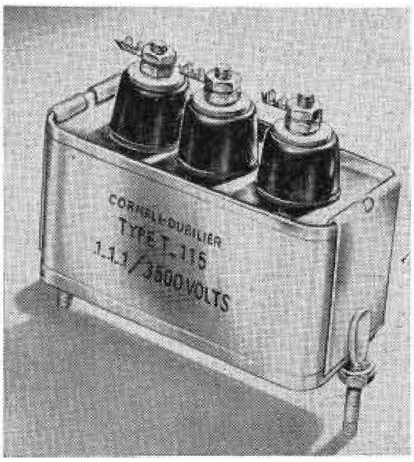


Wire Stripper and Cutter

This pocket-size combination wire stripper and wire cutter covers the range of wire sizes 22 to 10. The tool has shockproof, plastic handles and is provided with accurately sized stripping notches. It is also usable as a wire size gage.—**Aircraft-Marine Products, Inc., 1616 North 4 St., Harrisburg, Pa.**

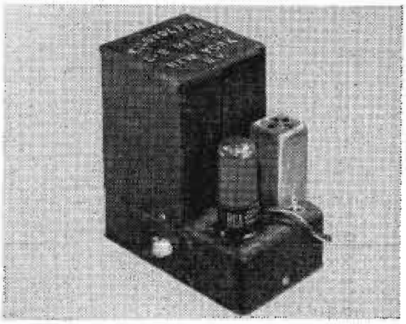
Interference Filters

Furnished in standard heavy cadmium-plated steel surface cabinets, type EB series radio interference filters are intended for continuous-duty service in 1-, 2-, and 3-phase circuits for equipment drawing from 5 to 200 amps., 250 V. ac/600 V. dc. Voltage drop is negligible. The individual filters in each assembly are housed in hermetically sealed, corrosion-resistant metal containers. Noise elimination range of the filter assemblies is from 150 kc to 250 mc.—**Solar Mfg. Corp., 1445 Hudson Blvd., North Bergen, N. J.**



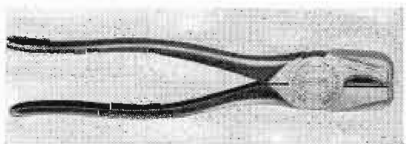
Television Capacitor

An addition to a line of television and high voltage capacitors, type T-115 is a 3 x .1 mfd. capacitor, rated at 3500 V dc working and having dimensions of 1¾ x 3¾ x 2 in. The unit is provided with three high voltage bakelite cone insulated screw terminals with the case common to all sections. The capacitor is impregnated and filled with Dykanol and hermetically sealed in a metal housing.—**Cornell-Dubilier Electric Corp., South Plainfield, N. J.**



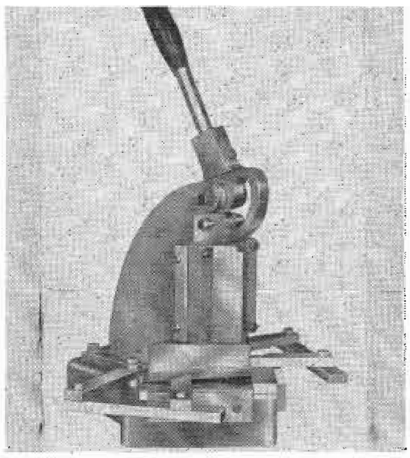
TV Power Supplies

Model 6 kilovolter, for use with 7-in. television picture tubes, will deliver 600 microamps. at 6,000 V dc or 1 ma at 4000 volts. The rf supply has an aircore transformer and an oscillator tube, which operates at a frequency close to the resonant frequency of the transformer secondary (high voltage) winding. The unit is mounted with two screws and connected by means of four wires to the low voltage power supply of the television receiver.—**C-B Manufacturing Co., 412 W. 37th St., New York 18.**



Coaxial Cutting Tool

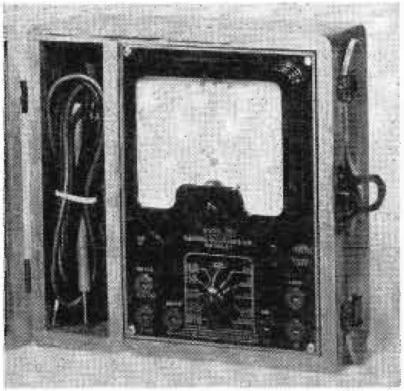
Designed for one-hand operation, this new coaxial cutter operates on a shear principle with a convex blade working against a straight blade. This results in a clean cut and a flattened end, preventing the unwinding of the stainless steel shielding tape on the coaxial tube. Tubes of .375 in. O.D. and .270 O.D. are accommodated. Handles are tempered steel drop forgings and are 8¾ in. in overall length.—**Mathias Klein & Sons, 3200 Belmont Ave., Chicago 18, Ill.**



Notching Tool

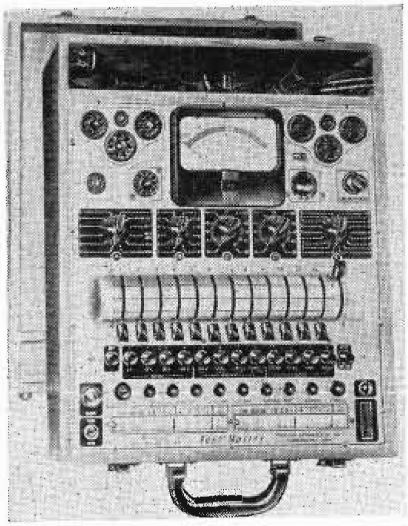
The Di-Acro notcher is a flexible, shearing unit for cutting notches in sheet materials. A 90-degree notch of any size, within the capacity of the machine, can be cut in one operation, either at the corner or in any position along the edge of the sheet. Cutting range extends from light materials such as plastics, fibre, mica, leather and rubber to heavy gages of aluminum, cobalt steel, chrome, molybdenum, etc. Material capacity of the notcher is 16-gage steel plate, maximum notch is 6 in. x 6 in.—**O'Neil-Irwin Mfg. Co., 348 Eighth Ave., Lake City, Minn.**

which is then applied to the equipment under test. The distortion of the wave introduced by the equipment is made visible on an oscilloscope. If driven by 10 volts RMS, the unit will supply an output 3.7 V from peak to peak of a clipped sine wave, 7.4V for a double clipped sine wave, and 3.4 V RMS for a sine wave. **Barker & Williamson, Upper Darby, Pa.**



AC-DC Voltmeter

Model 120 Voltmeter provides a resistance range from 0.2 ohms to 300 megohms in four scales, an ac voltage frequency range from 30 cycles to 1 mc, and a sensitivity of 20,000 ohms per V on dc and 10,000 ohms per V on ac. Six dc voltage ranges are provided from 0 to 600 V, six ac ranges from 0 to 6000 V, four dc current ranges from 0-60 microamps to 0-6 amps., and six db ranges from —4 to 77 db. The instrument is available as open face or portable model.—**Electronic Measurements Corp., 423 Broome St., New York.**



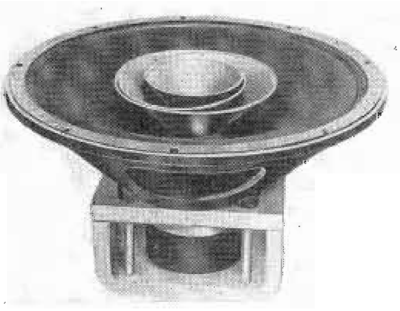
Tube and Set Tester

Series 10-20 "Electronamic Test Master" includes the "Electronamic" tube test circuit and a complete pushbutton operated ac-dc set tester. The special test circuit subjects tubes to appropriately phased individual element potentials which are swept over a complete operational cycle on a sinusoidal time base and include a wide range of characteristic curves. All standard receiving and low power transmitting tubes may be tested. The set tester circuit includes six ac, six dc, and six output voltage ranges from 0-3000 v; four resistance ranges from 0-10 megohms; six dc current ranges from 0-600 microamps to 12 amps; and six db ranges from —2 to +64 db. The unit is available as a portable instrument, for counter or rack mounting—**Precision Apparatus Co., Inc., 92-97 Horace Harding Blvd., Elmhurst, L. I., N. Y.**

Television Monitor

Model M 102 television picture and waveform monitor contains a kinescope amplifier with linear phase shift, and frequency response flat to 3 mc; a bar generator to check horizontal and vertical linearity; a phaseable horizontal and vertical pulse cross for checking synchronizing pulses; a synch. separator; and horizontal and vertical deflection. Resolution is greater than 600 lines. Both, a 10-in Kinescope and a 5-in. oscilloscope are provided. The relay rack cabinet also includes a voltage supply unit, a regulated power unit, and a voltage calibrator for the waveform monitor. The unit operates on 115 V, 50-60 cycles, ac.—**Polarad Electronics Co., 9 Ferry St., New York 7.**

Sound and Recording Equipment

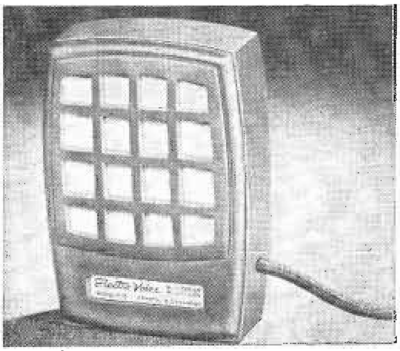


Co-Spiral Speaker

Tru-Sonic model P-52FR co-spiral speaker accomplishes high frequency dispersion with a sperical polar pattern of over 90 degrees. Frequency range is 40 to 14,000 cps. Record motor rumble below 70 cycles has been intentionally attenuated; the 500 cycle "power" band has been emphasized; the response is rising at 2300 cycles and gradually rolling off from 8000 cycles on, to subdue high frequency hash. The unit is supplied in both 12- and 15-in. cone diameters, with either 8- or 16-ohm voice coils. Power input handling capacity is 15 watts.—**Stephens Mfg. Corp., 10416 National Blvd., Los Angeles 34, Cal.**

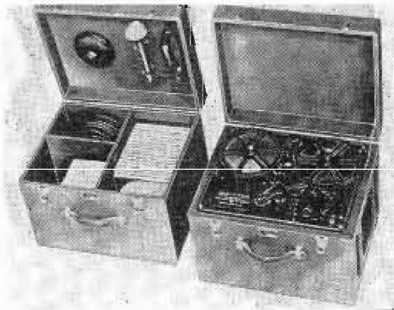
Phono Amplifier

Especially adapted to high-fidelity reproduction from phonograph records, AM or FM tuners, the Knight 20-watt amplifier has less than 2% harmonic and less than 8% intermodulation distortion at rated power output. Frequency response is within ±1 db from 20 to 20,000 cps. Individual tone controls permit boost and attenuation of bass and treble frequencies. Hum is 75 db below rated output, gain is 78 db. Adjustable automatic volume expansion, independent of volume control setting, is provided. Output impedances are 4, 6, 8, and 500 ohms, dual high impedance input is selected by switch.—**Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill.**



Low Cost Microphones

The multi-purpose "Century" series of low-cost die-cast metal microphones is available in a choice of crystal, dynamic, or carbon generating elements. Model 915 (crystal) has an output —50 db and a frequency response of 60 to 7,500 cps. The high-impedance dynamic type has —57 db output and a frequency response of 55 to 7,500 cps. The single-button carbon unit provides an output of 22 db below 6 milliwatts for 10 dynes/cm². Speech response extends from 200 to 4000 cps. with 48 in. cable. A slide-to-talk shorting switch is available on all three types. A slide-to-talk relay control switch and hang-up hook can be furnished for the dynamic and carbon types.—**Electro-Voice, Inc., Buchanan, Mich.**



