
JANUARY · 1948
electronics
A McGRAW-HILL PUBLICATION

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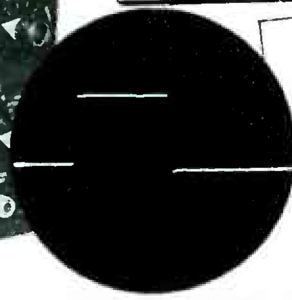
James H. McGraw, Jr., President; Curtis W. McGraw, Senior Vice-President and Treasurer; Nelson Bond, Director of Advertising; Eugene Duffield, Editorial Assistant to the President; Joseph A. Gerardi, Secretary; and J. E. Blackburn, Jr., Vice-president for circulation operations.
ELECTRONICS, January, 1948, Vol. 21; No. 1. Published monthly, with an additional issue in June, price 75c a copy. Directory issue $2.00. Allow at least ten days for change of address. All communications about subscriptions should be addressed to the Director of Circulation.
Subscription rates—United States and possessions, $6.00 a year, $9.00 for two years, $12.00 for three years. Canada (Canadian funds accepted) $7.00 a year, $11.00 for two years, $14.00 for three years. Pan American countries $10.00 for one year, $16.00 for two years, $20.00 for three years. All other countries $15.00 for one year, $30.00 for three years. Please indicate position and company connection on all subscription orders. Entered as Second Class matter August 29, 1936, at Post Office, Albany, New York, under the Act of March 3, 1879. BRANCH OFFICES: 520 North Michigan Avenue, Chicago 11, Ill.; 68 Post Street, San Francisco 4; Aldwych House, Aldwych, London, W. C. 2; Washington, D. C. 4; Philadelphia 3; Cleveland 15; Detroit 26; St. Louis 8; Boston 16; Atlanta 3, Ga.; 621 So. Hope St., Los Angeles 14; 738-9 Oliver Building, Pittsburgh 22.

CRYSTAL-CONTROLLED TIMING MARKERS ACCURATE TO PLUS/MINUS 0.02%

WIDE VARIETY OF SWEEP SPEEDS: 4, 10, 25, 100, 1000 OR 4500 MICROSECONDS MAY BE SELECTED

PRECISION, CALIBRATED, SWEEP-DELAY CIRCUITS

EXTENDED WIDE-BAND AMPLIFIERS: SINE WAVE RESPONSE DOWN 3 db AT 8 mc, DOWN 6 db AT 11 mc



Oscillogram of 1 microsecond pulse passed through video amplifier of Type 256-D Oscillograph.

SPECIFICATIONS . . .

Type 5CP-A cathode-ray tube. 4000 volts accelerating potential. Excellent brilliance and spot size.

Sweeps (A): 4500, 1000, 100, 25, 10 and 4 µsec.

Sweeps (R): 25, 10, 4 µsec; delayable to cover any portion of the 100 µsec A Sweep from 4 µsec up. 25 and 10 µsec; delayable to cover any portion of the 1000 µsec A Sweep from 5 µsec up.

Delay accuracy ± 0.1% of full scale. First few microseconds may be observed on the 4 or 10 µsec A Sweeps. Approx. 0.3 µsec required to start sweep.

Triggered operation—internal: Provides output pulse of 100 volts peak, positive or negative; rise time 0.3 µsec; duration 1.0 µsec; repetition rate 80 to 400 a second on 1000 µsec and 4500 µsec ranges; 80 to 2000 a second on 100 µsec range. Crystal-controlled time marks each 10 and 50 µsec. Timing mark: rise 0.25 µsec; duration 1.0 µsec; accuracy ± 0.02%.

Triggered operation—external: Trigger input ± 15 volts minimum at 100 volts/µsec rise for accurate timing. Trigger amplifier: operation independent of waveform; input trigger rise of 10 volts/µsec triggers the sweep. Repetition rate: 2000 max. on 100 µsec scale; 400 on 1000 µsec scale. No time marks available.

Intensity Modulation: Input available at Z IN position of markers switch.

Vertical Deflection—Direct: Deflection factor: 70 d-c v/in. Polarity: positive signal deflects upward. Maximum input voltage: 600 v d-c plus peak a-c.

Vertical Deflection—Video Amplifier: Attenuator: 1:1, 3:1, 10:1, 30:1 and 100:1, stepped, R-C compensated. Input Impedance: 1 megohm, 20 µµf. Gain: approx. 125. Sine wave response: Down 3 db at 8 mc; down 6 db at 11 mc. Pulse response: Sum of rise and fall time of 1.0 µsec pulse with rise and fall of 0.01 µsec does not exceed 0.08 µsec when passed through video amplifier. Max. input for undistorted deflection with no attenuation: Approx. 1 v. Deflection: 0.25 v rms and full video gain for ¾" min. Maximum Input Voltage: 600 v d-c + peak a-c. Polarity: Positive signal deflects upwards.

Power: 115 v, single-phase, 60 cps, 220 watts, usable to 1200 cps.

Dimensions: 11⅜" w., 16¼" h., 26" d.; wt. 104 lbs.

All this...and more too, in the *new* DU MONT TYPE 256-D *Cathode-ray* OSCILLOGRAPH

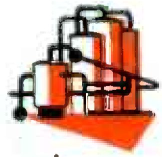
Ideally suited for applications where a variety of sweep lengths, accurate sweep-delay circuits, crystal-controlled timing markers, wide-band video amplifier, and variable internal trigger generator are *mandatory*.

Such applications embrace television transmitter and receiver research; study of multi-channel, pulse-time modulation systems; nuclear research; and general applications wherein high-speed, short-duration phenomena of low repetition rate are examined.

Immediate delivery! To any destination in continental U.S.A. (Type 256-D; Cat. No. 1296E) delivered price $1705.00.

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • *CABLE ADDRESS:* ALBEEDU, PASSAIC, N. J., U. S. A.



...high octane gasoline

...electric household appliances

partners in creating

● Creative men...engineers and engineering draftsmen...plan and build things to last. By the same token they look for instruments and equipment that will last. The tracing paper they draw on must be permanent. Their drawings must serve as lasting records. They may even have to use these same drawings years later to make new reproductions.

For 80 years there has been a lasting partnership between Keuffel & Esser Co. equipment and materials and the engineers and draftsmen of America. This partnership has been so general, that there is scarcely an engineering or construction project but what K & E products have played their part in it.

One of these products is ALBANENE* Tracing Paper. Its 100% pure white rag fibers are stabilized and transparentized with Albanite, a K & E synthetic solid. ALBANENE is permanent. Free from oils, it cannot "bleed" nor lose its transparency with time. For complete details, write to your nearest K & E distributor or to Keuffel & Esser Co., Hoboken, N. J.

*Reg. U. S. Pat. Off.

K+E

Drafting, Reproduction, Surveying Equipment and Materials, Slide Rules, Measuring Tapes.

KEUFFEL & ESSER CO.
EST. 1867
NEW YORK • HOBOKEN, N. J.
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LOS ANGELES • MONTREAL

$19,700 a yard!

Natvar insulating materials are prominently displayed in this Chinese Shipchandlery. According to the signs, they handle, in addition to electrical materials, "steamship machinery, agricultural machinery, rubber goods, hardware, mine and factory supplies, iron, steel and miscellaneous."

Natvar insulating materials, whether $19,700 Chinese a yard (approximately $.60 U. S.), or the prevailing domestic price, are a good buy because of their *uniformity*. Users have found that they can depend on Natvar insulation to be consistently up to specifications or above.

If you require insulating materials with good physical and electrical performance characteristics, and exceptional uniformity—plus prompt delivery—it will pay you to use Natvar. Get in touch with your Natvar distributor or with us direct.

Natvar

Natvar Products

- Varnished cambric—straight cut and bias
- Varnished cable tape
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- Varnished duck
- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded vinyl tubing
- Extruded vinyl identification markers

Ask for Catalog No. 20

THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE
RAHWAY 7-2171

CABLE ADDRESS
NATVAR: RAHWAY, N. J.

201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

1-NVP-4

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 10% 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.

—QUALITY COUNTS—

Distributed by GraybaR
OFFICES IN 92 PRINCIPAL CITIES

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

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

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STATION ____________

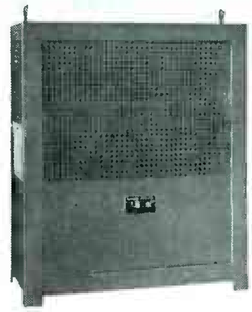
ADDRESS ____________

CITY ____________ STATE ____________

3-Phase Regulation

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
3P15,000	1500-15,000	0.5%
3P30,000	3000-30,000	0.5%
3P45,000	4500-45,000	0.5%

- **Harmonic Distortion on above models 3%. Lower capacities also available.**



Extra Heavy Loads

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
5,000†	500 - 5,000	0.5%
10,000†	1000-10,000	0.5%
15,000†	1500-15,000	0.5%

General Application

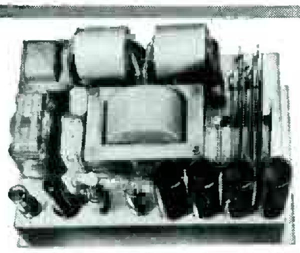
MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
150	25 - 150	0.5%
250	25 - 250	0.2%
500	50 - 500	0.5%
1000	100-1000	0.2%
2000	200-2000	0.2%

400-800 Cycle Line

INVERTER AND GENERATOR REGULATORS FOR AIRCRAFT.
Single Phase and Three Phase

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
D500	50 - 500	0.5%
D1200	120-1200	0.5%
3PD250	25 - 250	0.5%
3PD750	75 - 750	0.5%

Other capacities also available



The NOBATRON Line

Output Voltage DC	Load Range Amps.
6 volts	15-40-100
12 "	15
28 "	10-30
48 "	15
125 "	5-10

- **Regulation Accuracy 0.25% from 1/4 to full load.**

SORENSEN

The First Line of standard electronic AC Voltage Regulators and Nobatrons

GENERAL SPECIFICATIONS:

- Harmonic distortion max. 5% basic, 2% "S" models
- Input voltage range 95-125: 220-240 volts (—2 models)
- Output adjustable bet. 110-120: 220-240 (—2 models)
- Recovery time: 6 cycles: † (9 cycles)
- Input frequency range: 50 to 65 cycles
- Power factor range: down to 0.7 P.F.
- Ambient temperature range: —50°C to +50°C

All AC Regulators & Nobatrons may be used with no load.

*Models available with increased regulation accuracy.

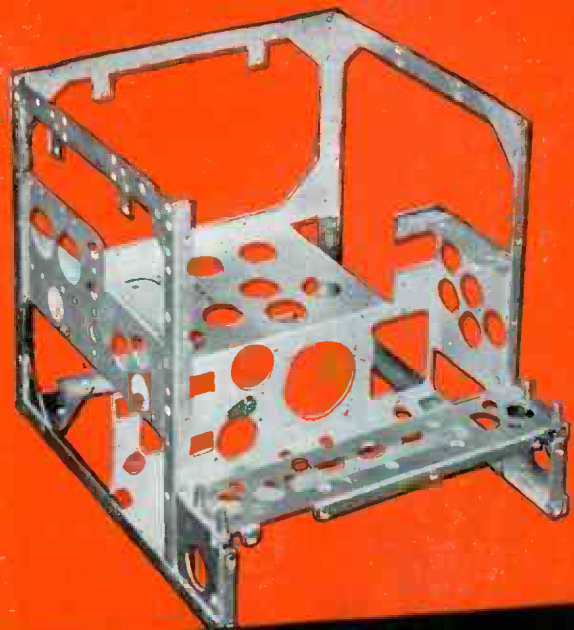
Special Models designed to meet your unusual applications.

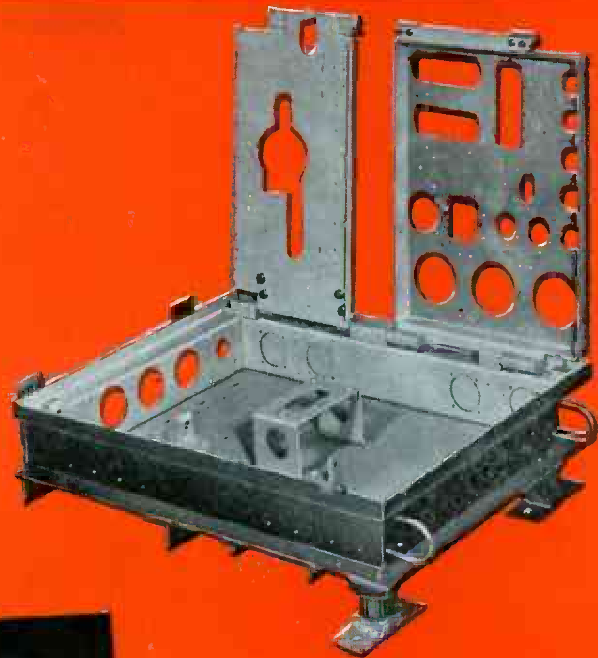
Write for the new Sorensen catalog. It contains complete specifications on standard Voltage Regulators, Nobatrons, Increvolts, Transformers, DC Power Supplies, Saturable Core Reactors and Meter Calibrators.

SORENSEN & CO., INC.
STAMFORD CONNECTICUT

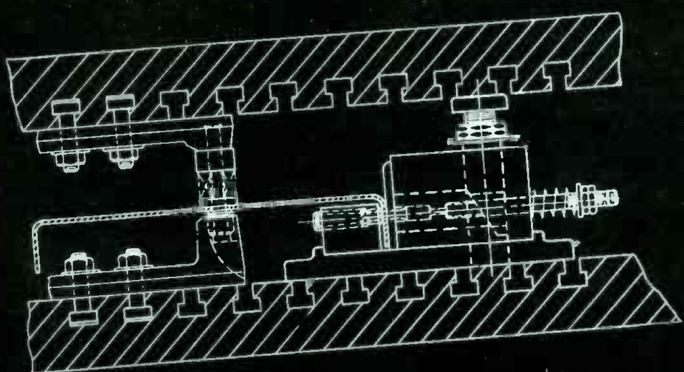
Represented in all principal cities.

WHISTLER ADJUSTABLE DIES... USED BY OVER 1000 MANUFACTURERS





Simplifying Complicated Piercing Operations...



LEADING manufacturers find it fast, simple, accurate, and economical to use Whistler adjustable dies for the tough jobs. Complicated patterns can be set up quickly. It's easy to change hole arrangements too... without waiting and at no extra die cost. New HU-50 units, that pierce at 90° angle, can be used in conjunction with standard perforating equipment. Fewer press operations are necessary.

Savings, through continued re-use of the same dies in different arrangements on many jobs, are most important.

Whistler adjustable dies can be used in practically every type press. Standard sizes of punches and dies up to 3″ are available in a hurry. Only a few days are necessary to get special shapes made to order.

S. B. WHISTLER & SONS, INC.

746 Military Road   Buffalo 17, N. Y.

HU-50 Perforating unit used in conjuction with standard Whistler adjustable dies on the same job.

For more details on this modern way to speed production and save money, write for your copies of the Whistler catalogs.

WHAT MAKES A GOOD RECORDING BLANK GOOD*?

- *The 'Broadcaster'*
  10" 12" 16"
- *The 'Playback'*
  6½" 8" 10" 12" 16"
- *The 'Audition'*
  6½" 8" 10" 12" 16"
- *The 'Maestro'*
  12" 13¼" 17¼"

No. 1 THE ALUMINUM BASE

- Of all metals, compositions, and plastics ever tried, sheet aluminum more nearly meets product requirements. Other materials may lack a truly smooth surface, warp or curl, or are not available in quantities and at prices commensurate with the market.
- *So that your Soundcraft disc surface will be a perfect darkened mirror, a premium grade of sheet aluminum is used. Lacquer coatings, unless hand-rubbed, are only as smooth as the base to which they are applied. The best recording surface, therefore, is obtained only with sheet aluminum rolled at the mill to a mirror finish.*
- This "reflector sheet" aluminum is further processed for Soundcraft by "stretcher leveling," a treatment which slightly elongates the sheet to relieve strains, eliminates warp, and hardens it somewhat to increase bend resistance. The now flat "reflector sheet" is next stamped into the various size circular bases which are shipped to Soundcraft degreased and individually packed to prevent scratching. At this point a Soundcraft precoating inspection takes over. Not *just* aluminum, but the *right kind* of aluminum helps keep Soundcraft on top qualitywise.

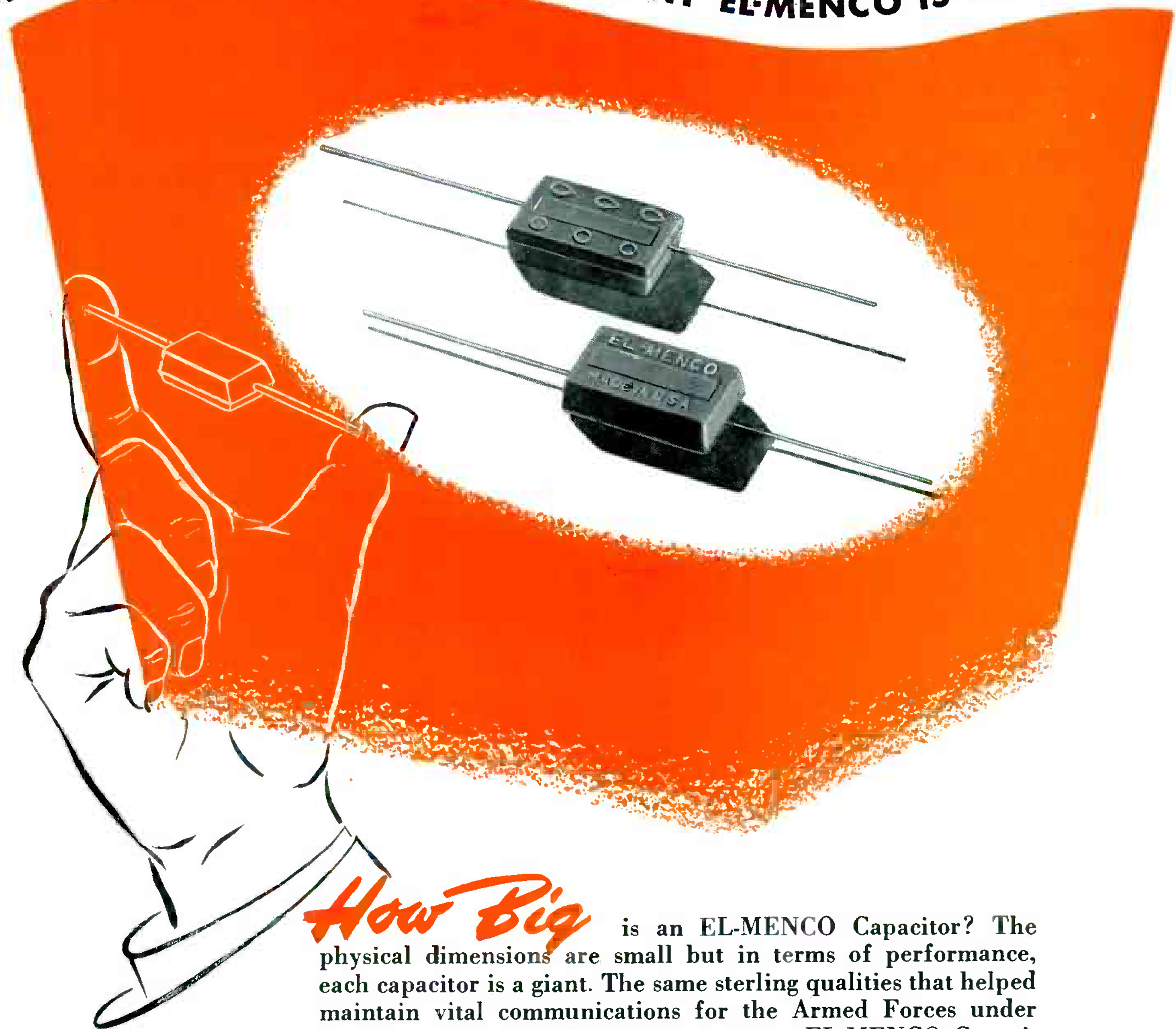
**Watch this space for succeeding ads in this informative series on how Soundcraft discs are made.*

Soundcraft

REEVES SOUNDCRAFT CORPORATION

10 EAST 52nd STREET • NEW YORK 22, N. Y.

IF DEPENDABILITY IS THE REQUIREMENT—EL-MENCO IS THE CHOICE



How Big is an EL-MENCO Capacitor? The physical dimensions are small but in terms of performance, each capacitor is a giant. The same sterling qualities that helped maintain vital communications for the Armed Forces under grueling wartime conditions are in every EL-MENCO Capacitor that goes into your circuit.

We who design and make EL-MENCO Capacitors are proud of the reputation of dependability that our products have earned. We pledge our every effort to its continuance.

THE ELECTRO MOTIVE MFG. CO., Inc. Willimantic, Conn.

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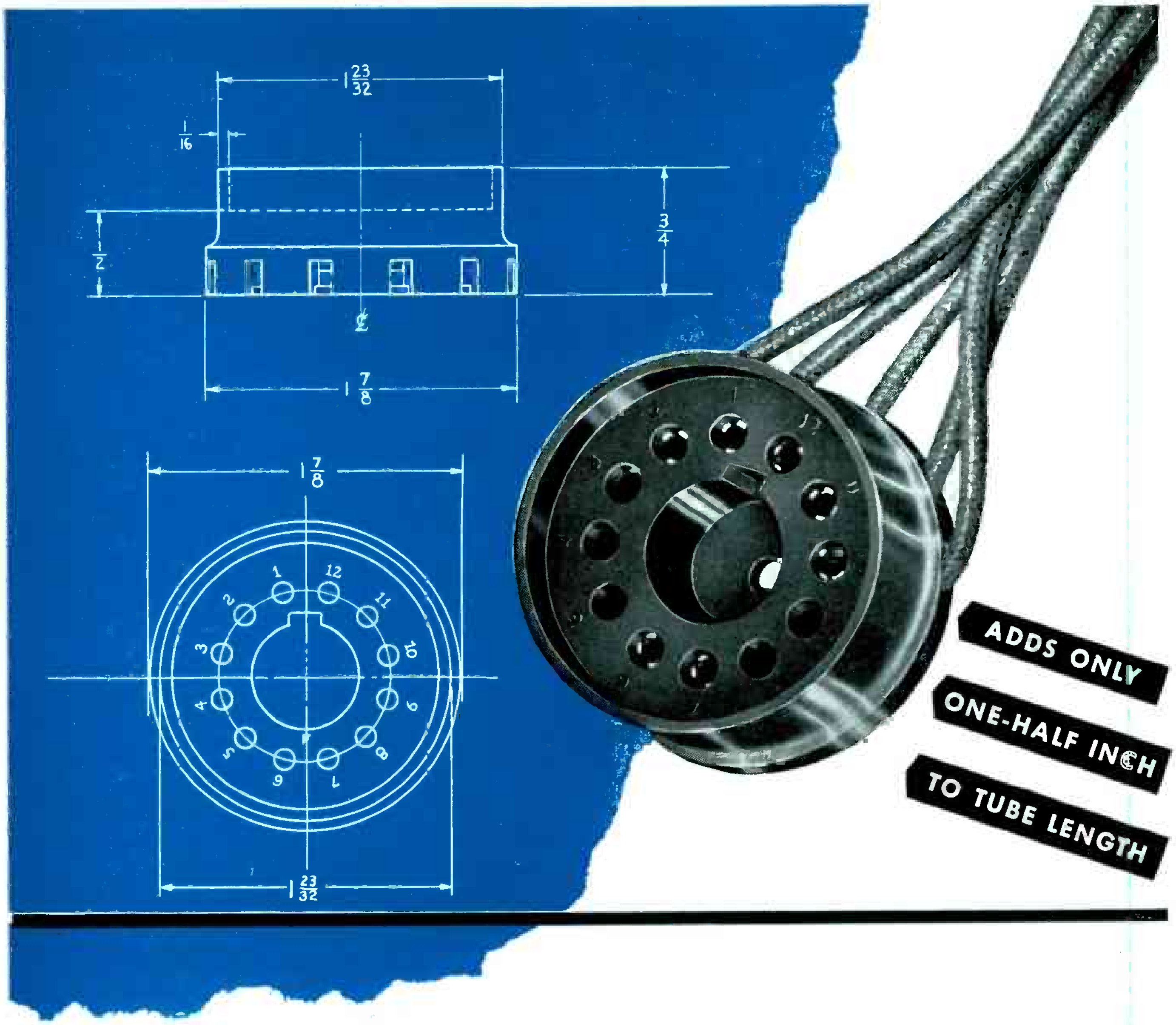
El-Menco