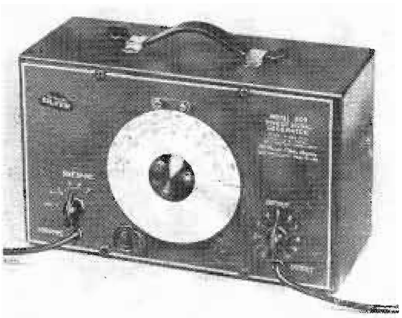
Portable Tape Recorders

Four models of portable Magnetape recorders are being offered, each consisting of a twin set of carrying cases. One case holds the self-contained recording and playback unit, the other a sensitive microphone, extension line cord, accessories, and space for 25 reels of tape. Model TP-800-C has a frequency range up to 12,500 cycles, with less than 3% distortion. Model TP-800-D, in addition to the extended frequency range, is provided with instantaneous start-stop clutch mechanism for dictation and conference recording. A simple inverter adapts the recorders for 6-V automobile operation. The units operate in any position and are not affected by vibration.—**Magnephone Div., Amplifier Corp. of America, 398 Broadway, New York 13.**

Cueing Device

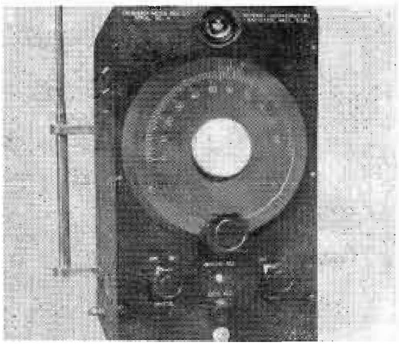
Primarily designed for radio broadcasting studios, this automatic cueing device permits the record to stop, and continue instantly at the correct speed, when the starting button is pushed. A magnetically controlled unit raises the record and pickup arm allowing the turntable to continue at constant speed. The device, which is set prior to the broadcast, is available as an attachment.—**Duotone Co., 799 Broadway, New York.**

New Lab and Test Equipment



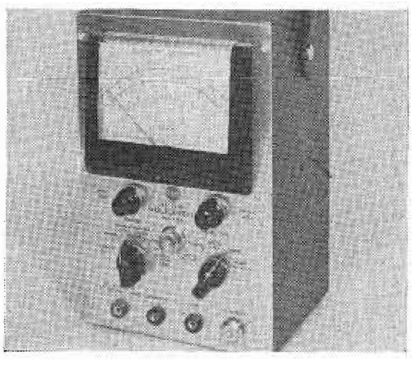
FM-TV Sweep Generator

Designed to permit rapid, visual alignment of FM and television rf, IF, and video amplifiers, Model 909 sweep generator covers a center-frequency range from 2 to 226 mc in three bands, without requiring band switching. FM sweep is adjustable from 40 kc to over 9 mc, by a panel control, while output may be adjusted from zero to ½ volt maximum. Synchronization of the scope for alignment is at the power line frequency, or at twice the power frequency by means of a saw-tooth synch. voltage, provided by the unit.—**McMurdo Silver Co., Inc., 1240 Main St., Hartford, Conn.**



Frequency Meter

Designed for transmitter frequency measurements in the 72-76 and 152-162 mc bands, Model S-7 frequency meter has an accuracy in either band of .005%, or .0025% where minor precautions are taken. A whip antenna mounted at the side furnishes coupling to the transmitter, and also serves as carrying handle. Charts supplied with the instrument show deviation from assigned frequency. The unit is available in single or two specified frequencies in either or both bands. It operates from 117 V ac or dc. Weight is 15 lbs.—**Browning Laboratories, Inc., Winchester, Mass.**

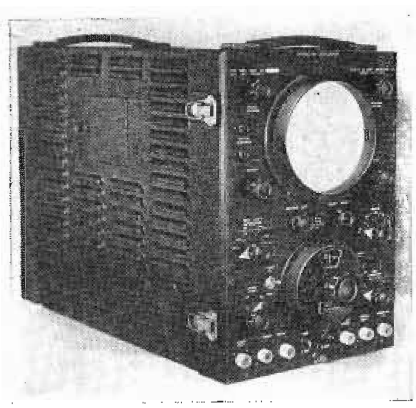


Battery Volt-Ohmeter

The RCA battery VoltOhmyst, RCA Type WV-65A, is a self-contained, light-weight vacuum tube voltmeter which operates independent of any external power source. Used with the RCA crystal probe, the WV-65A can be used to measure voltages up to 100 mc. The neon lamp mounted on the front panel flashes on and off whenever the selector switch is in "+ voltage", "— voltage", or "ohms" position, indicating that the instrument is in operation. Including batteries, the new meter weighs 9 lbs., measures 9½ high, 6¼ wide, and 5½ in. deep—**RCA Victor, Camden, N. J.**

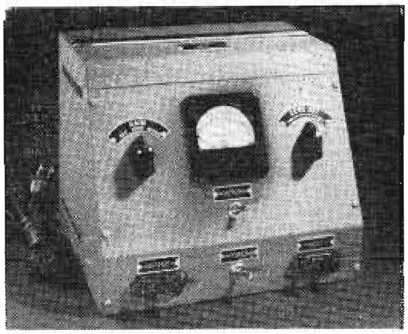
Wheatstone Bridges

Two production Wheatstone bridges incorporate improvements. A standard portable model is complete with batteries and hardwood case. Another model has Murray and Varley loops. The indicator is a moving coil galvanometer with a pointer dial having 15 millimeter divisions each side of zero, and with adjusting knob and safety clamp. Sensitivity of the galvanometer is 1 microamp. per millimeter. Separate binding posts are for use with an external galvanometer.—**Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.**



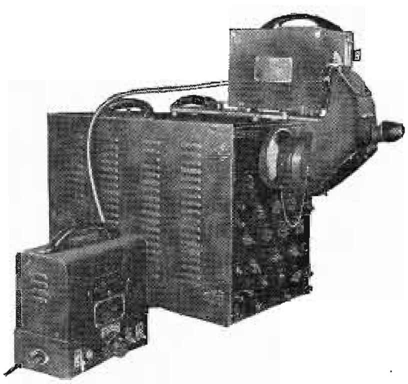
Cathode-Ray Oscillograph

Du Mont Type 256-D cathode-ray oscillograph provides a variety of sweep lengths from 4 to 4500 microseconds, accurate delay circuits, crystal-controlled markers, a variable internal trigger generator, and a wide-band video amplifier. Calibration of its own sweep circuits is possible with the instrument. A type 5CP-A cathode-ray tube with 4000 V accelerating potential is used as indicator. The response of the amplifier is down 3 db at 8 mc. and is down 6 db at 11 mc. Deflection sensitivity is 1 V rms/in. Power requirements of the unit are 115 V, 60 cycle.—**Allen B. Du Mont Labs., Inc., 1000 Main Ave., Clifton, N. J.**



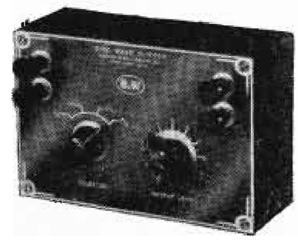
DC Amplifier

The "Microsen" amplifier measures and amplifies voltage impulses as low as 0.2 microvolts, with high stability in a compact laboratory instrument. These signals, such as from ionization gages, photoelectric cells, thermocouples, or a Wheatstone bridge are linearly amplified by means of an electromechanical balance. The input circuit consists of a moving-coil galvanometer with a metal flag attached, which moves between the coils of a tuned-grid, tuned-plate oscillator. The motion of the flag loads and unloads the tank circuits with consequent variation in the input current of the oscillator. Output is stabilized by means of a feed back circuit. The unit has low input resistance, adjustable gain, and a mechanical zero adjustment.—**Manning, Maxwell & Moore, Inc., Bridgeport 2, Conn.**



Oscillograph Recording Camera

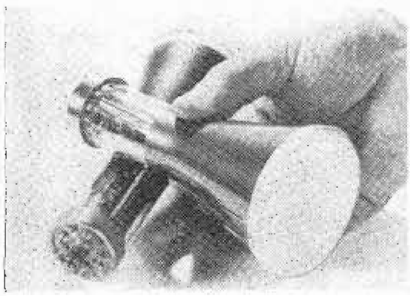
Du Mont Type 31 oscillograph-record camera, is applicable to all standard 5-in. scopes, serves for single-frame exposures of stationary patterns as well as for continuous recording of constantly changing phenomena. For continuous recording, the film speed is variable from 1 in. per minute to 5 ft. per second. A viewing port permits simultaneous viewing and recording.—**Allen B. Du Mont Labs., Inc., Instrument Div., Clifton, N. J.**



Audio Test Generator

When used in conjunction with an audio oscillator and an oscilloscope, the "Sine Wave Clipper" is useful in examining frequency and transient response of audio circuits. Driven by any standard audio oscillator, the instrument provides a clipped sine wave,

New Types of Electron Tubes

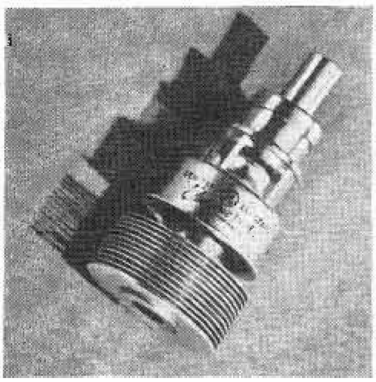


CATHODE RAY TUBE

Providing improved electron-optical characteristics at the screen edge, type 3QP1 cathode ray tube for oscilloscope use has a flat face and is 6 1/8 in. long with a face diameter of 2¾ in. The tube utilizes electrostatic focus and deflection and has improved cross-talk characteristics between deflection-plate pairs. Rated heater drain is 0.3 amps. at 6.3 V. Under typical operating conditions, Eb_2 is 800 V dc, Eb_1 300 V, Eg (cut-off) —35 V dc. Deflection factor for D1-D2 is 168 V per inch and for D3-D4, 105 V per inch. To produce 3 ft-lamberts on a 2 in. x 2 in. raster, a modulation of 25 V max. is required. — **North American Philips Co., Inc., 100 W. 52 St., New York 17.**

MINIATURE TUBES

Three new types have recently been added to RCA's miniature tube line. RCA-1U5 is a diode-pentode for use in portables receivers and is intended to replace the 1S5 in new equipment design. It utilizes a different basing arrangement and an improved structure which reduces any tendency toward microphonic effects. RCA-6BJ6 is a remote-cutoff amplifier pentode particularly useful in mobile equipment where heater current drain is an important consideration and in ac/dc FM and AM receivers. It has a 6.3 V, 150ma heater, high transconductance, and low grid-plate capacitance. RCA-12AL5 is a high-perveance twin diode like the 6AL5, but has a 12.6 V, 150ma heater, and is intended specifically for use as a ratio detector in ac/dc FM receivers. In circuits utilizing wide-band amplifiers, the low internal resistance of thhe 12AL5 makes it possible to obtain increased signal voltage from a low-resistance diode load.—**Tube Dept., RCA Victor Div., Harrison, N. J.**