MOLDED MICA **CAPACITORS** **MICA TRIMMER**



Franklin Announces

THE NUMBER 40 DUODECAL TELEVISION SOCKET

ADDS ONLY ONE-HALF INCH TO TUBE LENGTH
PHENOLIC MOLDED CONSTRUCTION
WITH RADIAL LEADS
AND THE HAND GRIP SHAPE

ELECTRONIC COMPONENTS

. . . designed and manufactured in the traditional FRANKLIN manner . . .
by skilled craftsmen with the finest materials

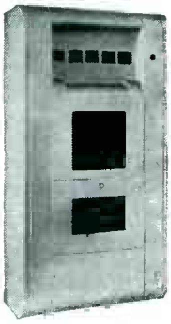
A. W. FRANKLIN MFG. CORP.

MANUFACTURERS OF A COMPLETE LINE OF RADIO AND TELEVISION TUBE SOCKETS

43-20 34th STREET • LONG ISLAND CITY 1, NEW YORK

For Blue Ribbon Quality in Sheet Metal Housings

Send Your Blueprints to Karp

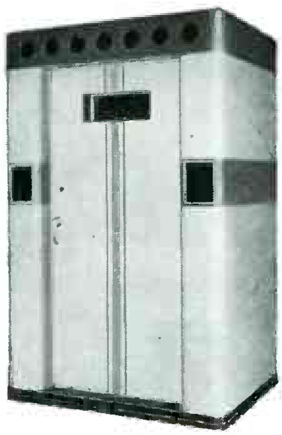


When manufacturers of electronic, radio and electrical apparatus, situated as far as 2000 miles and more from our plant, insist on Karp sheet metal craftsmanship, there must be good and profitable reasons.

One important reason is that Karp-constructed cabinets, enclosures, housings and chassis are custom-built to individual requirements; so precisely and uniformly made that time and money are saved on your assembly line. Another reason is that Karp builds good looks and streamlined styling into the product, giving you added sales and profit advantages.

Remember the Karp blueprint man symbolizes blue ribbon quality in cabinets, housings, enclosures and chassis. Tell us your needs. Get our quotations.

- *Any metal*
- *Any gauge*
- *Any size*
- *Any quantity*
- *Any finish*



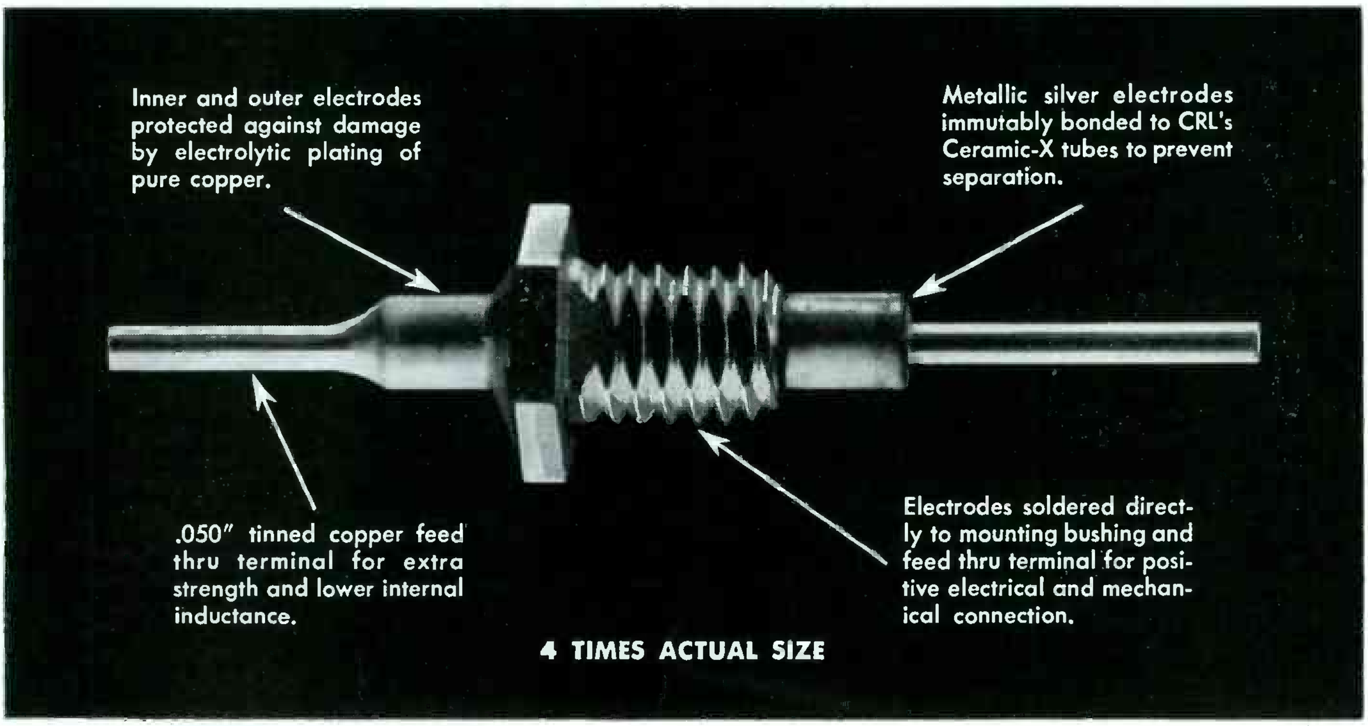
KARP METAL PRODUCTS CO., INC.

124 - 30th STREET, BROOKLYN 32, NEW YORK

Custom Craftsmen in Sheet Metal

Announcing FT Hi-Kaps!

Centralab's New Feed-Thru or Bushing Mounted Capacitors made with high dielectric Ceramic-X!



Your choice of leads or terminals

Three types to meet your needs: 1) both ends straight. 2) both ends bent. 3) one end straight, other end bent. Special terminal or lead requirements can be supplied.

New mechanical bond eliminates structural and electrical damage during installation!

HERE, AT LAST, are the Feed Thru or Bushing Mounted Capacitors you have been waiting for! Made with high dielectric Ceramic-X, these new additions to Centralab's growing *Hi-Kap* line once and for all eliminate the problems of damage during installation. Secret of this new CRL development is two tough, mechanical bonds — 1) between inner feed-thru terminal and inside diameter of tube, and 2) between mounting bushing and outside diameter of tube. Special high temperature solder is then applied to assure a positive electrical connection. Result: top quality, efficiency, and long life.

FT Hi-Kaps are for use in high frequency circuits where, in addition to feed-thru, a capacity ground to either the chassis or shield is desired. *Ratings:* Capacity from 55 to 2,300 mmf. 500 WVDC. Flash test, 1,000 VDC. See your Centralab representative, or write for bulletin 975.

Look to Centralab in 1948!

First in component research that means lower costs for the electronic industry.

Centralab CRL
Division of GLOBE-UNION INC., Milwaukee

. . . this is Capacitor
ENGINEERING ACHIEVEMENT EVIDENCE!
The six basic new capacitor types illustrated were pioneered and perfected by Sprague. Each represents a distinct advance over previous types. Each supplies convincing evidence of the progressiveness of Sprague engineering.
FLUORESCENT BALLAST CAPACITORS
A Notable Development
Sprague fluorescent ballast capacitors easily withstand the severe combination of high temperature and over-voltage to which they are subjected under blink start conditions. This results from the use, in these capacitors, of a new and exclusive impregnant developed by Sprague. This impregnant, known as *Vitamin Q, is thermally stable at temperatures far higher than those encountered even under most severe ballast conditions.
*HYPASS CAPACITORS
High-Frequency Resonance Problems Solved
Sprague *HYPASS 3-Terminal Network Capacitors have established new standards of performance in eliminating anti-resonant frequencies up to 150 megacycles or more. Conventional methods of by-passing vibrator "hash" usually call for a by-pass capacitor shunted by a mica capacitor. Today, these 3-terminal network capacitors make such compromise methods no longer necessary. If you have a "hash" problem, we'd welcome the opportunity to stack Hypass Capacitors against it.
*MIDGETS AND MINIATURES
Extending the Boundaries of Practical Electronics
"Make it smaller, make it better" is the ever-recurring demand on design engineers charged with creating today's electronic devices. Sprague *Midget Capacitors are the first small size paper dielectric tubulars to operate dependably at 85° C., to have adequate humidity protection, and to be priced for widespread use. Sprague Miniature Capacitors are even smaller, have adequate humidity protection, and are rated for operation at 65° C.
SPRAGUE
SPRAGUE VITAMIN Q
PIONEERS OF ELECTRICAL AND ELECTRONIC PROGRESS

* Trademarks Reg. U. S. Pat. Off.

WILCO precision products are at the "HEART" of modern industrial machines

WILCO engineers and craftsmen are quality-minded specialists in the design and development of precision products found at the *heart* of countless industrial and domestic devices—WILCO Thermometals (Thermostatic Bimetals), Electrical Contacts, and Precious Metal Bimetallic Products.

Specialists for 34 years in these products and materials so vital to modern industry, the H. A. Wilson Company commands the *specialized skill*, the *specialized machinery* and manufacturing processes to manufacture *precision products.*

WILCO annually supplies thousands of manufacturing customers with millions of thermometal parts and contacts.

You, too, can depend on these *special products* . . . on their uniformity, precision performance and long life . . . on the ability of WILCO engineers and craftsmen to mold them to your exact requirements.

WILCO PRODUCTS INCLUDE

THERMOSTATIC BIMETAL

WILCO—American pioneer in the development and manufacture of thermostatic bimetals—supplies thermometals as sheet or strip, in partly or completely fabricated form, and as parts of assemblies. All temperature ranges, deflection rates and electrical resistivities.

CONTACTS

WILCO produces contact materials and assemblies in every size, shape and variety to meet a wide range of applications. WILCO contacts include . . . silver, platinum, tungsten . . . also silver-copper, platinum-iridium, tungsten-osmium, Wilcoloy silver-tungsten, Wilcoloy copper-tungsten, Wilcoloy silver-graphite and other alloys.

SILVER CLAD STEEL JACKETED WIRE

Economical non-corrosive wire with electrical characteristics of solid silver for high and ultra-high frequency current applications. Silver on steel, copper, invar or other combinations requested.

ROLLED GOLD PLATE AND WIRE

All colors and karats, on any base metal.

NI-SPAN* C

A new and remarkable age hardening constant modulus alloy. Uniquely combines modulus control with high elastic and strength properties. Suggested applications . . . precision springs for all purposes; tuning forks; bourdon tubes; instrument diaphragms; bellows. Available in all commercial forms.

WILCOLOY T-1 and T-7. Two copper alloys combining high strength with high electrical conductivity, high endurance limits and high service temperatures. Available in rod, strip, cold drawn bars, fabricated parts, wire. Many important applications.

SPECIAL MATERIALS

Copper clad steel with special ratios—copper clad beryllium copper—high strength, high expansion and high strength, low expansion alloys.

•

CONSULT OUR ENGINEERING DEPARTMENT—A representative of the WILCO Sales and Engineering Department will gladly help develop the proper application of WILCO materials to your products.

*TRADE MARK INTERNATIONAL NICKEL CO.

THE H. A. WILSON COMPANY
105 CHESTNUT STREET, NEWARK 5, NEW JERSEY
Branch Offices: Chicago, Detroit, Los Angeles, Providence

WILCO

SPECIALISTS FOR 34 YEARS IN THE MANUFACTURE OF THERMOMETALS • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS AND SPECIAL ALLOYS

Illustrated: The Leland Loadstar Type RA Repulsion Start-Induction Run Motor

PICKUP! *Higher starting torque per ampere of starting current characterizes Type RA Repulsion start-induction run motors.*

QUIET! *Exceptionally close tolerances eliminate vibration, prolong motor life. Engineered throughout for smooth, silent operation under most exacting conditions.*

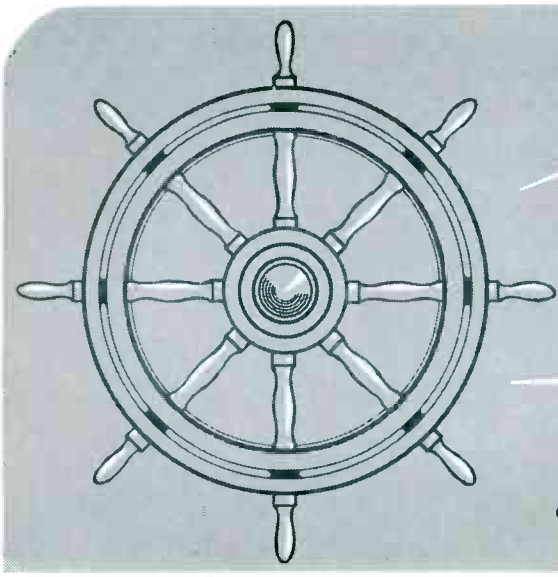
SELECTION! *1/3 to 5 HP. Types—ball bearing and sleeve bearing; open and enclosed; explosion-proof; horizontal and vertical.*

Together, they'll go far. If your product, too, stands for down-to-earth engineering aimed at standards raised sky-high, then you'll find your performance values enhanced by similar characteristics in the Leland Loadstar. Sales-wise, too, you'll find the nameplate on your Loadstar a potent business beacon. Your customers who have long known Leland, find in Leland Loadstars the coolest-running, sweetest Lelands yet . . . Specify Loadstar for HP per cubic inch as high as any—for HP per pound higher than most. *Write for descriptive literature.*

THE LELAND ELECTRIC COMPANY, DAYTON 1, OHIO. ***Branches in all principal cities.***

LELAND LOADSTAR MOTORS

MOTORS OF ALL TYPES—ENGINEERED TO INDUSTRY'S SPECIFIC NEEDS



How a One-eyed Phantom Steers a Boat

INCO Nickel Alloys help this new robot pilot "see" and correct tiny deviations from course

Plunging through rough seas . . . with no hand at its helm . . . a ship equipped with a Kirsten Photo-Electric Pilot clings to its course with uncanny accuracy.

This robot, manufactured by the Marine Division of the Kirsten Pipe Company, Seattle 9, Washington, gets its initial signal from an electric eye in the compass binnacle.

The slightest deviation of the compass increases or decreases the intensity of a beam of light. This energizes a power unit which, in turn, operates the steering mechanism.

In designing their power unit, Kirsten ran into trouble with the solenoid shaft.

This vital part had to be non-magnetic, strong, and able to take a high polish to cut down friction between the shaft and the steel clutch. It had to be easy to machine and capable of resisting corrosive marine atmospheres.

After experimenting with many metals, Kirsten engineers finally found the one with *all* the properties required. Its name? "KR"* Monel.

Also, when perfecting their binnacle unit, these men chose another INCO Nickel Alloy . . . "K"* Monel. Ball bearings of this strong, extra-hard, corrosion-resistant metal enable the binnacle assembly to move freely and easily . . . despite constant wear, damp sea air, and changing temperatures.

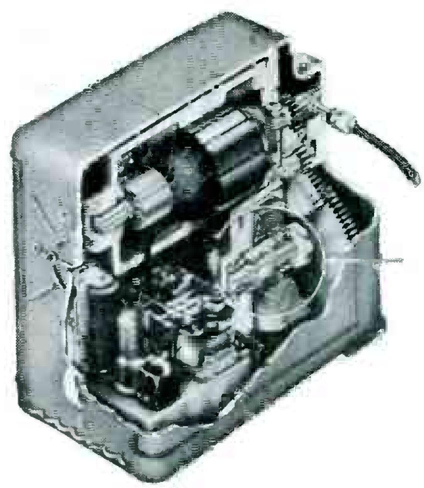
Find out where and how one or more of the family of INCO Nickel Alloys can help *you* solve metal-selection problems. Put these alloys at the top of the list when you're searching for metals with a hard-to-find combination of properties.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE

MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL
INCONEL* • NICKEL • "L"* NICKEL • "Z"* NICKEL *Reg. U.S. Pat. Off.

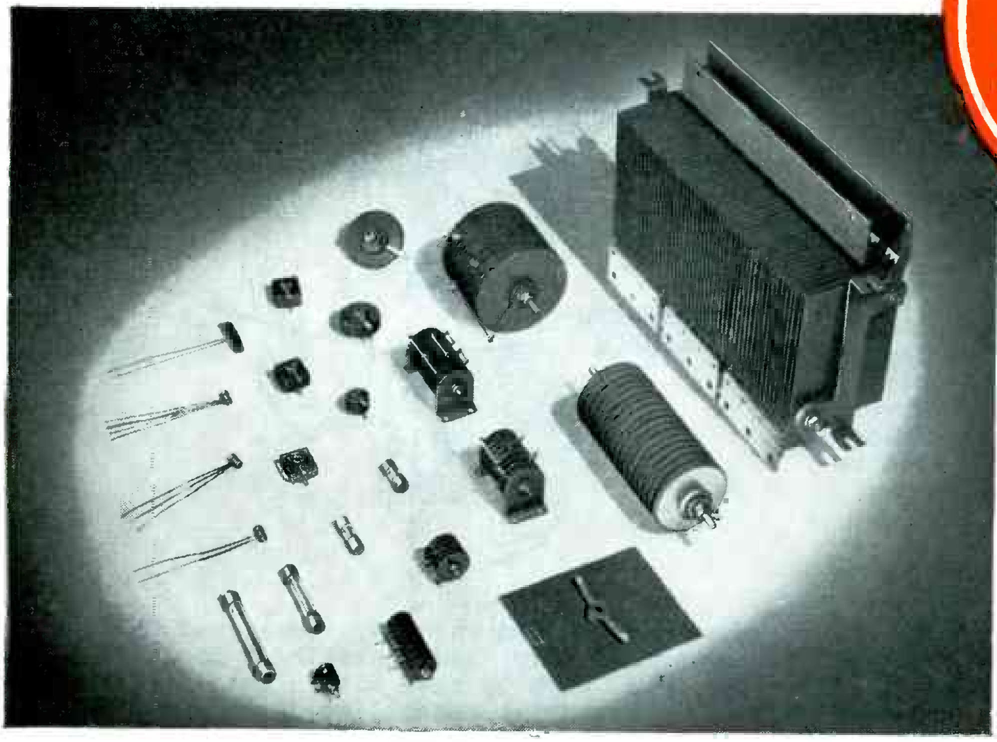
Section of Kirsten Photo-Electric binnacle. The compass assembly rotates on hard, corrosion-resistant "K" Monel ball bearings. Robot pilots such as these are used today on commercial and pleasure craft up to 100 ft. in length.



Power unit of Kirsten Photo-Electric pilot. Arrow shows "KR" Monel solenoid shaft which engages the clutch mechanism.

The FIRST NAME in Selenium Rectifiers

FTR



HERE'S HOW IT CAN HELP KEEP YOUR PRODUCTS FIRST IN THE FIELD.

When your electrical products go into service, your reputation as a manufacturer goes with them! Their competitive survival depends on how they stand up on the job — on the quality and dependability of every component. And where your equipment calls for conversion of AC to DC, a *rectifier* is one of those vital parts. That's where Federal can really help you build a better product—one that will stay first in the field.

Here's why. The Selenium Rectifier — an IT&T development — was first introduced into this country by Federal, in 1938. And, by constant research and improvement, Federal Selenium Rectifiers have continued to set the industry's standards for long, trouble-free service. The initials "FTR" on any Selenium Rectifier mean the last word in engineering excellence and craftsmanship — the inherent reliability that assures longer life for your product.

There's a Federal Selenium Rectifier for practically every power-conversion job—from milliwatts to kilowatts. For complete information, write Federal today. Dept. F313.

FTR
An IT&T Associate

Federal Telephone and Radio Corporation

SELENIUM and INTELIN DIVISION, 1000 Passaic Ave., East Newark, New Jersey

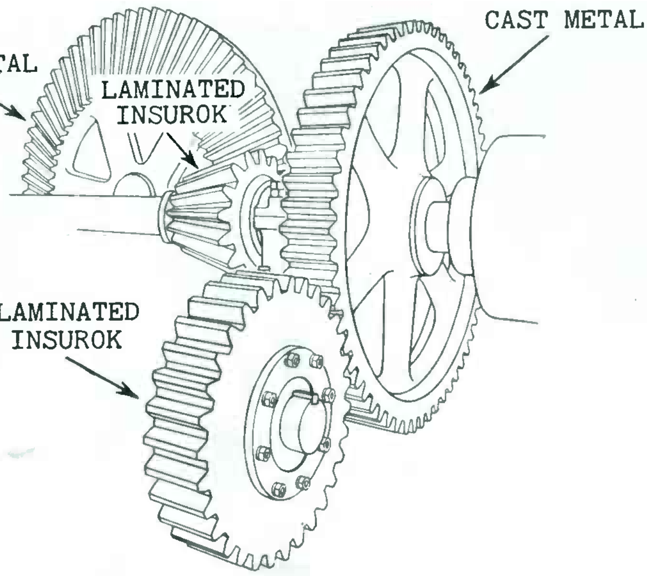
KEEPING FEDERAL YEARS AHEAD...is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N. Y.