"LIGHTHOUSE" TUBE

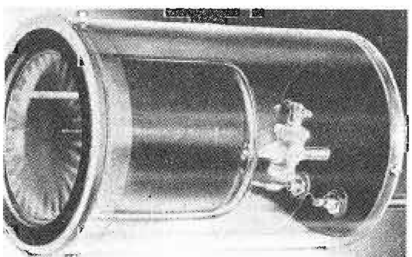
Designed for commercial radar, FM and television, type GL-5648 forced-air cooled, uhf triode performs at frequencies up to 2,500 mc under full plate input. Cathode voltage of the tube is 6.3 V. Under class C telegraphy conditions, the maximum dc plate voltage is 1000, maximum plate input is 100 watts. When used as a grid-separation oscillator at 500 mc a power output of 25 watts can be obtained. Grid-cathode capacitance of the tube is 7.25 mmfd.; grid-plate, 1.95 mmfd.; cathode-plate, 0.035 mmfd.—**Tube Div., General Electric Co., Electronics Dept., Schenectady, N. Y.**

VHF POWER PENTODE

RCA-5618 (tube on left in illustration below) is a low-drain, filament-type, miniature pentode designed for use in doubler and tripler stages of mobile FM transmitters in the 152 to 162 mc band. It has a maximum plate dissipation of 5 watt and can be operated with full input up to 100 mc. In class C telegraph and FM telephone service at 80 mc, the 5618 can deliver a useful power output of 4.5 watts at a plate voltage of 300 with 0.3 watt driving power. The filament is of the mid-tapped, instant-heating type permitting operation at either 6 or 3 V with less than 1.5 watts.—**Tube Dept., Radio Corp. of America, Harrison, N. J.**

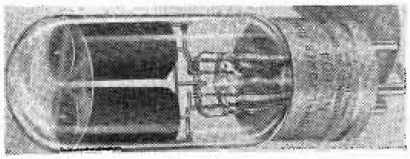
VACUUM PHOTOTUBES

Designed to provide a 100% modulated carrier for use with a conventional ac amplifier, RCA-5652 (tube on right in illustration above) twin-type vacuum phototube is useful in applications, such as facsimile, which require mechanical means for modulation. The tube has two flat, photoemissive electrodes, which alternately serve as cathode and anode on successive half-cycles, when operated on ac. A balancing capacitance permits adjustment of carrier output to zero or some predetermined level with no incident light. By orienting the position of the electrodes it is possible to balance their impedance characteristics. The tube has high sensitivity to blue radiation and no response in the infra-red region. For light-operated relay use, the RCA-5653 vacuum phototube has been brought out. The tube has S-4 response and is useful, where a wide range of luminous sensitivity can be tolerated. — **Tube Dept., Radio Corp. of America, Harrison, N. J.**



GEIGER TUBE

Designed for satisfactory life of 109 counts, type 410-A Geiger tube is available with window thicknesses from 0.7 mg. to 2.3 mg. per sq. cm. The unsupported mica window is 2½ in. in diameter, overall width is 3½in., length 5 in. The tube is especially suitable for Alpha and soft Beta radiations. In use it has registered 25% of total disintegrations for alpha particles from uranium. For soft Beta radiation such as from C^{14}, FE^{59} and S^{35} efficiency was 36% of total disintegrations.—**Cyclotron Specialties Co. Moraga 11. Calif.**

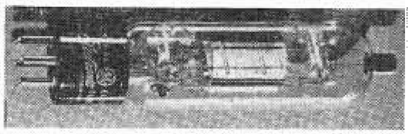


INDUSTRIAL RECTIFIER

Combining two half-wave gaseous rectifiers in one envelope, NL-604 is a quick-heating, full-wave rectifier especially useful for industrial rectifier and motor speed control applications. The tube is rated for 250 V dc output at 2.5 amps. with a peak current of 10 amps. Maximum peak inverse voltage is 900; filament voltage is 2.5 current 11.5 amps. The gas and mercury filling gives quick starting and uniform characteristics over wide temperature limits. — **National Electronics, Inc., Batavia Ave., Geneva, Ill.**

RECEIVING TUBES

Miniature RCA-types 6AV6 and 12AV6 are twin-diode high-mu triodes for combined use in detector and avc circuits and as resistance-coupled audio amplifier stages. The triode has a transconductance almost 50% higher than previous similar types having an amplification factor of 100. RCA-12AX7, a companion tube to the miniature series, is a small, high-V twin-triode amplifier with characteristics similar to Type 6SL7-CT, except that it has an amplification factor of 100. It utilizes the small-button 9-pin base. Operation is from either a 6.3- of 12.6 V supply, because of its mid-tapped heater and separate terminals for each cathode. RCA-6S8-GT triple diode triode combines three diodes and a high-mu af triode in one bulb. One of the diodes has its own cathode, while the other diodes and the triodes share a common cathode. This arrangement provides for detection and amplification of either AM or FM signals without necessity of switching detector circuits.—**Tube Dept., Radio Corp of America, Harrison N. J.**



ELECTROMETER TUBE

Designed primarily for measurement purposes, the 5674 "split-anode" electrometer tube combines high current sensitivity with operating stability, when a Wheatstone bridge circuit is utilized. Control grid and plate of the tube are cut in two and connected to function as a pair. This permits measurement of the differential response between the two halves of the tube, independent of random fluctuations. When a 10^{11} ohm grid resistor and 10^{-10} ampere-per-millimeter galvanometer are used, sensitivity of approximately 75,000 millimeters per volt is obtainable. The thoriated tungsten filament operates at 3.8 V and .09 amps. Maximum plate voltage is 6 V, maximum plate current 20 microamps. per plate.—**Tube Div., General Electric Co. Schenectady, N. Y.**

7-INCH PICTURE TUBE

Sylvania Type 7GP4 is an electrostatic focusing and deflection type cathode ray tube particularly designed for use in smaller size television receivers. When used at recommended voltages the deflection sensitivity is better than for some smaller tubes, thus permitting a larger image with no increase in amplifier gain. Type 7GP1 utilizes the green P1 medium persistence phosphor and is designed for use in large size oscilloscopes. Heater voltage is 6.3, current 0.6 amps. Maximum anode voltage is 4000, focusing anode voltage 1500, grid circuit resistance 1.5 megohms. The deflection factor for the vertical plates is 108 V dc per inch, for the horizontal plates 90 V per inch.—**Sylvania Electric Products Inc., Emporium, Pa.**

News of the Industry

IRE Awards Honors

The Board of Directors of The Institute of Radio Engineers has made the following awards for the year 1948:

To L. C. F. Horle for "his contributions to the radio industry in standardization work, both in peace and war, particularly in the field of electron tubes, and for his guidance of a multiplicity of technical committees into effective action" the Institute's Medal of Honor.

To S. W. Seeley, the Morris Liebmann Memorial Prize for "his development of ingenious circuits related to frequency modulation."

To W. H. Huggins for his paper on "Broadband Noncontacting Short Circuits for Coaxial Lines," the Browder J. Thompson Memorial Prize.

The following members have been elected to the grade of Fellow by the Board of Directors:

M. W. Baldwin, Jr., Bell Telephone Laboratories
L. H. Bedford, 16 Heathgate, London, England
H. S. Black, Bell Telephone Laboratories
R. M. Bowie, Sylvania Electric Products, Inc., Flushing, N. Y.
D. E. Chambers, General Electric Co., Scotia, N. Y.
J. B. Coleman, RCA, Camden, N. J.
A. Earl Cullum, Jr., Dallas, Texas
R. B. Dome, General Electric Co., Bridgeport, Conn.
B. S. Ellefson, Sylvania Electric Products, Inc., Bayside, N. Y.
J. J. Farrell, General Electric Co., Schenectady, N. Y.
H. C. Forbes, Colonial Radio Corp., Buffalo, N. Y.
E. W. Herold, RCA Laboratories, Princeton, N. J.
William Hewlett, Hewlett-Packard Co., Palo Alto
J. A. Hutcheson, Westinghouse Electric Corp., East Pittsburgh
J. E. Keto, Aircraft Radio Laboratory, Dayton, Ohio
N. E. Lindenblad, RCA Laboratories, Port Jefferson, N. Y.
Knox McIllwain, Hazeltine Corp., Little Neck, N. Y.
D. W. R. McKinley, National Research Council, Ottawa
L. A. Meacham, Bell Telephone Laboratories, Murray Hill, N. J.
David Packard, Hewlett-Packard Co., Palo Alto
J. R. Pierce, Bell Telephone Laboratories, New York, N. Y.
Albert Rose, RCA Laboratories, Princeton, N. J.
Arne Schleimann-Jensen, Stockholm, Sweden
R. E. Shelby, National Broadcasting Co., New York
J. E. Shepherd, Sperry Gyroscope Co., Great Neck, N. Y.
D. B. Smith, Philco Corp., Philadelphia, Pa.

"Surplus" Distributors Washed Up March 1

War Assets Administration has notified distributors of surplus electronic equipment that sales through them will be terminated March 1, 1948. Even though the distributors now have a rather large inventory of electronic equipment comprising a variety of end radio-electronic products, radio components and vacuum tubes, the WAA stated that disposal progress has indicated the present distributor inventories will be largely depleted by March 1.

Should any inventory remain in the hands of distributors after the March 1 deadline, WAA said, it will be disposed of by donations to educational institutions in line with the program now applying to electronic inventories still in possession of WAA. It is anticipated, War Assets Administration added, that there may be no opportunity to purchase electronic equipment after the distributor disposal program has been terminated.

One of the seven hilltop relay stations in the 220-mile stretch between New York and Boston on the Bell System TV relay

GE Equips WTVO

It is expected that Detroit's television station WTVO will get a test signal on the air by the second quarter of 1948. The station will be completely equipped by General Electric and will have one of the highest powered television transmitter installations yet authorized by FCC. The station will operate on Channel 2. Included in the GE equipment which covers antennas, studio cameras, control consoles and remote pickup equipment will be a combination television and frequency modulation antenna system, consisting of a three-bay super turnstile television antenna, above a four-bay FM circular antenna, both mounted at the top of a 415-ft. steel tower. Studio apparatus includes two of the new General Electric 35 mm Synchrolite projectors, two 16 mm projectors of the same kind, and a special slide projector for station identification and other announcements.

ATT Preparing to Expand Mobile Service

Plans for a considerable expansion of its mobile radio-telephone service have been completed by the American Telephone & Telegraph Co. Applications have been filed with FCC for authority to install stations in Baltimore, Chicago, Cincinnati, Columbus, Denver, Houston, Milwaukee, additional equipment in New York, Philadelphia, Pittsburgh, St. Louis, Salt Lake City and Washington. The limited two-way vehicular service that has been operated for some time in New York and Boston for emergency use by certain public utilities companies, is to be expanded so that similar equipment may be used on all sorts of privately-owned cars, trucks, buses and harbor and river craft operating within the areas served. Types of vehicles to be equipped include ambulance services, armored car services, burglar and fire alarm services, construction contractors, doctors, express companies, food distributors, newspapers, oil companies, pick-up and delivery services serving department stores, public service companies, trucking companies and railroad switch engines. The service will operate in the frequency range between 152 and 162 mc with fixed transmitters of about 250 watts power and mobile units of about 15 watts power. Eventually, it is planned to expand the service to include a long list of key cities as far West as San Francisco and Seattle and as far South as Miami in Florida.

New York-Boston Radio Relay

A Bell System radio relay is now in experimental operation between New York and Boston. At present it is the longest television network and may soon bring television programs to a viewing audience in the neighborhood of 25 million people. Seven hilltop relay stations between these two cities are required to complete the circuit. The radio distance is 220 miles, and there are eight jumps ranging in length from eleven to thirty-five miles.

Each relay station has four antennas; two are for repeat in one direction and the other two for repeat in the other direction. The antennas are of the metallic lens type which focus the

(Continued on page 73)

CONVENTIONS AND MEETINGS AHEAD

January 26-30—American Institute of Electrical Engineers, Winter General Meeting, Pittsburgh, Pa.

January 30-31—Instrument Society of America, New York Section Regional Conference, Pennsylvania Hotel, New York.

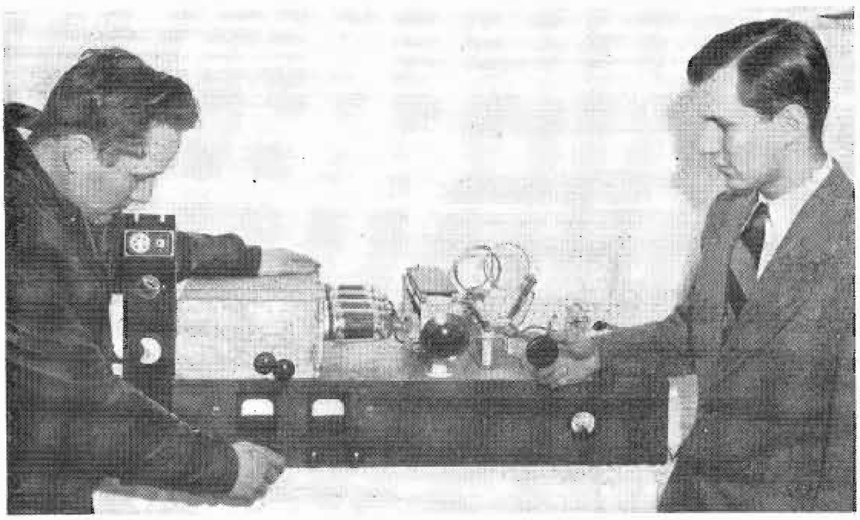
March 22-25—IRE Convention and Radio Engineering Show. Grand Central Palace and Hotel Commodore, New York.

April 24—Regional Television Conference, IRE Cincinnati Section, Cincinnati, Ohio.

May 10-15—Radio Parts and Electronic Equipment Shows, Inc. Show, Hotel Stevens, Chicago.

May 17—National Association of Broadcasters, 26th Annual Convention and Engineering Conference, Los Angeles.

SIMPLIFIED SINGLE SIDEBAND TRANSMITTER



Dave Thompson and Robert D. Smith of Stanford University Radio Club, with the final amplifier section of the newly developed single sideband transmitter

Devised late last year as the result of a research program sponsored by the Air Materiel Command's Watson Laboratories in Red Bank, N. J., a new type of considerably simplified single sideband transmitter has been developed by Oswald G. Villard, Jr., member of the electrical engineering faculty of Stanford University, Palo Alto, Calif. The new transmitter, in operation in the amateur frequency bands since last October, requires only one stage of high power amplification, and is said to be so simple that anyone can build the equipment. It requires no special components. Simplicity of the unit is expected to open up single sideband operation for widespread use where its principle of operation will multiply the number of channels available, reduce required power by one-third, permit duplex operation and help to eliminate selective fading. The system is viewed as particularly valuable for police, aviation and point-to-point services.

Instrument Men Meet

"Electrical Methods in Industrial Instrumentation" will be the subject of a two-day regional conference of the New York Section of the Instrument Society of America, to be held on January 30 and 31, 1948 at the Pennsylvania Hotel, New York City. R. R. Batcher, of Electronic Industries and Instrumentation is (acting) president of this section. Of interest to laboratory men and technicians in the communication field is a one-day short course on electrical instrument maintenance and repair with practical demonstrations of repair technics.

Capacitron to Jefferson

Jefferson Electric Co., Bellwood, Ill., has purchased the Capacitron Co., Chicago, manufacturer of oil-filled and electrolytic capacitors, AC motor starting capacitors and Ballastrons for power factor correction. The capacitron production is to be continued and enlarged.

Edison Medal to Slepian

The Edison Medal for 1947, one of the nation's top engineering honors for meritorious achievement in electrical science, has been awarded to Dr. Joseph Slepian, associate director of the Westinghouse Research Laboratories. Dr. Slepian was selected as the 37th winner of the Medal "for his practical and theoretical contributions to power systems through circuit analysis, arc control, and current interruption."

Code Signal Typewriter

An electronic converter designed to translate radio code signals directly to typewritten messages has been developed by Bennett and Langmuir Development Corp., Mamaroneck, N. Y. The unit receives code signals and operates into an IBM Electromatic or an Underwood electric typewriter attaining speeds of 60 to 75 words per minute.

Radio teletype requires special transmitting and receiving equipment at both ends of the circuit. A special 5-unit code must be used, i.e., each letter is made up of a unique positioning of units, thus requiring the same amount of transmission time. A considerable portion of the world's radio circuits is equipped for transmission and reception of Morse International code only. For this reason, key radio centers have a need for code converters to monitor outgoing Morse signals and thus provide permanent records for their legal departments. The United Press headquarters in New York uses two such units.

The Morse Code Printer itself is capable of high word speeds, but the limit is in the electric typewriters now available. This printer can also be used to translate conventional codes to the 5-unit radio teletype code for retransmission to another point. The printer consists of two standard 8¾ in. rack panels for easy mounting. It can operate from a tone keyer, and uses about 30 tubes to accomplish the change-over.

TBA Clinic Theme: Television is here!

The Dec. 10 TBA television clinic at the Waldorf-Astoria honored two television engineers as having contributed most to the advancement of television for the past year. One award went to Frank Back who invented the Zoomar lens. Considerable savings in dolly and boom apparatus, as well as operators in studio production are due to this important development in camera technics.

Captain Bill Eddy, Television Director for WBKB, Chicago, was awarded the other honor for his work in the development of the Chicago-Southbend, Indiana, radio relay which allowed telecasting of the Notre Dame football games during the past season. This 100-mile radio relay has 3 repeater stations and will be used shortly to link WBKB and the new Southbend TV station. Eddy announced for the first time that rates on the network will be $40 per hour of program delivered to the station. The link will operate on a 40-hour per week basis.

Another highlight of the clinic was the showing of a film which was made directly from a TV screen. Television Productions, Inc., shot the TV screen with a breadboard model camera and had the processed film ready for theatre television or reshipment to other TV stations in 66 seconds! The projected film was remarkably clear of fuzziness or banding.

Other speakers included N. H. Swanson WMAR, G. E. Markham WRGB, J. D. McLean WPTZ, R. E. Shelby WNBT and Scott Helt WABD.

NAB Meets May 17

The National Association of Broadcasters is to hold its 26th annual convention in Los Angeles during the week of May 17. The first two days of the conference are to be devoted to an engineering conference under the guidance of the NAB Engineering Committee. Beginning with the New Year, NAB activities now centered in New York and Los Angeles offices are to be moved to Washington headquarters. The Association has maintained the Los Angeles office for two years; the New York offices have been in operation since 1942.

"News" Readies TV

New York's first newspaper-owned television station, to be operated by "The Daily News", is to use RCA equipment. The contract has been signed for a 5-kw RCA television transmitter and associated pick-up and relay equipment. The station has been assigned the call letters WLTV and will operate from the Daily News Building on channel 11 (198-204 mc). It is expected that the station will go on the air with test patterns early next spring.

Telicon Becomes Telicor

Telicon Corp., 851 Madison avenue, New York, mas made a slight change in its corporate style. Hereafter the company is to be known as Telicor Corp. to avoid conflicting with GE's Telechron clock designation.

WASHINGTON

★ ★ ★ **Latest Electronic News Developments Summarized by Tele-Tech's Washington Bureau** ★ ★ ★

FCC DEEMED CERTAIN TO ELIMINATE TELEVISION CHANNEL NO. 1—Because of slashing attacks at the public need value of television contrasted with police, highway maintenance and other general mobile services which feel they are starved for frequencies in recent week-long hearings before the FCC, Commission is certain to uphold proposed finding of eliminating Television Channel 1 so as to give the entire six megacycles to these safety and mobile radio services. Latter, of course, are growing by leaps and bounds and frequency allotments of sufficient operational area must be given them in near future. Mobile Radio services and special industry radio systems are really at present in embryonic status, in opinion of many observers, and present operations are on experimental basis and will be greatly expanded when FCC gives "green light" for regular public service licenses.

HOPE OF RECARVING SPECTRUM SPACE MAY RESULT—Television, FM broadcasting and the new general mobile and industrial radio services out of this hearing may receive benefits in a larger share of the spectrum as the result of views expressed about the abundance of frequencies assigned to the Federal Government through the planning activities of the Interdepartment Radio Advisory Committee. While there have been no public disclosures, TELE-TECH'S Washington Bureau has learned from highly authoritative government sources that the resurvey of the government use of frequencies has been commenced by IRAC and the Armed Services. It was learned that the Joint Communications Board, composed of the Signal Corps, Naval Communications and Air Forces, has launched a comprehensive study of the armed forces' spectrum space with the aim of conserving frequencies and already a joint operation by the three services of radioteletype networks has been commenced that could well eventuate in returning frequencies back from governmental usage to civilian private services.

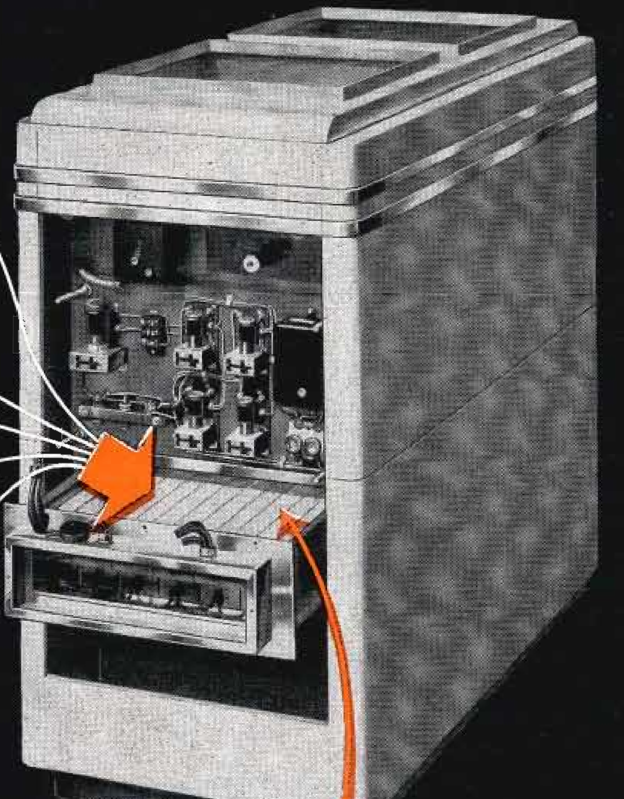
MOBILE SERVICES' MUSHROOM-LIKE EXPANSION—Pattern for regular radio public service in the general mobile radio service was slated for speedy formulation by FCC after week-long hearings during second week of December with determination of frequencies for respective industries and organizations—telephone companies, limited common carriers, taxicabs, bus and truck radio systems and miscellaneous noncommon carrier groups. Public need and safety aspects of proposed services formed major measuring-stick of Commission. Size of mobile services illustrated by latest FCC figures: taxicabs, 865 land stations and 22,365 mobile units; telephone companies, 110 land stations and 7500 mobile units in urban mobile service and 114 land stations and 4253 mobile units in highway service limited common carrier, 50 land stations and 2226 mobile units; bus systems, 10 land systems and 240 mobile units; and truck systems, one land station and 300 mobile units.