Problems Solved by Richardson...in plastics

#4 Noise reduction through use of plastic gears

PROBLEM: A cast-metal gear assembly forming the back-drive of a 132" paper board machine was creating an almost unbearable screech and howl - so much in fact that the effect on the nerves of the employees was slowing production. Furthermore, teeth were frequently being sheared from the spur pinion because of tremendous back-lash.



SOLUTION: Richardson Plasticians were called in. They redesigned the tooth structure on the entire gear assembly, and installed a Laminated INSUROK spur pinion and beveled gear, each to mate with a metal gear. This was so satisfactory that all back-drive assemblies on this machine, as well as on similar machines in other plants, were changed to conform. Result:

(1) Stripping of teeth completely eliminated.

(2) Less wear and longer life for all gears in the assembly.

(3) Elimination of approximately 80 per cent of the noise.

(4) Greatly improved working conditions.

(5) Increased daily production.

INSUROK *Precision Plastics*

INSUROK is the name of industrial laminated and molded synthetic plastic products produced by Richardson. Laminated INSUROK is available in sheets, rods, tubes, punched and machined parts, made with paper, fabric, glass, etc. Molded INSUROK products are made from Beetle, Bakelite, Plaskon, Tenite, Styron, Durez, Lucite, etc., by compression, injection and transfer molding.

The RICHARDSON COMPANY

Sales Headquarters, MELROSE PARK, ILL. FOUNDED 1858 LOCKLAND, CINCINNATI 15, OHIO

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RICHARDSON MEANS *Versatility* IN PLASTICS

For Quality and Performance

BURNELL *offers*

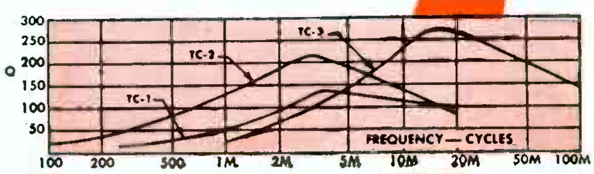
High Q TOROIDAL COILS

The solution of filter network problems, has been greatly simplified through the use of toroidal coils wound on molybdenum permalloy cores. Design engineers have learned to depend upon them since discovering that only these toroids possess all the necessary qualities of a good high "Q" coil.

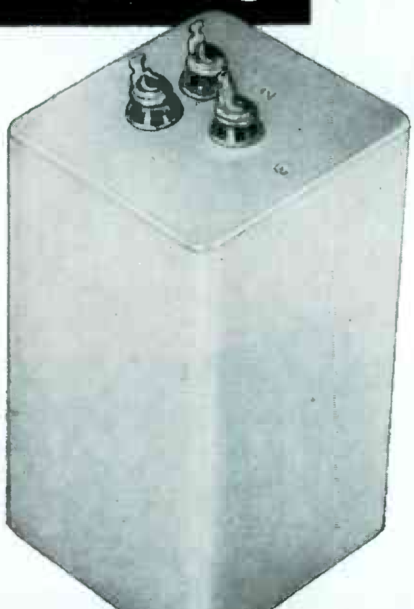
The most available types now being supplied are

TYPE	IND. RANGE
TC-1 Any Ind. up to	7 HYS
TC-2 Any Ind. up to	20 HYS
TC-3 Any Ind. up to	350 MHYS

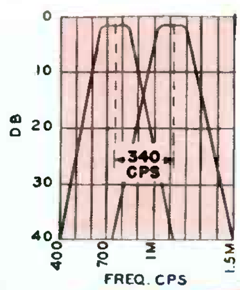
Be sure to state desired inductance.

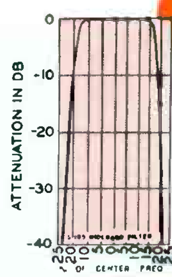


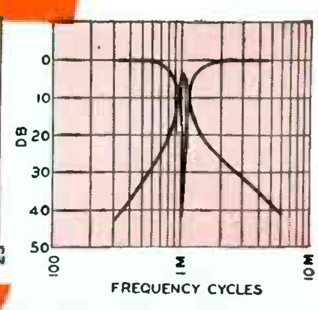
TOROIDAL COIL FILTERS



Our toroid filters have become a by-word in every phase of electronics where only the best results are acceptable. Toroidal coils wound on MOLYBDENUM PERMALLOY DUST CORES are the primary basis for our success in producing filters unexcelled in performance. We are producing toroidal coil filters which consistently demonstrate the value of toroidal coils. These filters cannot be matched in stability, accuracy and sharpness by filters made with the usual laminated type of coil.







Burnell & Company

DESIGNERS AND MANUFACTURERS OF ELECTRONIC PRODUCTS

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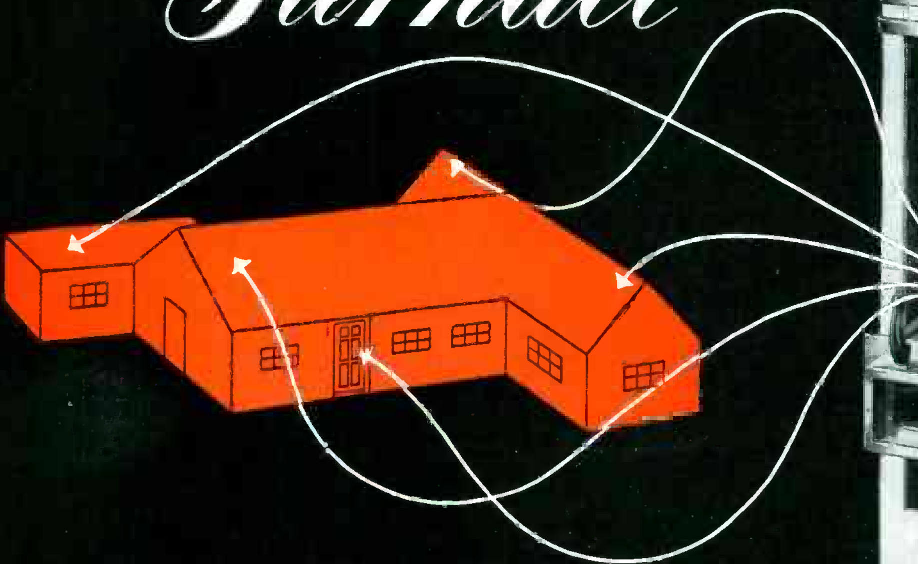
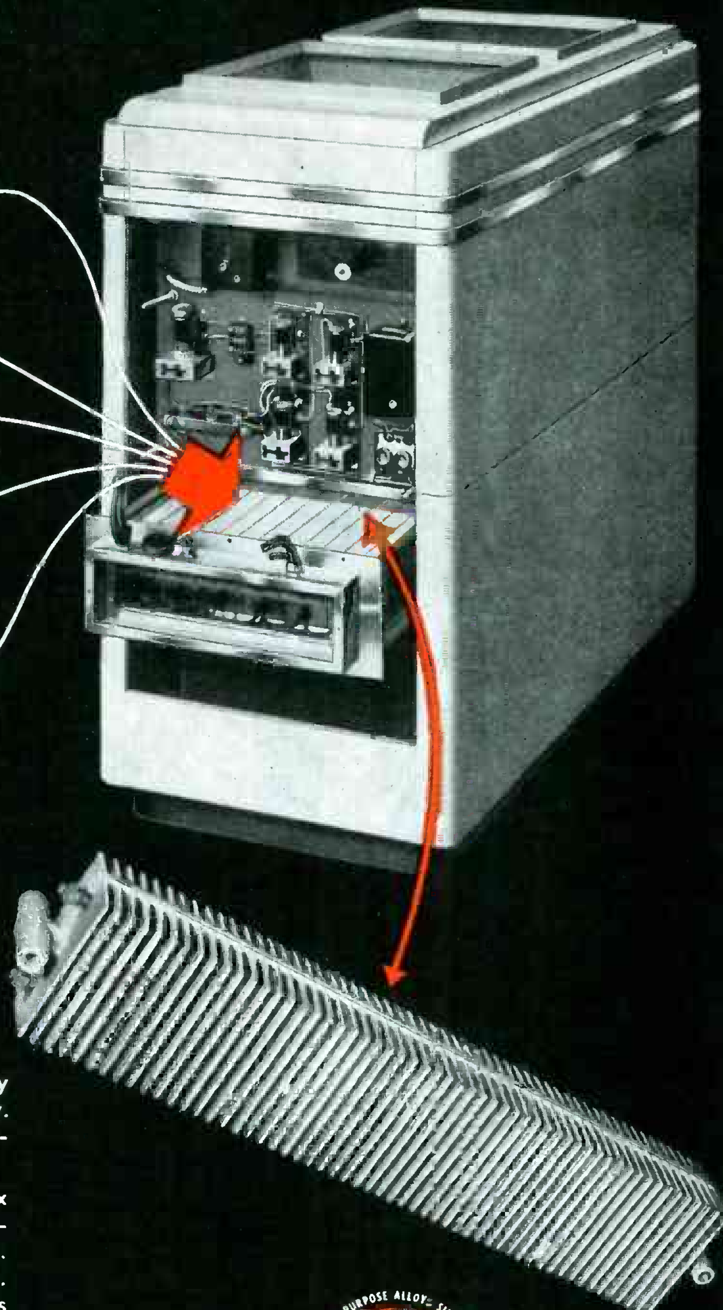
ALL INQUIRIES WILL BE PROMPTLY HANDLED
WRITE FOR OUR CATALOGUE

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.

Driver-Harris
COMPANY

Exclusive Manufacturers of Nichrome

HARRISON, N. J.

BRANCHES: Chicago • Detroit • Cleveland
Los Angeles • San Francisco • Seattle

THE B. GREENING WIRE COMPANY, LTD.
Hamilton, Ontario, Canada

*Trade Mark Reg. U. S. Pat. Off.

"FASTER four ways"
says
The Rudolph Wurlitzer Co.

Extracts from another of the series of independent surveys by James O. Peck Co., of assembly savings made with Phillips in leading plants.

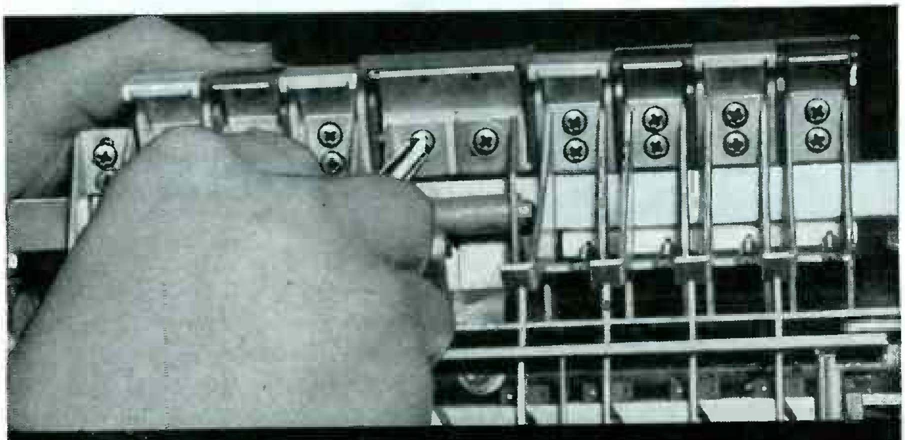
"We specify Phillips Screws for our coin-operated phonographs," said Wurlitzer's engineering staff, "because they're faster four important ways.

"Start quicker, drive faster. Although we haven't made actual time studies, it's fairly easy to see how much shorter assembly time is with Phillips Screws. That's natural . . . the perfect fit of the driving bit in the Phillips Recess makes locating the screw and driving it much more positive.