FM BROADCASTING HAS BOOMING PROSPECTS—Network telephone program wire facilities and radio relay systems are imperative for FM broadcasters to establish networks and FM Association has launched drive to present problem to FCC which in turn has called in telephone companies to evolve most suitable FM network program rates. Optimistic outlook of FM broadcasting illustrated by prospect that within the next year the investment in FM broadcasting facilities by radio stations will amount to $100 million and the distribution of FM receivers will bring manufacturers gross sales revenues of $400 million in 1948.

PETROLEUM INDUSTRY GEARS SELF FOR BIG RADIO SYSTEMS' PROGRAM—Formation of new central committee on radio facilities by American Petroleum Institute, composed of top executives of oil companies, augurs widespread use of radio in practically every phase of the petroleum industry's operations. Another activity just launched by petroleum industry in radio facilities' expansion is an API Radio Technical Committee for Marine Services to handle the frequency and equipment standardization matters for petroleum tankers on the high seas and inland waters. F. W. Littell of Shell Pipeline Co. of Texas and J. A. Polhemus of Standard Oil Co. of California are mainsprings in formation of central committee. Many expanded uses of radio projected—growth of geophysical radio, radiotelephone and telegraph in remote drilling fields with drilling contractors likely to install 300 or more transmitters in next year, pipeline radio systems to supplement oil companies' own wire telephone systems, radio-equipped pipeline patrol planes, radar installations on tankers and even VHF radio uses in petroleum laboratories in experiments for conversion of oil among many uses contemplated.

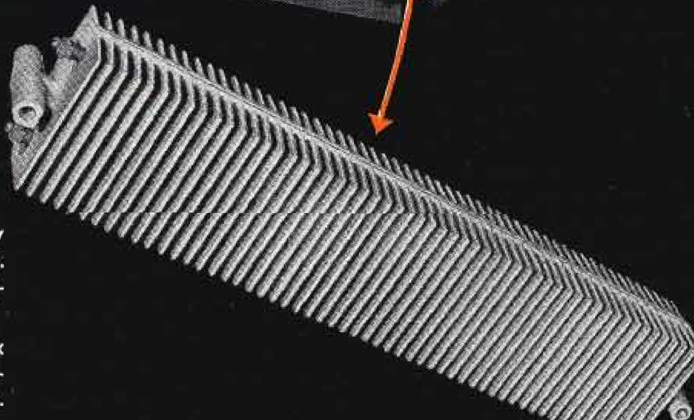
ROLAND C. DAVIES
Washington Editor

Fireless Furnace



Heats Homes the Modern Way with

NICHROME*



This new, fireless home-heating furnace, manufactured by Electromode Corporation, heats a house noiselessly by electricity. No dust, no ashes . . . no fuel storage tanks, no elaborate installations.

The furnace, which is only 40" x 26½" x 58", contains six heating elements, each consisting of an insulated NICHROME resistor wire in metal sheath, embedded in a finned aluminum casting. A master thermostat inside the house controls two of the units. The four remaining units are controlled from exterior thermostats set at various temperatures. As outside temperature falls, additional heating units are cut "in" as the various thermostat settings are reached; conversely, when outside temperature rises, units are cut "out". Thus maximum heating flexibility is combined with economical operation. Room temperatures vary only about 3° from floor to ceiling.

In developing this heating equipment, the Electromode Corporation encountered the problem of providing electrical heating elements efficient enough to heat an entire home, yet sufficiently compact to fit into a space-saving outer cabinet. They selected NICHROME as the resistance wire for this exacting job, in order to assure top-level performance and a life-time of trouble-free operation.

Whatever your product, if it requires a resistance element combining high efficiency with long life, specify NICHROME. And remember, there are more than 80 Driver-Harris electrical resistance alloys specifically designed to fill the numerous requirements of the Electrical and Electronic Industries . . . get in touch with us for expert advice.

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PERSONNEL

Edward E. Lewis has been elected president of Colonial Radio Corp., Buffalo, N. Y. He has been serving as an independent industrial consultant for Sylvania, of which Colonial is a wholly owned subsidiary since 1945, was elected executive vice president of Colonial in 1947.

J. K. Poff has been promoted to general sales-service engineer for both manufacturer and jobber divisions of the Astatic Corp., Conneaut, Ohio. He was formerly service engineer of the company's jobber division. Coincidentally, William Schmid has been appointed assistant engineer.

Allan W. Parkes, Jr. has been appointed head of the field engineering and sales department of the Aircraft Radio corp., Boonton, N. J. He joined Aircraft in 1927.

Captain L. B. Blaylock, U. S. Navy (retired) has been appointed director of the Radio Division of the Federal Telephone and Radio Corp., Clifton, N. J. He was formerly in charge of the Research and Design Section, Radio Division, Bureau of Ships, Washington.

Albert R. Hodges has joined the patent department of Stromberg Carlson, Rochester, N. Y. He has served with the Airborne Instruments Laboratory, Mineola, N. Y. and in electrical and engineering capacities for General Electric, Farnsworth and other companies.

George W. Little, chief of research and electronic development of the Maico Co., Inc., Minneapolis, manufacturers of audiometers and hearing aids, has been elected vice-president of the company.

Robert L. Coe has been appointed to head up the staff which will operate the New York "Daily News" television station scheduled to go on the air early in 1948. He has been chief engineer of KSD-TV, St. Louis. At the same time, Clifford E. Denton has been made operations manager and B. O. Sullivan commercial manager.

Kay Enlarges

Kay Electric Co., makers of Mega-Sweep and Mega-Match equipment, has moved into new and enlarged quarters. The new address is Maple Avenue, Pine Brook, New Jersey.

AUDIO TRANSFORMERS *for* UNIFORM RESPONSE / LOW DISTORTION IN 3 FREQUENCY RANGES

Write for Catalog showing complete new stock line

Full Frequency Range

30 to 15,000 Cycles, provides uniform response over this entire band with ± ½ db up to 10 watts of audio power, within ± 1 db over 10 watts. Standard RMA impedances. Hum balancing coil structures and nickel alloy shielding. Included are Input, Output, Driver, and Modulation Transformers; Modulation Reactors. *Sealed in Steel* construction, stud mounting, with pin-type terminals.

Public Address Range

50 to 10,000 Cycles, frequency response within ± ½ db up to 10 watts of power, within ±1db over 10 watts, throughout this range. Secondary impedances match 600 and 150-ohm lines, 16, 8 and 4-ohm reproducing systems. Listed are Driver and Output Transformers. *Sealed in Steel* construction, flange mounting, with solder lugs or wire leads.

Communications Range

200 to 3,500 Cycles, affords response with variations not exceeding ± 1 db over the range of voice frequencies. For use with 600 or 150-ohm lines. Input, Output, Driver and Modulation Transformers offered. *Sealed in Steel* construction, flange mounting, with wire leads or solder lugs.

CHICAGO TRANSFORMER TRADE MARK REG.

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NEW BOOKS

Higher Mathematics for Students of Chemistry and Physics

With special reference to practical work. By J. W. Mellor, D.Sc., F.R.S., published by Dover Publications, New York City, 1946, 641 pages, $4.50.

This text is an unusual approach to mathematics; its concepts and methods are closely interrelated with laws of physical chemistry, chemistry and physics. It is a competent representation of several branches of mathematics selected for the student of these subjects.

The chapter on differential calculus contains a section on the gas equations of Boyle and van der Waal; while the chapter on functions with singular properties discusses hydrates in solution and pv-curves. Analytical geometry, integral calculus, infinite series, numerical equations and differential equations, Fourier's theorem, probability and theory or errors, calculus of variations, and determinants are treated in separate chapters. A collection of formulas and reference tables are appended.

Guide to the Literature of Mathematics and Physics

Including related works on engineering science by Nathan Grier Parke III, Research Associate in Physics, Research Laboratory of Electronics, M.I.T.; published by McGraw-Hill Book Co., Inc., New York, 1947, first edition; 205 pages, $5.00.

Part I of the book entitled "General Considerations", discusses reading techniques, principles to be followed when studying, and considerations of importance in the selection of reference and text books. Advice on how to conduct a literature search is given; methods of locating and consulting available reference material are suggested. It is a guide on the general aspects of the acquisition of information from written sources. These sources are classified and their comparative advantages for different purposes are pointed out.

This part of the text is well written and contains excellent recommendations. Most of its contents, however, may be assumed to be familiar to anybody engaged in either serious studies or research work.

Part II "the literature" lists about 2,300 bibliographical items on domestic and foreign literature in the field of mathematics and physics, as well as electronics and electrical mechanical and aeronautical engineering. Subject headings are arranged alphabetically and each is followed by an explanatory note. Alphabetically arranged author index and subject index are appended and facilitate location of a desired reference. Scientists, engineers, librarians, and students, in search for pertinent literature will find this bibliography very helpful. It may serve as a guide for the systematic study of a particular subject, or for the finding of special information. It will supply selected reading material and indication of the most suitable material for a particular investigation.

Electronic Transformers and Circuits

By Reuben Lee (Westinghouse). Published by John Wiley & Sons, New York, 282 pages, well illustrated. Price $4.50.

A reference book on the design of transformers for electronic apparatus and the effects of transformer characteristics on electronic circuits. Physical concepts are emphasized with the mathematical treatment simplified wherever possible. Much new and previously unavailable material is included. The book includes material on the construction and performance of transformers, rectifiers and reactors. Transformers, amplifier and modulator service are taken up as to design and use, including transformers adapted to use at the higher frequencies, as well as for pulse and video services. A section on control contains ideas for many specialties in transformers which are of value in industrial work. It is an excellent reference work on this subject.

Engineered Sound Systems

The Architects Manual of Engineered Sound Systems issued by Architectural Relations, Sound Equipment Section, RCA, Camden, N. J. Price $5.00.

This Manual is designed to aid and guide those engaged in the increasing field of engineered sound systems in present day structures. It is also a guide to architects and designers of new structures in drawing up specifications which allow for the installation of such systems.

It offers particular appeal to those acoustical engineers who will be responsible for the acoustical performance in over 1000 existing AM stations and an additional 2000 AM and FM stations which are scheduled for operation in the near future. The chapters on Architectural and Engineering Specifications, Loudspeakers, Studios and Control Rooms, and Acoustics—the latter one covering such important computations as reverberation time, absorption, noise levels, etc.—are replete with typical manual data.

The Manual is comprised mainly of two parts: 1) General information on all component parts of a complete sound system, and 2) Typical layouts and specifications.

Transvision Starts Wiring

To supplement its television receiver kit business, which in no way will be affected by the change, President Herbert Suesholtz of Transvision, Inc., New Rochelle, N. Y., has formed an entirely separate company for the purpose of supplying pre-wired television receivers to be equipped with 10, 12 and 15 in. tubes. The plan is to supply combination television-with-FM receivers at popular prices. Officers of the new company which will do business as the Sightmaster Corp. from headquarters at 220 Fifth avenue, New York, are: President, Herbert Suesholtz; Treasurer, Michael Kaplan; Vice-President, Bernard Kaplan; Sales Manager, F. Wakefield Minor.

NEW BULLETINS

Speakers and Horns

A new catalog, issued by Racon Electric Co., 52 East 19 St., New York 3, N. Y., lists their standard line of horn and cone speakers, double re-entrant marine speakers, projectors, trumpets and new microphone stands. An attached sheet contains a number of price changes, effective after October 25. (Mention T-T)

HF Conductors

Titeflex water-cooled, flexible leads for conducting high-frequency currents are described in a folder issued by Titeflex Inc., 614 Frelinghuysen Ave., Newark 5, N. J. Included is a description of power loss tests performed on the leads. (Mention T-T)

Capacitors

A comprehensive line of oil, wax, electrolytic capacitors and special units designed to specifications is described in the 16-pg. catalog No. 1083, published by Industrial Condenser Corp., 3243 N. California Ave., Chicago 18, Ill. In addition to standard units, the booklet includes motor starting capacitors, interference eliminators, vibrator, and photoflash capacitors. (Mention T-T)

Electrical Alloys

This 72-pg. reference book, published by Driver-Harris Co., Harrison, N. J., lists properties, applications, current-temperature characteristics, life expectancy etc. of Nichrome, Chromax, Advance and a number of other high nickel electrical heat and corrosion resistant alloys in wire, ribbon, and other forms. A number of tables and charts are included. (Mention T-T)

Laminations and Magnets

Catalog No. 47, issued by Thomas and Skinner Steel Products Co., 1124 E. 23 St., Indianapolis 5, Ind., gives complete mechanical, electrical and dimensional information on six grades of electrical sheet steel laminations for transformers and small motors. "E", "I", "LE", and "EK" laminations are described. The same company has published a new 16-pg. treatise on permanent magnets, showing various shapes, air-gaps, steel and Alnico grades available. (Mention T-T)

Rack Connectors

Type "DP" connectors for rack and panel radio, and electronic equipment are described in a 24-pg. "DP" bulletin available from Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 13, Calif. Two general types having up to 46 contacts and the new "DPD2" two-gang type are shown in the bulletin. (Mention T-T)

Fittings and Connectors

This 62-pg., loose-leaf catalog, prepared by Gedney Electric Co., RKO Bldg., Radio City, New York 20, contains in nine separate sections, descriptions, illustrations, price data and dimensions of Gedney conduit fittings, EMT fittings, box connectors, entrance fittings, cable and ground fittings, connectors for non-metallic sheathed cable, straps and clamp backs, conduit bodies and EMT bodies. (Mention T-T)

Switches and Plugs

Various "Little-Jax", "SF-Jax", "Littel-Plugs", "Littel-Switches", "FF-Switches" and stack switches are described in detail in the 8-pg. catalog No. S47, published by Switchcraft Inc., 1735 West Diversey Parkway, Chicago 14, Ill. Mechanical drawings, photographs and specifications are given for each component. (Mention T-T)

Instrument Replacement Parts

Precision instrument screws, washers, nuts, lock washers, taps and dies are listed in price list 100A, issued by the R. Y. Ferner Co., 131 State St., Boston 9, Mass. (Mention T-T)

Capacitors

A comprehensive 32-pg. catalog, published by the Gudeman Co., 361 W. Superior St., Chicago 10, Ill., describes and lists specifications for various types of dry electrolytics, AC motor capacitors, paper capacitors, hermetically sealed oil capacitors, and special types such as fluorescent lamp capacitors and photoflash capacitors. (Mention T-T)

Printed Circuit Technics

This first comprehensive treatment of "Printed Circuit Techniques" by Drs. Cledo Brunetti and R. W. Curtis of the National Bureau of Standards consists of 10 chapters totalling 43 pages, illustrated with 39 cuts and five tables. The NBS circular (No. 648, Printed Circuit Techniques) is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 25 cents per copy.

Photographic Paper

A new silver-sensitized photographic paper for reproducing engineering drawings with standard blue-print or direct process printers, is described in an 8-pg. pamphlet issued by Eastman Kodak Co., 343 State St., Rochester 4, N. Y. The paper is available in packages of 100 or 500 sheets, and in 60 ft., 100 ft., and 250 ft. rolls. (Mention T-T)

Design of Sound Equipment

Data on mixer circuits, showing circuit diagrams and applications are given in a 4-pg. technical bulletin, issued by Daven Co., 191 Central Ave., Newark, N. J. The folder also includes a table of "impedance vs. decibel loss" with values calculated for impedance mismatch, minimum "T" loss, and bridging pad loss. (Mention T-T)

Tube Data for Hams

A roundup of amateur tube information is contained in a technical bulletin and price list for hams issued by RCA Tube Dept., Commercial Eng. Section, Harrison, N. J. Included are new ratings on the RCA 807, 808, 810, 813 and 829-B, new operating conditions for frequency doublers, and data on modulators. (Mention T-T)

Speakers and Transformers

Data on 52 types of permanent magnet speakers, 54 types of electro-magnetic speakers, inclnding P.A. and high fidelity models, and 20 types of output transformers are contained in a 4-pg. bulletin available from Permoflux Corp., 4900 West Grand Ave., Chicago 39, Ill. (Mention T-T)

Resistance Bridges

Bulletin 100, published by Rubicon Co., 3667 Ridge Ave., Philadelphia 32, Pa., describes in detail a complete line of resistance standards and resistance bridges. Operation, application and construction data are furnished on a variety of models of Wheatstone, Kelvin, Mueller and limit bridges. Descriptions of standard resistors, standard shunts, and deeade resistance boxes are included. (Mention T-T)

Manual on Sound Systems

Designed for use by architects, building engineers and the construction industry, the new "Architects Manual of Engineered Sound Systems" is a guide to the installation of sound systems in industrial plants, auditoriums, schools, etc. The manual is divided into two parts. The first part defines and discusses the principal components of sound systems and describes the specifications used in installing the equipment. The second part contains complete specifications on sound systems for seven principal types of buildings. The 288-pg. illustrated manual is available at the price of $5 from the RCA Sound Products Section, Camden, N. J. (Mention T-T)

Carrier Communications Equipment

Booklet B-3882, issued by Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa., describes type JY power line carrier communications equipment. Included in the 8-pg. bulletin are descriptions and illustrations of the two-frequency duplex, manual simplex, and automatic simplex transmitter-receiver assemblies, along with their component parts. (Mention T-T)

Instrument Knobs

Catalog 103A lists in 13 pages the line of radio knobs, instrument knobs, and control balls manufactured by Kurz-Kasch Inc., 1464 South Broadway, Dayton 1, Ohio. Dimensions, illustrations and application data are given for each type.

Miniature Tube Guide

This revised reference guide for miniature tubes, published by Hytron Radio & Electronics Corp., Salem, Mass., contains characteristic data and typical operating conditions for all presently available minia-

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ture types. Corresponding prototypes in larger envelopes and basing diagrams are also given.

Capacitors

Catalog No. C-307, prepared by Sprague Products Co., North Adams, Mass., gives complete listings, specifications, dimensional sketches, prizes, etc. of the company's line of capacitors, resistors, interference filters and test equipment. The 40-pg. catalog is profusely illustrated and contains numerous engineering charts.

Crystal Data

Specifications, frequency ranges, construction features and dimensions of twelve widely used crystal types are given in bulletin No. 201, issued by Premier Crystal Laboratories, Inc., 57-67 Park Row, New York 7. Information on ultrasonic crystal blanks is also given. (Mention T-T)

Image Orthicon Chain

A 32-pg. illustrated brochure, prepared by Allen B. DuMont Labs., Clifton, N. J., describes the Type TA-124-B image orthicon camera chain for field use. Included are descriptions of the camera with electronic viewfinder, the field pickup auxiliary, low voltage supply, control and monitor unit, synchronizing generator, distribution amplifier, mixer amplifier and monitor, and other associated equipment. (Mention T-T)

Replacement Cones and Field Coils

A complete listing of replacement cone assemblies and universal field coil replacements for most existing receivers is contained in catalog No. 48, published by Waldom Electronics Inc., 911 N. Larrabee St., Chicago 10, Ill. (Mention T-T)

Microwave Equipment

A reference manual and catalog on microwave equipment has been published by De Mornay-Budd, Inc., 475 Grand Concourse, New York 51. A 40-pg. introductory section is divided into chapters on "Introductory Concepts in Microwaves" and "Microwave Test Equipment Measurement and Calibration Procedures". The rest of the catalog describes test equipment and standard component X and K band parts. The manual is free and new pages will be sent automatically to owners. (Mention T-T)

NY-Boston Relay

(Continued from page 62)

signal into a beam ten thousand times more powerful than unfocused signals. Each antenna is connected to either a transmitter or a receiver by waveguide. Reflex Klystrons generate carriers in the 4,000 mc region (4 begacycles). The power output is only about ½ watt.

The receivers (repeaters) are of the radar type and use cartridge crystal detectors. The IF frequency is 65 mc. These receivers are designed to handle any type of modulation, and at present are set up for FM. However, tests are being carried on with amplitude and pulse modulation.

Experimental work has shown that hundreds of telephone circuits and many television channels can operate over the new system. The microwaves (3700-4200 mc) are not seriously interfered with by rain, snow and most man-made interference.

Climax of a series of demonstrations of the new relay system was when a television program which originated in New York was sent to Boston twice and returned to the television screen in New York. An operator switched the receiver picture tube so that it alternately showed the direct received picture and the double relay picture. For an observer sitting at a comfortable distance from a 10 in. screen, no discernible difference in detail was noticed when the switch was made from one to the other.

Enter the Video Ham

The time may soon come when it will be necessary to make a distinction between a radio ham and a video ham. Appearance on the market recently of a newly developed television camera tube at an eye-bugging price ($25), bids fair to launch at least some of the amateur field on the first fresh and exciting tangent since the days when hams were looking hopefully to the generation of a handful of watts in the 100 mc region. It is entirely possible to construct a complete prototype television station with parts that can be purchased for approximately $300. Small TV camera tubes were used in wartime applications, such as radio-controlled missiles and aircraft* (*See Electronic Industries, May 1946, pp. 62, 63).

Two-Way Ferry System

Four ferryboats running between Sandy Point and Matepeake, Maryland, on Chesapeake Bay have been equipped with GE two-way FM communication units. The installation is believed to be the first of its kind, linking the boats with each other and with the terminals approximately four miles apart. System operates at a frequency of 43.02 mc.

Midget Meters

International Instruments, Inc. has been formed from the instrument division of MB Mfg. Co., New Haven, Conn. for the production of a specialized line of midget meters. The instruments mount in a one-inch hole and are supplied in six basic ranges from 100 microamperes to 10 milliamperes. Shunted ammeters and ac and dc voltmeters, self-contained, are slightly larger.

New TACO Home

Technical Appliance Corp. has moved manufacturing facilities to its own plant in Sherburne, N. Y., 40 miles south of Utica. Company has long produced antenna systems, will produce other electronic specialties in its new 30,000 sq. ft. home.

California Consultants

Burgess Dempster and R. B. Bonney have organized the Electronic Engineering Co. of California. The company will operate a general consulting business from headquarters at 2008 West Seventh street, Los Angeles.

Waveguide Components

Carl W. Schutter, long steam and diesel engineering specialist, with offices and factory at Rockville Center, N. Y., now is producing a complete assortment of waveguide assemblies in standard and special shapes, as well as chokes, choke flanges, coaxial connectors and related radar and UHF components. The company also does subcontract work.

GE Equips WNAC

General Electric Co. will supply complete television transmitting equipment for WNAC, key station of the Yankee Network in Boston. Transmitting facilities are to be located in Medford, Mass., and the station is scheduled to go on the air early this year.

Gray Drops Phones

Gray Manufacturing Co., Hartford, Conn., has sold its telephone pay-station business to the Automatic Electric Co., Chicago. Henceforth Gray is to devote its energies to the production of the Audograph, an electronic dictation instrument.

To Make Rectifiers

International Rectifier Corp. has been formed in Los Angeles for the production of colorimetric equipment, photo-electric cells and selenium rectifiers. Headquarters and factory are at 6809 South Victoria avenue.

More Du Mont Tubes

The tube plant of the Allen B. Du Mont Labs., Inc., in Passaic, N. J. is to be considerably enlarged. A new addition, recently finished, is to be devoted to tripling the capacity for the production of 12 in. tubes.