One screw driver slip at this point in the assembly and an expensive, highly polished piece of Plexiglas would be ruined; and worse still, a half hour of assembly time irretrievably lost. Wurlitzer uses Phillips Screws and avoids slips.

"Tricky assemblies simplified. The firm seat of the driver in the Phillips Recess speeds up otherwise slow jobs such as blind driving, sensitive adjustments, spring assemblies, and driving with jigs.

"No mental hazards . . . steadier work. Inside and out, there are a lot of places where a skidding screw driver would do a vast amount of harm to these machines. Since that danger is non-existent with Phillips Screws, our assemblers make better time, work more smoothly.



Adjusting the selector keys. The absolute seat of the driver bit in the Phillips Recess lets the assembler concentrate all her attention on the adjustment.

"New help learns faster. Even people who have never driven screws in factory production can be trained to drive Phillips Screws much easier and faster than they could be taught to drive slotted screws. Also eliminated is the danger to hands and arms from jagged, burred heads turned up so frequently on slotted screws. And far fewer screws are dropped on the floor . . . a not inconsiderable saving to us."

Ideas for your assembly operations . . . FREE, in this Wurlitzer report and in other assembly reports . . . covering metal, wood and plastic products. Use coupon.

PHILLIPS *Recessed Head* SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

24 SOURCES

American Screw Co.
Central Screw Co.
Continental Screw Co.
Corbin Screw Div. of American Hdwe. Corp.
Elco Tool & Screw Corp.
The H. M. Harper Co.
International Screw Co.
Lamson & Sessions Co.
Milford Rivet and Machine Co
National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.
Pheoll Manufacturing Co.
Reading Screw Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wolverine Bolt Company

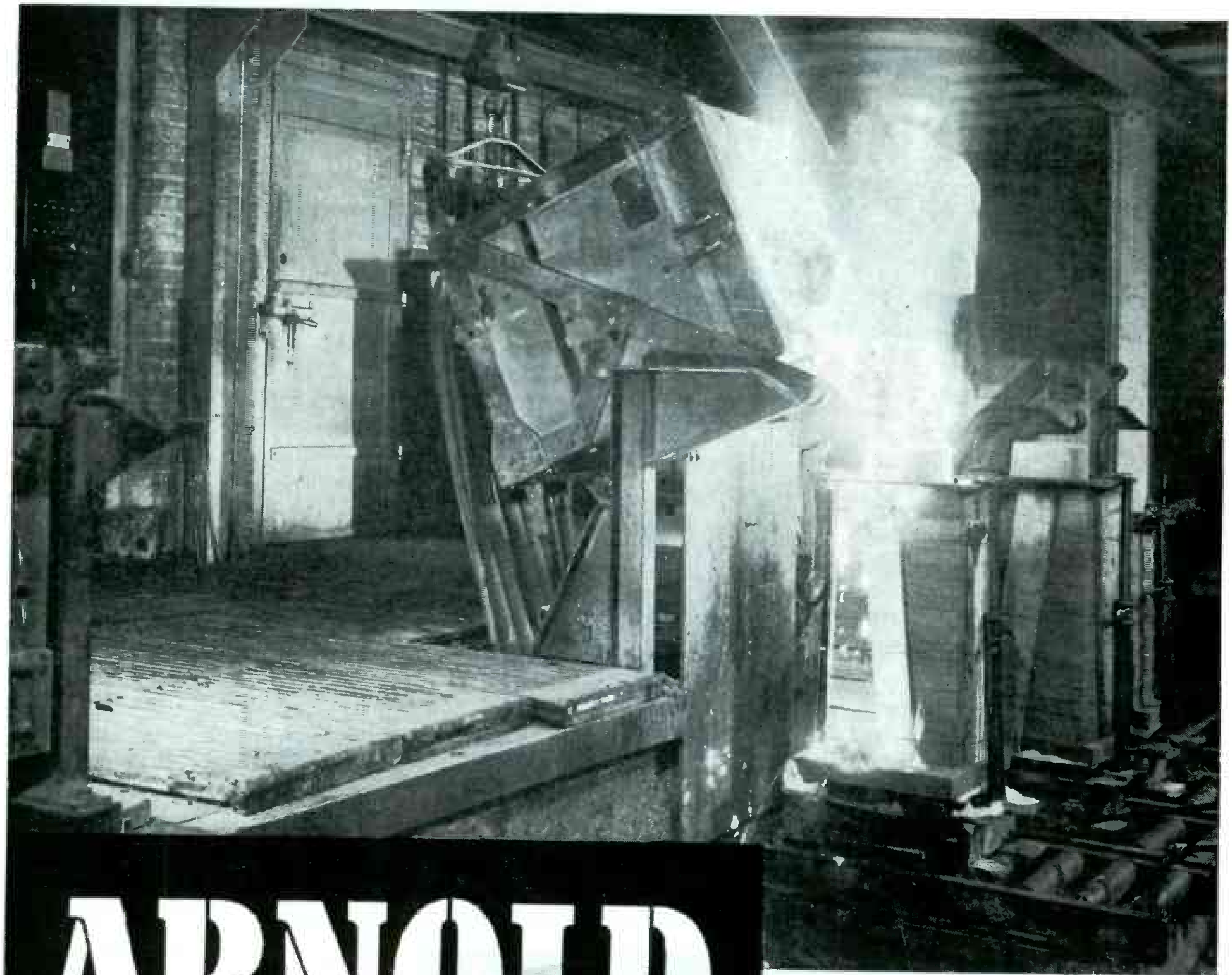
Phillips Screw Mfrs., c/o Horton-Noyes
1800 Industrial Trust Bldg.,
Providence, R. I.

Send me reports on Assembly Savings with Phillips Screws.

Name ....

Company E-25

Address ....



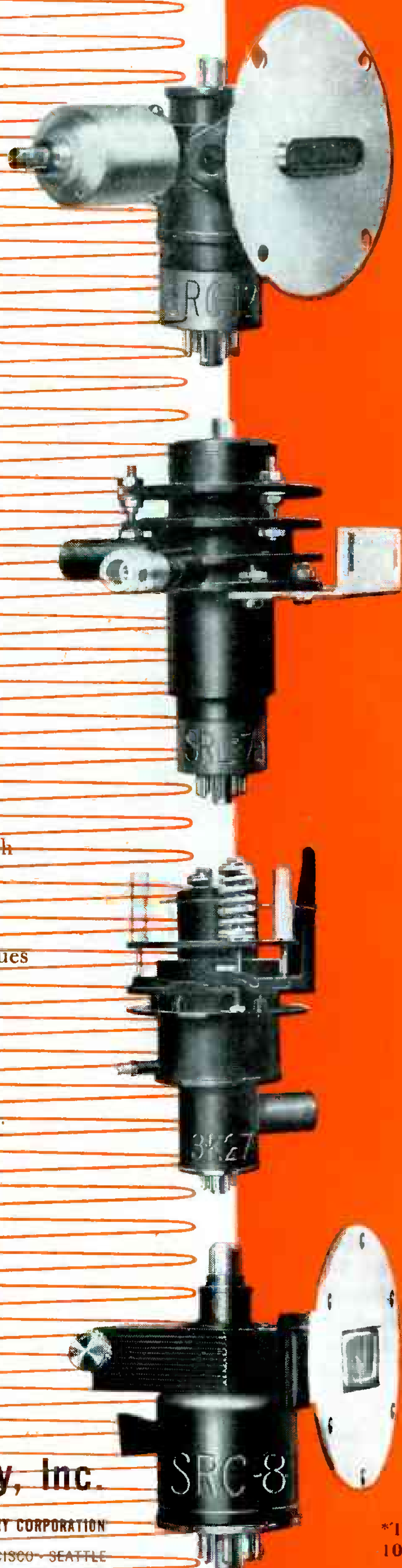
new klystron tubes

NOW AVAILABLE FOR MICROWAVE RELAYS

■ Four Sperry Reflex Klystron oscillators for microwave relay systems are now available for commercial use. These Klystrons can be used either as transmitting types or local oscillators. They can also be used in the laboratory as bench oscillators in the development of microwave relay systems.

■ With these new Klystron tubes, relay techniques are simplified and the mechanical problems associated with lower frequency relay links are overcome.

■ Other Sperry Klystrons are available in the frequency range from 500 to 12,000 megacycles. Our Industrial Department will gladly supply further information.



TYPE SRC-12,-20,-21
FREQUENCY 4400-5000 mc
POWER OUTPUT 5 WATTS MAX.

TYPE SRL-7a
FREQUENCY 1825-2100 mc
POWER OUTPUT 5 WATTS MAX.

TYPE 3K27
FREQUENCY 750-960 mc
POWER OUTPUT 1.5 WATTS MAX.

TYPE SRC-8 SERIES
FREQUENCY 5500-7800 mc*
POWER OUTPUT 4.5 WATTS MAX.

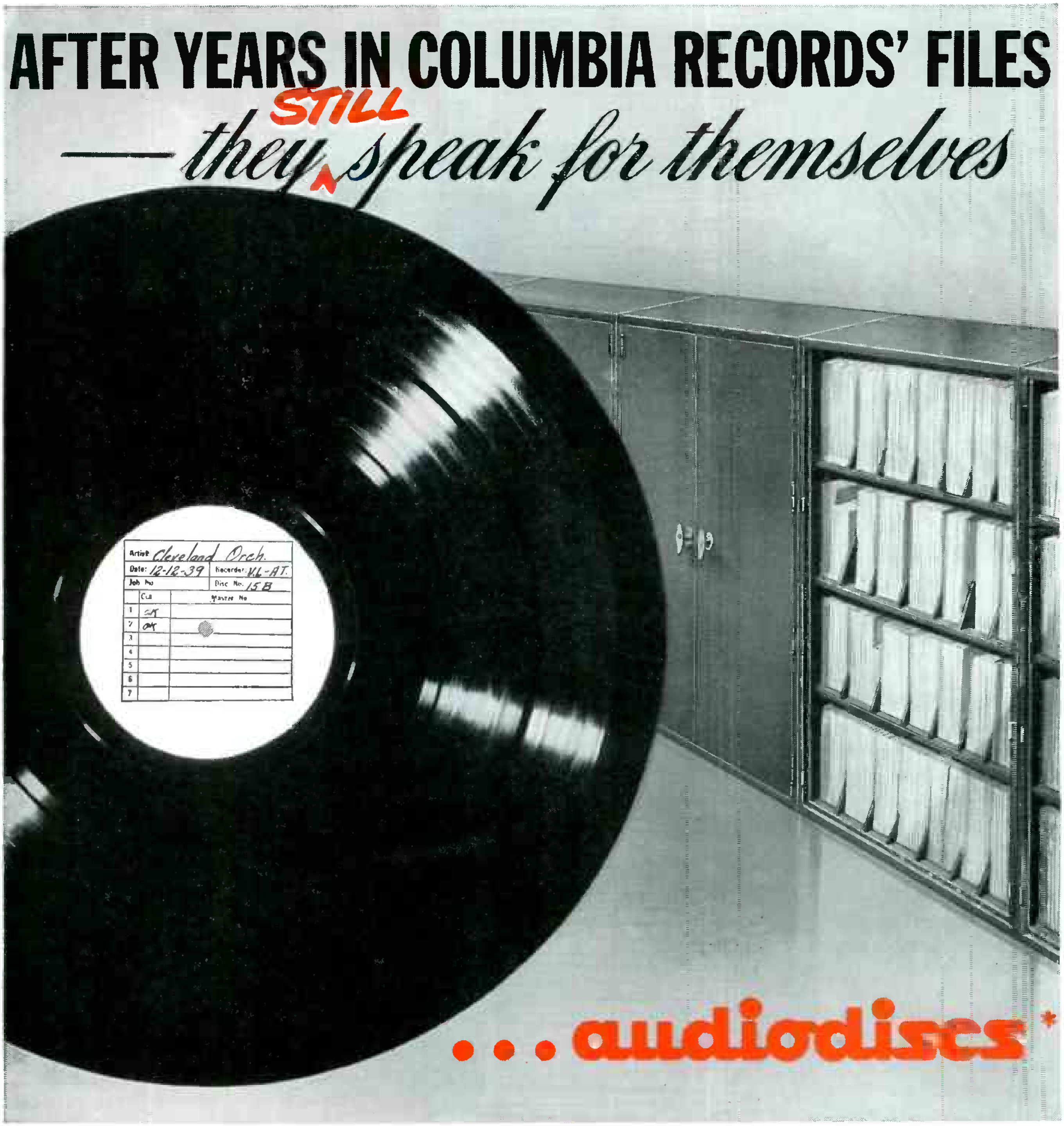
*The SRC-8 tubes are available in 100 megacycle steps except for 3 models, SRC-8A, SRC-8B, SRC-8C which are bench oscillators in 400 megacycle steps from 5850 to 7050.