Beam-Deflection Amplifier Tubes

C. R. Kilgore (RCA Review, September 1947, pp. 480-505).

An extensive survey of the theory of operation and of the properties of beam-deflection amplifier tubes is presented. Insight in the expected transconductance, current, input and output capacities and their dependence on the essential structural features are gained. The design method is illustrated by a numerical example for a particular tube which was used in experimental work. Results obtained with this tube in connection with a secondary emission electron multiplier are presented. —JZ

Lead-Sulfide Cell for Sound Reproduction

R. J. Cashman (Journal of the Society of Motion Picture Engineers, October, 1947, pp. 342-348).

Photoconductive cells made of thallous-sulfide and lead-sulfide have been recently released by the Government. The lead-sulfide cell is particularly adapted for use in sound reproduction by virtue of its high sensitivity, low noise, low impedance, excellent frequency response, and general sturdiness in the presence of background radiation.

One important characteristic of the lead-sulfide cell is its high infrared response which enables it to be operated with a source of radiation at a much lower temperature (2700° C) than was possible with any previous photoelectric cell. For this purpose an indirectly heated exciter lamp has been developed in which the heating current is supplied by an ordinary filament transformer.—JZ

British Television

(*Continued from page* 28)

stations is possible. It is called "Rotatime".

Nearly every exhibitor displayed sets especially made to suit export requirements, including sets designed for particular territories. Thus several firms show sets designed for China, for India and South Africa. One receiver intended for the middle east was equipped with a dial in Arabic.

Aircraft radar and navigational equipment included a new piece of apparatus designed by EMI and styled "Rebecca" Mark IV, a light-weight miniature airborne interrogator which operates at between 170 and 240 mc and provides the pilot with "heading" and distance information from a ground or airborne responder beacon. In addition to navigational information the set also provides for blind approach and landing. Another piece of new equipment designed for a somewhat similar purpose is the Marconi "Radiolocator". This unit permits the picture received in the PPI screen of the radar set to be compared immediately with a chart, thus facilitating instant identification of objects detected.

National Conference

(*Continued from page* 51)

An unusual amount of interest was shown in the session on "Operation of Electronic Research". A paper describing the methods for handling electronic research as conducted at several research organizations was presented by E. Ziegler. In particular the types of research organization, their management and the methods of laboratory operation at the Armour, Midwest, Battelle, Mellon and Southern Research Institutes were discussed. Visits disclosed that electronic research, on the whole, is not handled in any one of the institutions as a separate department but is organized as a sub-group in one or more of the major sections.

The principles of organization and the operation of an electronic research group to give the most effective results were listed in a paper by R. M. Bowie (Sylvania), an analysis of considerable value to management as well as the physicists and engineers of such a group.

Microwave Link

(*Continued from page* 57)

The transmitter oscillator is a reflex Klystron of approximately 75 mw output. The carrier is fully pulse modulated with equal amplitude pulses having a repetition frequency of 17 kc; these pulses are width modulated by the audio frequency signal. With this method the mean carrier power is modulated at audio frequency, and it can be received by a conventional wideband AM receiver.

The local oscillator in the receiver is also a Reflex Klystron, its output being coupled into the receiving branch of the waveguide. A crystal mixer is placed across the waveguide and tuned by a filter piston behind it. The live end of the crystal is connected through an RF filter to the input of the first IF amplifier stage. AVC and automatic frequency control voltages are both derived from the 17-kc pulses; the latter voltage is applied to the reflector electrode of the local oscillator Klystron.

A signal-to-noise ratio of about 55 db is obtained; distances to 70 miles may be covered.—JZ

Receiver Noise Figure

(Continued from page 39)

two frequencies above and below the tuned or resonant frequency at which the response has fallen to half the tuned output power level (70.7% output voltage). The difference between these two frequencies is taken as the bandwidth.

The noise factor is easily computed from the following data: (A) Bandwidth; (B) Effective input resistance to receiver; (C) Reading of output meter without input signal; (D) Reading of output meter with signal generator input volts reading.

As an example, assume: (A) Bandpass = 0.9 megacycles; (B) Effective input resistance = 90 ohms; (C) Output meter reading = without input signal .5 volts; (D) Output meter reading = with input signal 1 volt; generator reading of 5 microvolts.

For the above assumed values, the noise-factor is:

$$F = \frac{E_a^2}{4KT(\Delta f)R_a} \times \frac{P1}{P2 - P1}$$

$$F = \frac{(5x10^{-6})^2}{4x1.374x10^{-23}x300(.9x10^6)90} \times \frac{(.5x1.12)^2}{1^2 - (.5x1.12)^2}$$

$$F = 8.55$$

or, converting to decibels

$$F = 10 \log 8.55 = 9.32 \text{ db}$$

or, converting to volts

$$E_n^2 = F$$

$$E_n = \sqrt{8.55} = 2.92 \text{ microvolts}$$

Acknowledgment is given to the Research Products Division of Stevens-Arnold Co., Inc., Boston, Mass., for their assistance.

RF Coil Finishes

(*Continued from page* 44)

Q-Dope. It may be observed that this coil shows a decreasing temperature coefficient as it is stabilized, approaching that of the coil represented by curve No. 1 which was stable after its original finish.

The coil represented by Fig. 10 is a low-temperature-coefficient type, and consists of 74 turns of silvered No. 20 invar wire on a 1¼-in. grooved ceramic form (Alsimag No. 202) having a linear expansion coefficient of 1.88 x 10^{-6}/°C. The expansion coefficient of the invar conductor is about 1 x 10^{-6}/°C, and the overall temperature coefficient of inductance for the coil, measured at 3 mc is 4.1 x 10^{-6}/°C.

The two complete temperature cycles shown by the full line curves indicate shifts occurring during the heating portion of the cold half of the thermal cycle. The dashed portion from the point marked "X" represents a further test conducted after removal of the coil for four cycles of —40 to +70°C treatment. Although some shift evidently still occurs on the initial heating, the coil appears to be better stabilized. Construction of stable coils using wire as stiff as the invar conductor used on this coil or of hard-drawn copper wire of an equivalent size proves very difficult, and winding under regulated tension and axial pressure, as well as rigid conductor end fastenings are required. Coils wound with soft-drawn copper conductors are stabilized with less difficulty.

The tests described above were carried out by the writer while in the employ of the Northern Electric Co., Ltd., of Montreal, Canada, who have kindly permitted publication of the results.

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Cavity Type Filters

(*Continued from page 37*)

be approximately 1-to-1 where the same powers and elevation were used. For this arrangement, remote receivers would be used and there should be very little limitation in the interference-free adjacent channel operation.

So far, the discussion of selectivity has referred primarily to reception in the mobile units. For land station installations, the receiver selectivity need not be the controlling factor. Under some conditions where high signal levels are received from opposing transmitters, receiver intermodulation becomes a limiting factor and no degree of IF selectivity can affect this interference produced by intermodulation.

Every engineer knows that when two or more signals appear together in a non-linear circuit, the cross beating of intermodulation which results will produce sum and difference frequencies, together with a whole array of additional by-products resulting from beats between the sum and difference products and the original signals or their harmonics.

Any system of allocation which establishes the channels at equal frequency interval separations is particularly vulnerable to interference produced by intermodulation.

Consider three transmitters operating 60 mc apart. Two of the transmitters may produce a frequency difference by intermodulation in the receiver non-linear circuits of 60 kc, and the 60 kc may combine with the third channel to produce a new carrier 60 kc removed from the third carrier. In another

case, two carriers may combine to produce a 60 kc product, which in turn combines with one of the carriers to produce a third carrier 60 kc removed from this carrier.

There are several other ways of combining harmonics and beats for the production of undesired carriers, and when any two transmitter signals combine in a receiver to produce a new carrier on the desired frequency, no amount of selectivity can remove this artificial carrier. We must either eliminate the intermodulation or mask out the undesired signal by a superior desired signal.

Fig. 2 shows the relationship between the level of two undesired signals B and C in producing an interfering signal on desired Channel A at threshold, or quieting, level. You will note that under all conditions, at least one strong signal is required to produce the intermodulation in the receiver. This points to the fact that a strong signal on the rf amplifier grid will carry the tube into non-linear operating characteristics. The chart shows that Channel B with approximately 10,000 microvolts will produce an intermodulation quieting signal on Channel A when Channel C is approximately five microvolts. When Channel C is 10,000 microvolts, the Channel B signal required to produce a threshold intermodulation product on the desired frequency is approximately 250 microvolts.

For the conditions of the test, B is 120 kc removed from the receiver desired and C is 240 kc removed. Approximately .6 of a microvolt is required in this particular experimental setup to produce 20 db of quieting on the receiver frequency. Since the received signal in the mobile unit drops off rapidly as the mobile unit moves away from the land station, the area where intermodulation will be produced in a mobile receiver will be decidedly limited.

No intermodulation products of a level sufficient to interfere would be produced, if all three transmitters were located at the same land station site. While intermodulation would be produced in the receiver, it follows that the products of intermodulation on the desired channel would always be less than the level of the signal from the desired station located at the same point as the cross-modulating stations. Under these conditions, the intermodulating signal would be blanked out by the strong desired signal. Nuisance interference would result whenever the two opposing stations were on the air without the presence of the desired station.

The nuisance interference could be controlled by the use of selective calling equipment which would open the receiver only when the desired station was on the air. Fig. 3 shows the various levels of interfering signals produced on Channel A as a result of the products of intermodulation from B and C combining in the non-linear receiver circuits. Note that for a signal level of 5,000 to 50,000 microvolts on Channel B, a 50 microvolt signal is required on Channel C to produce a 1 microvolt interfering signal on Channel A. When we drop the Channel B signal to 1,000 microvolts, a 500 microvolt signal is required on C to produce 1 microvolt on A. Note also that, with 1,000 microvolts on Channel B, there is no level of signal on Channel C which will produce 10 microvolts of interfering signal on Channel A.

Under conditions where the signals from Channel B and Channel C are both strong, the interfering signal produced on Channel A is very severe. For 10,000 microvolts on Channel C and 5,000 microvolts on Channel B, more than 100 microvolts of interfering signal will be introduced in the receiver on the desired Channel A. Such signal levels will not be encountered in mobile receiver applications, but they may readily be encountered in land station installations where efficient antennas are located at very high elevations and where little attention is paid to the location of the opposing stations. The conditions considered here are for 120 and 240 kc separation of the two opposing stations. The conditions are somewhat more severe as we deal with 60 kc and 120 kc separation. The intermodulation produced where the opposing stations are ±60 kc relative to the desired station is entirely negligible.

The production of intermodulation is a more severe limiting factor in the design of systems for successful adjacent and alternate channel operation in the same area than the factor of selectivity in the IF channel of the receiver. Power tubes may be used as rf amplifiers in the receivers to reduce the amount of intermodulation, but this approach seems to be impracticable, since strong signals would require high power transmitter tubes as rf amplifiers to provide satisfactory linearity. Intermodulation will not take place if strong signals are not allowed to reach the rf tube or mixer stages.

The one way to prevent the off-channel strong signals from reaching the amplifier is to introduce a high degree of selectivity at carrier frequency. Effective selectivity cannot be introduced at 150 mc without the use of extremely high-Q circuits. To produce such high-Q circuits, it becomes necessary to resort to the use of cavity filters with effective Q's of the order of 3600.

Fig. 4 shows the selectivity curves for the Motorola anti-intermodulation cavity for various insertion losses. In a number of applications, we have found this cavity to be extremely effective. In one particular case, intermodulation from three undesired stations operating on successive 120 kc channels produced a strong signal by intermodulation in the receiver. This strong signal on the desired channel blocked out the talk-back from the mobile unit. The introduction of the cavity in series with the receiver reduced the undesired signal levels sufficiently to wipe out the intermodulation and the interfering signal was completely eliminated.

While the cavity is much too large for use in mobile units, actual tests were made with the cavity in mobile units and it was found to be very effective in the elimination of intermodulation problems. For all of the curves shown, the intermodulation levels are actual measurements for a particular receiver. This receiver is designed with intermodulation problems in mind and the values represent a substantial improvement over those encountered in receivers where no attention is paid to the problem.

Now the cavity has other uses. In the operation of a transmitter adjacent to a receiver location where duplex operation is required, a strong signal at the receiver will result in the desensitizing of the receiver even though no modulation is transmitted through the IF and de-modulation system. This effect is shown whenever the mobile unit is operating with a weak signal and the operation of the local transmitter wipes out the reception from the mobile unit, even though interference from the local transmitter is not received.

For frequency separations between the transmitted signal and the talk-back or received signal of as little as 400 kc, the introduction of the cavity profoundly affects the desensitizing level. In Detroit, duplex operation was possible over the entire city limits with the receiving antennas and 250 watt transmitting antenna mounted on the same tower, but with one of the Motorola cavities installed to control the desensitizing of the receiver.

While the construction of the cavity appears to be simple, there is one very important element of design which is an absolutely essential refinement for successful operation. With simple construction and without means for automatic temperature compensation, the cavity may drift completely off the channel to which it is tuned with a comparatively slight change in temperature. The Motorola cavity is automatically temperature compensated, so that the relative length of the frequency determining element remains constant over wide ranges of temperature.

One of the first applications of the cavity was in Indianapolis, where two 250 w. police transmitters and the fire dept. transmitter were to operate simultaneously from a single antenna. Under ordinary conditions, the connection of three transmitters to a single antenna would tend to produce the division of power more or less equally among the two opposed transmitters and the antenna, so that approximately one-third of the power would be radiated from each transmitter.

The introduction of a cavity in each transmitter output circuit efficiently isolated the transmitters to prevent interaction, so that power loss was limited to something less than 10% and the transmitters could be operated independently or simultaneously without interaction of any kind. The use of the single antenna will insure the protection of a 1-to-1 desired to undesired signal ratio at the receiving point for any of the transmitters, and thus the effects of intermodulation or cross interference of all kinds are eliminated. The receivers for the system are, of course, located at a remote point.

Sometime ago, the Federal Communications Commission proposed that the 40 mc band should be reallocated on the basis of 20 kc channels, instead of the usual 40 kc channels. Intermodulation introduces a severe limitation and adjacent and alternate channel operation for the present bandwidths is impracticable under some conditions. Further, the introduction of front-end selectivity is the only practicable way of controlling intermodulation. As the bands are cut and the channel spacing becomes closer and closer, the problems of the control of intermodulation are increased.

The data available at the present state of the art indicates that the halving of channels does not double the number of channels available for use in the same area. Any increase in channel loading should be approached on the basis of multiplexing, rather than channel-splitting at carrier frequency. If the multiplexing is confined to a sharing of the modulation band, rather than to the sharing of a carrier, the problems of stability as well as the problems of intermodulation can be brought under proper control.

Of course, it must be remembered that multiplexing cannot be used without a degradation of the signal-to-noise ratio and that the placing of four communication channels on a single band will reduce the signal-to-noise ratio by a factor of four. However, under conditions where the range is limited and sufficient signal level can be provided to insure the proper signal-to-noise ratio, even with the degradation introduced by multiplexing, the use of multiplexing will increase the channel loading. The splitting of the carrier channel will be subject to the same degradation of signal-to-noise ratio as the multiplexing by sharing of the modulation band.

Every effort must be made to push the standards for all factors relating to adjacent and alternate channel operation to their limits as soon as possible. The use of cheap equipment inadequately designed for proper protection will waste valuable spectrum space, and precision equipment must be used for the benefit of the user, the manufacturer, and of the Federal Communications Commission.

Even with the efficient use of all channels assigned, we are still short of channels for the proper expansion of our many mobile services, but we are not in a strong position to insist upon the assignment of new channel space until we have set the standards for the efficient and effective use of the channel space already assigned. Manufacturers and users must cooperate toward the end that large amounts of unsuitable equipment will not be placed in operation to plague all users of mobile equipment for the next five or ten years.

Central Television Distribution

(*Continued from page 48*)

combination sound volume-off-on control and a contrast control. All other controls are pre-set under locked doors.

The off-on switch available to the user is interlocked with both protective interlock switches and a key operated off-on switch which prevents the use of the unit when the rental fee is not paid. The contrast control is applied to a low level video amplifier stage. Because the line level for each channel is maintained within close tolerances, it is unnecessary to have a wide range of contrast control, and the user gets a vernier action as a result, which simplifies adjustment. This is a distinct advantage over contrast control action in complete television receivers where the contrast control range must be at least 2000:1 unless automatic gain control is incorporated. A range of 5:1 has been found adequate for this service.

The table model viewer contains the sweep and synchronizing circuits, the video amplifier, the audio amplifier and necessary power supplies. It is mounted in a tamperproof wooden cabinet which is approximately 20 in. wide, 13 in. high and 19 in. deep. Both modern and period styling are available to match the decor of any room.

The 15 in. and 20 in. viewers have the same features as the 10 in. viewer except, of course, higher accelerating voltages are used to obtain adequate picture brightness and resolution. These units also have pushbutton selection of the television and sound channels and are mounted in all-metal cabinets.

The use of only two operating controls plus the pushbutton selector insures proper operation by the casual viewer who has had no previous experience with television. While the system might be further simplified from the viewer standpoint by eliminating the contrast control and monitoring the video line level even more closely, variations in the television station output level and individual preferences as to desired contrast would cause this to be a distinct limitation on the performance of the viewers.

Each type of viewer is equipped with interchangeable connector fittings, and it is possible to disconnect viewers and reconnect them in different outlet locations while the system is in use.

The economic advantages of Central Control Television over complete receiver installations are outstanding only in relatively large scale installations. A major item is, of course, central control cost and the distribution network. Completely aside from the operational advantages both to the management and the viewer of a central control system, the central control system may be expected to be less expensive both in initial cost and upkeep where 25 or more viewing units are provided.

Electron Emission

(*Continued from page 45*)

It is further shown that a straight line should be obtained if the logarithm of the current intensity is plotted against the square of the angle α. This assumes Maxwellian distribution of initial tangential electron velocities. The slope of this line is a measure of the cathode temperature associated with the particular velocity distribution.

In the results plotted in Fig. 2, the currents received in the Faraday cage in 10^{-10} amp are plotted against the relative positions of the target slot in millimeters. The curves are measured under space-charge limited conditions; anode voltages and total cathode-current are marked on each curve. One curve shows five distinct maxima, each corresponding to an elementary pencil and thus indicat-

TELE-TECH

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ing five separate tangential velocity groups.

If the squares of the spreading angle α are plotted against the relative current intensities in a logarithmic scale, a straight line is obtained in some instances. Thus the experimental values represent a Maxwellian distribution of initial tangential electron velocities. However, though the cathode is at 1000°K, the experimental curve corresponds to another cathode temperature, for instance to 700°K. Computations from experimental results thus frequently indicate temperatures which are substantially different from the actual cathode temperature.

Moreover, experimental values obtained from other measurements do not plot as straight lines, and therefore do not represent a homogeneous cathode temperature but rather discrete groups of electrons emitted by cathodes of temperatures ranging from below 700°K to far above 1000°K. The pencil appears to split up in a multiplet of elementary pencils; sometimes as many as 30 elementaries can be observed. The pencils seem to spread mainly in the

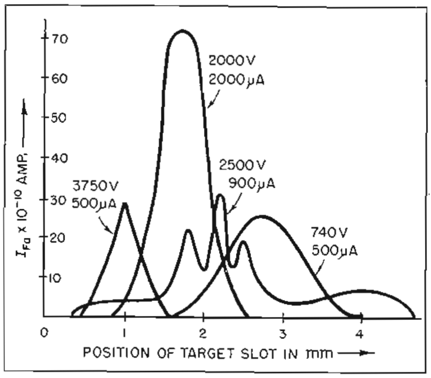

Fig. 2—Measured current intensity across width of electron pencil

direction in which the strip cathode extends.

These somewhat surprising results have been confirmed by various experiments under different conditions, and the possibility of substantial influences of spurious effects seems to be ruled out.

The present results—i.e., either a reduction of the temperature of emission with respect to the cathode temperature, or, under other circumstances, a splitting up of the continuous distribution in discrete velocity groups—are attributed to space-charge effects in front of the cathode. The effect of temperature reduction might be related to the known effect of reduction of shot noise by space charge.

The splitting-up effect is explained by the influence of space-charge oscillations which may cause an uneven withdrawal of current over the cathode surface. With suitable boundary conditions, a standing wave may be formed in the space charge, producing a stable pattern of nodes and antinodes of constant pitch. The periodic pattern formed by the splitting of the electron pencils is interpreted as an image of the nodes and antinodes at the cathode. If this explanation holds, the wavelength of the standing waves can be computed from the angular deviation of the electrons, resulting in a frequency range from 100^8 to 10^9 cycles.

Standing oscillations can be detected with the great majority of all cathode systems, the wavelength being substantially the same for different geometrical arrangements, but the amplitudes, indicated by the number of elementaries into which the pencil appears to be spit, vary over a wide range.

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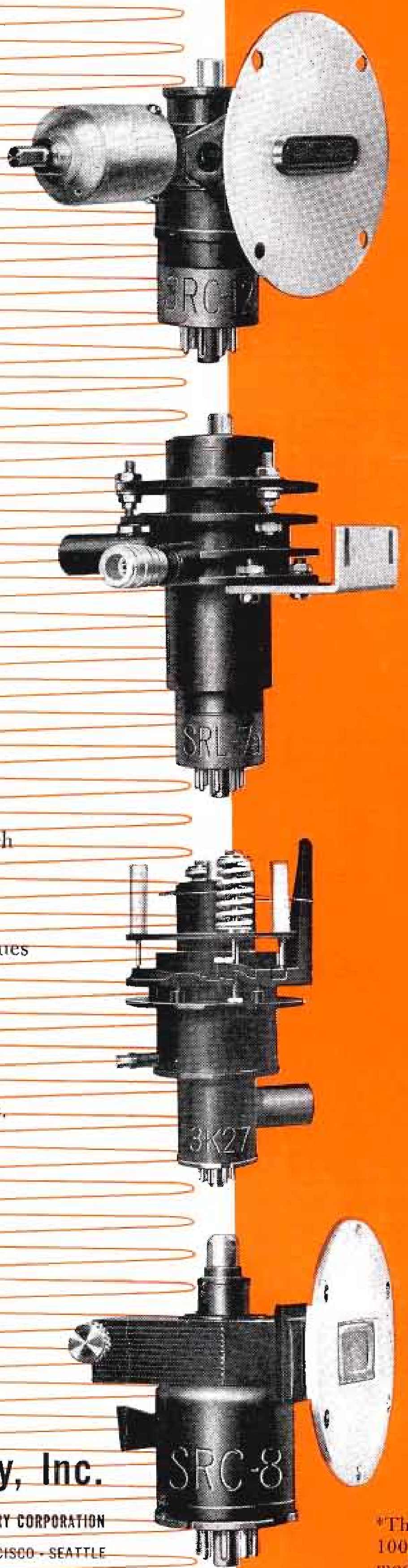

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