SPERRY

Sperry Gyroscope Company, Inc.

EXECUTIVE OFFICES: GREAT NECK, NEW YORK • DIVISION OF THE SPERRY CORPORATION

NEW YORK · CLEVELAND · NEW ORLEANS · LOS ANGELES · SAN FRANCISCO · SEATTLE



"Master safety disc No. 15B — an AUDIODISC — recorded December 12, 1939, was taken from our files and played back on September 12, 1947. This test showed that after almost eight years the recorded quality was still excellent and there was no measurable increase in surface noise. Surface noise of a new cut, made on this disc at the same date in 1947, was no different from the original cut."

This is the brief, factual report by Columbia recording engineers on a test made to measure the lasting qualities of AUDIODISCS. In the photograph the two large bands show the orchestral recording made in 1939. Close to these are the unmodulated grooves cut this year.

One more convincing proof of a most important claim — *"AUDIODISCS do not deteriorate with age either before or after recording, and there is no increase in surface noise from the time of recording to playback or processing—whether it be a few days or many years."*

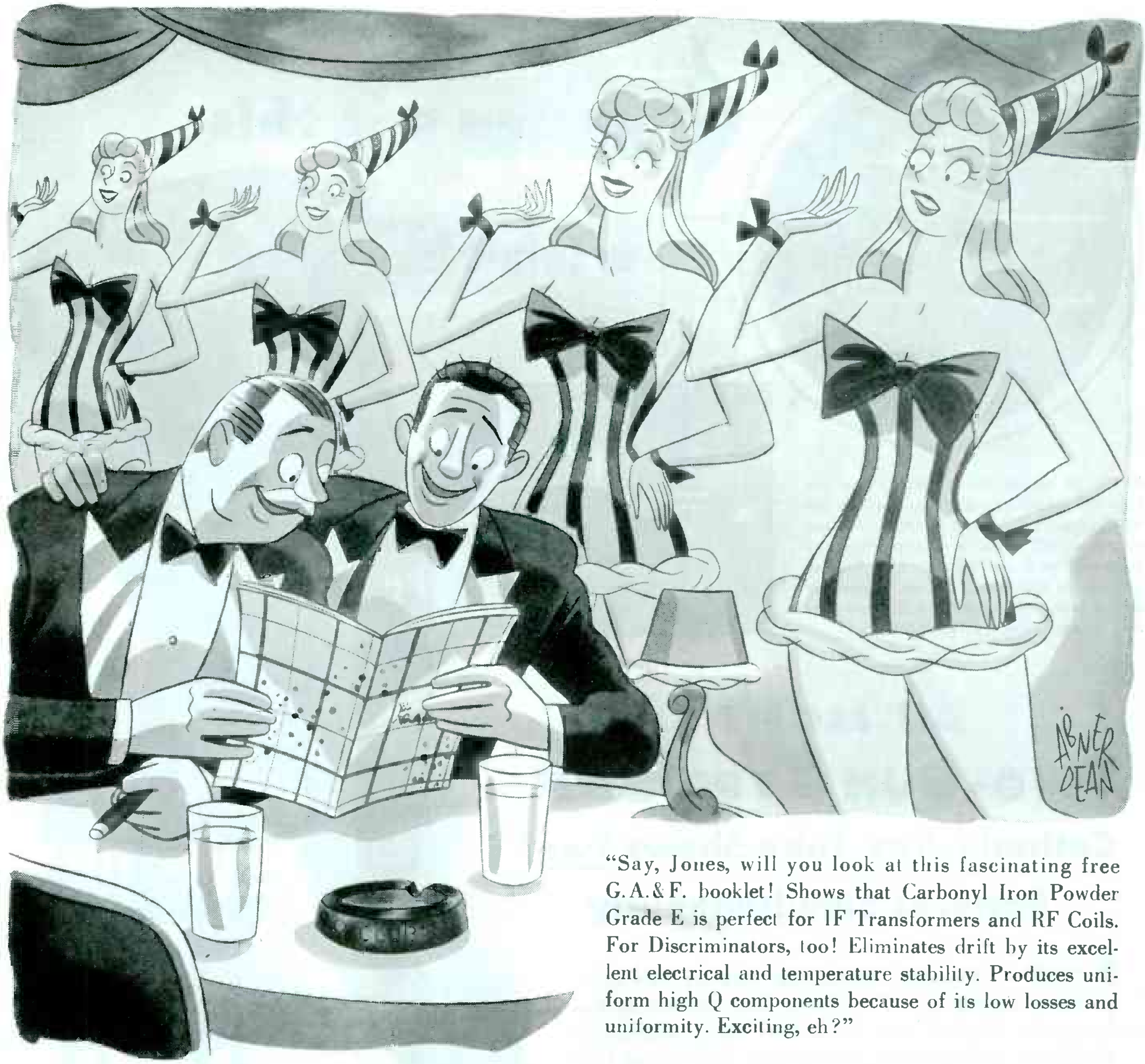
AUDIO DEVICES, INC., 444 Madison Avenue, New York 22, N.Y.

Export Department: Rocke International Corp., 13 E. 40th Street, New York 16, N. Y.

Audiodiscs are manufactured in the U.S.A. under exclusive license from PYRAL, S.A.R.L., Paris

* REG U S PAT. OFF.

they speak for themselves **audiodiscs**

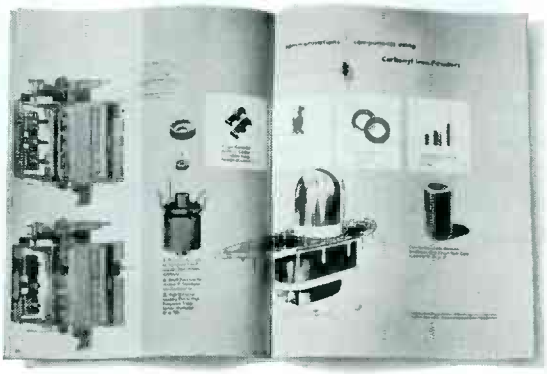


"Say, Jones, will you look at this fascinating free G.A.&F. booklet! Shows that Carbonyl Iron Powder Grade E is perfect for IF Transformers and RF Coils. For Discriminators, too! Eliminates drift by its excellent electrical and temperature stability. Produces uniform high Q components because of its low losses and uniformity. Exciting, eh?"

G.A.&F.

carbonyl iron powders

An Antara* Product of General Aniline & Film Corporation



FREE! This easy-to-read booklet that can save money — *real* money — for every radio engineer and electronics manufacturer!

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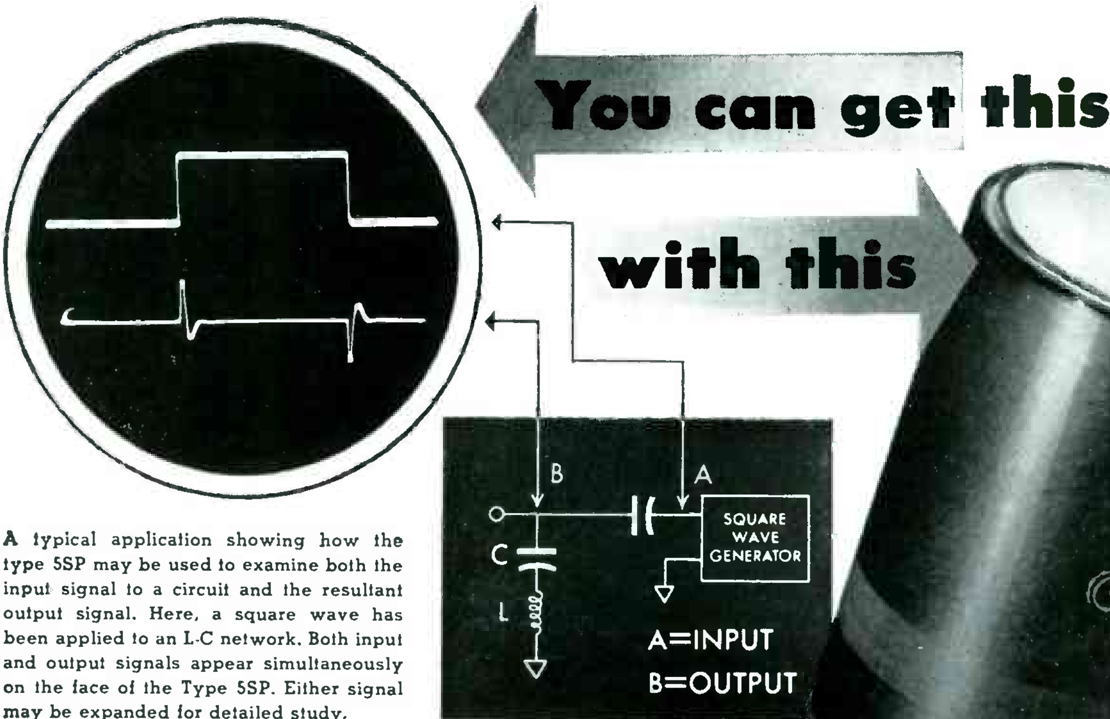
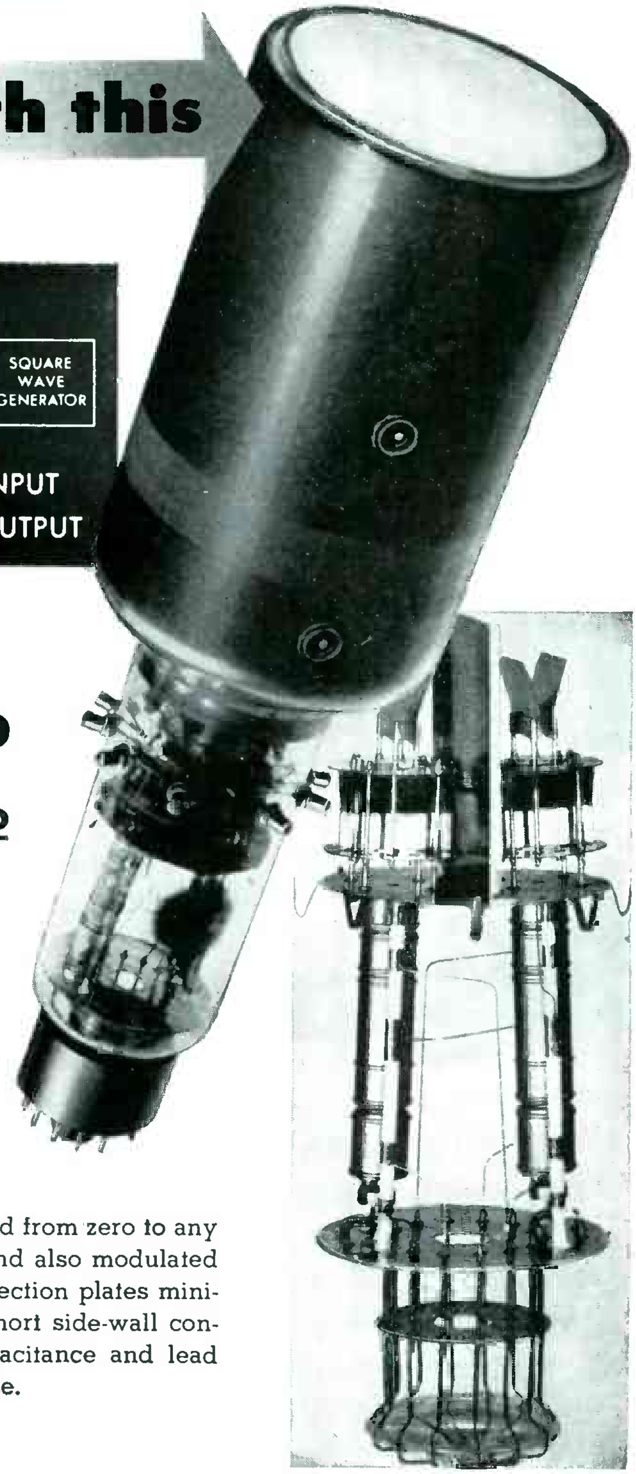


A typical application showing how the type 5SP may be used to examine both the input signal to a circuit and the resultant output signal. Here, a square wave has been applied to an L-C network. Both input and output signals appear simultaneously on the face of the Type 5SP. Either signal may be expanded for detailed study.



DU MONT'S
TWO-GUN TYPE 5SP
Cathode-Ray Tube Shows Two Patterns Simultaneously

NOW—a superior method for viewing *two* independent signals *simultaneously*. Not subject to the frequency limitations encountered when using the electronic switch. More convenient than using two oscillographs side by side.

Du Mont's Type 5SP tube contains *two complete electron guns* in a 5-inch flat-faced envelope. The X, Y and Z axes of each electron gun can be independently controlled, thus permitting two traces to be spaced from zero to any value desired within limitations of the tube diameter, and also modulated as desired. Adequate shielding betweens guns and deflection plates minimizes "cross-talk" particularly at higher frequencies. Short side-wall connections to deflection plates minimize shunt-input capacitance and lead inductance. Army-Navy approved diheptal 12-inch base.

Further Details on Request

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

MEASURE TOTAL DISTORTION
Between 20 cps and 20 kc

-hp- 330B DISTORTION ANALYZER

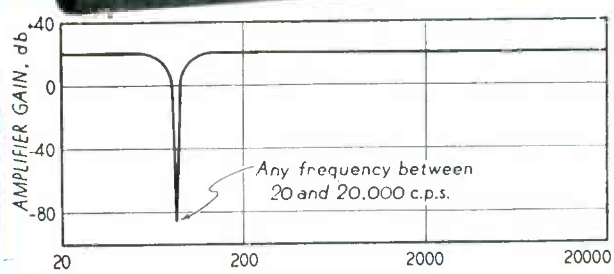


Figure 1

CHECK THESE SEVEN IMPORTANT FUNCTIONS:

1. **Measures total audio distortion.**
2. **Checks distortion of modulated r-f carrier.**
3. **Determines voltage level, power output.**
4. **Measures amplifier gain and response.**
5. **Directly measures audio noise and hum.**
6. **Determines unknown audio frequencies.**
7. **Serves as high-gain, wide-band stabilized amplifier.**

This fast, versatile *-hp-* 330B Analyzer measures distortion at *any* frequency from 20 cps to 20 kc. Measurements are made by eliminating the fundamental and comparing the ratio of the original wave with the total of remaining harmonic components. This comparison is made with a built-in vacuum tube voltmeter.

The unique *-hp-* resistance-tuned circuit used in this instrument is adapted from the famous *-hp-* 200 series oscillators. It provides almost infinite attenuation at one chosen frequency. All other frequencies are passed at the normal 20 db gain of the amplifier. Figure 1 shows how attenuation of approximately 80 db is achieved at any pre-selected point between 20 cps and 20 kc. Rejection is so sharp that second and higher harmonics are attenuated less than 10%.

Full-Fledged Voltmeter

As a high-impedance, wide-range, high-sensitivity vacuum tube voltmeter, this *-hp-* 330B gives precision response flat at any frequency from 10 cps to 100 kc. Nine full-scale ranges are provided: .03, .1, .3, 1.0, 3.0, 10, 30, 100 and 300. Calibration from +2 to −12 db is provided, and ranges are related in 10 db steps.

The amplifier of the instrument can be used in cascade with the vacuum tube voltmeter to increase its sensitivity 100 times for noise and hum measurements.

Accuracy throughout is approximately ±3% and is unaffected by changing of tubes or line voltage variations. Output of the voltmeter has terminals for connection to an oscilloscope, to permit visual presentation of wave under measurement.

Measures Direct From R-F Carrier

The *-hp-* 330B incorporates a linear r-f detector to rectify the transmitted carrier, and input circuits are continuously variable from 500 kc to 60 mc in 6 bands.

Ease of operation, universal applicability, great stability and light weight of this unique *-hp-* 330B Analyzer make it ideal for almost any audio measurement in laboratory, broadcast or production line work. Full details are immediately available. Write or wire for them—today Hewlett-Packard Company, 1437A Page Mill Road, Palo Alto, Calif.

-hp- laboratory instruments
FOR SPEED AND ACCURACY

Noise and Distortion Analyzers — Wave Analyzers — Frequency Meters — Audio Frequency Oscillators — Audio Signal Generators — Vacuum Tube Voltmeters — Amplifiers — Power Supplies — UHF Signal Generators — Attenuators — Square Wave Generators — Frequency Standards — Electronic Tachometers

PLASTICON HIVOLT SUPPLIES

High Voltage - Low Current DC Power Supplies

for

Television—Radiation Counters—Photoflash Devices—Electrostatic Precipitators—Spectrographic Analysers, Oscilloscopes, Etc.

HiVolt Supplies are self-contained in hermetically sealed metal containers. They are designed to transform low voltage AC to high voltage - low current DC.

HiVolt PS-1

Specifications:

Volts Input: 118 VAC, 60 cycles.
Volts Output: 2400 VDC (capacitor load)
Current Output: .006 Amps., half-wave DC.
Max. Watts Input: 15 watts.
Type of Filter: Not filtered.
Terminals: 8-32 screw and nuts.
Insulation: 118 VAC—2 bakelite washers;
2400 VDC—1 porcelain standoff;
2400 VDC—lug spotwelded to case.
Container: Terne plate steel—gray lacquer finish.
Size: 3¾" x 3 3/16" x 5½".
Weight: 2.2 lbs.

List Price $18.95 F. O. B. Chicago

NOTE: The PS-1 is designed to charge a parallel-wired bank of not more than 15 AOCOE-22C3 Plasticon Energy Storage Capacitors (48 mfd.).

HiVolt PS-2

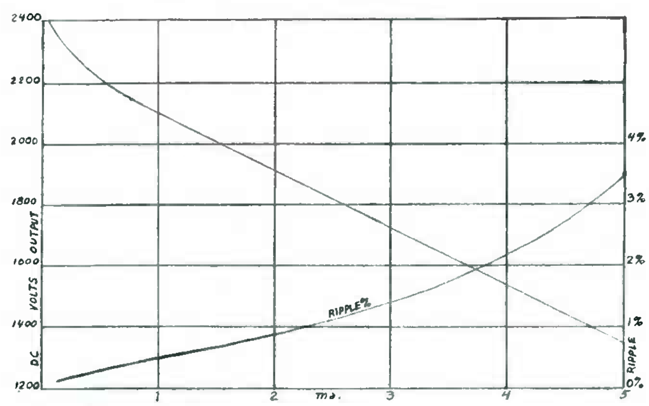
Specifications:

Volts Input: 118 VAC, 60 cycles.
Volts Output: 2400 VDC, maximum.
Current Output: .005 Amps. DC. maximum.
Max. Watts Input: 10 watts.
Type of Filter: R. C. Filter: 50,000 ohms, 2x.1 mfds.
Terminals: 8-32 screw and nut.
Insulators 118 VAC—2 bakelite washers;
2400 VDC—2 porcelain standoffs;
container neutral.
Container: Terne plate steel—gray lacquer finish.
Size: 3¾" x 3 3/16" x 5½".
Weight: 2.5 lbs.

List Price $25.75 F. O. B. Chicago

NOTE: The PS-2 is similar in appearance to the PS-1 except that all four terminals are on the recessed top of the container.

Regulation and Ripple Curves



Condenser Products Company

1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS

THE ONE DEPENDABLE SOURCE OF SUPPLY FOR EVERYTHING IN ELECTRICAL INSULATION

*MIRAGLAS

WOVEN TAPES, TUBINGS

SLEEVINGS & CORDS

CLOTHS, ETC.

VARNISHED TUBINGS

SLEEVINGS & TAPES

COTTON TAPES & SLEEVINGS

*MIRAGLAS-MICA COMBINATIONS

VARNISHES—WAXES—COMPOUNDS

* Woven of Fiberglas Yarn

MITCHELL-RAND INSULATION CO. Inc.

51 MURRAY STREET · COrtlandt 7-9264 · NEW YORK 7, N. Y.

A PARTIAL LIST OF M-R PRODUCTS: FIBERGLAS VARNISHED TUBING, TAPE AND CLOTH · INSULATING PAPERS AND TWINES · CABLE FILLING AND POTHEAD COMPOUNDS · FRICTION TAPE AND SPLICE · TRANSFORMER COMPOUNDS · FIBERGLAS SATURATED SLEEVING · ASBESTOS SLEEVING AND TAPE · VARNISHED CAMBRIC CLOTH AND TAPE · MICA PLATE, TAPE, PAPER, CLOTH, TUBING · FIBERGLAS BRAIDED SLEEVING · COTTON TAPES, WEBBINGS AND SLEEVINGS · IMPREGNATED VARNISH TUBING · INSULATED VARNISHES OF ALL TYPES · EXTRUDED PLASTIC TUBING

One of a series *of messages to help you increase your understanding of business paper advertising, and its effect on your business.*

What happens when the "push-overs" start pushing back?

ASK ANY GOOD SALESMAN, and he'll tell you that the lush days are just about gone—along with shortages, slow production and the sellers' market.

Today, customers are playing hard to get. The "push-overs" are beginning to push back. Production isn't lagging any more—it's already nearly double the pre-war level, and fast catching up with demand. There's plenty of healthy competition in sight. And you can be glad there is.

American business has always thrived on competition. It still can. But the machinery of selling and distribution will have to work at peak efficiency.

And that means — *more mechanization!*

Mechanization is simply the application of assembly-line methods to the *manufacture of a sale.* It's the only way to balance mass production.

With mechanized selling, you won't turn prospects into "push-overs," but you'll certainly get them leaning your way. By exploring the field, arousing interest, creating a preference for the things your company makes, mechanized selling multiplies the productive capacity of your sales force by the hundreds, or thousands, or by any number your market requires.

But this machine is no stranger to *you.* You know it by its first name—ADVERTISING.

We'd just like to point out that now is the time to put the machine to work, more consistently, more aggressively than ever. And remember that when your advertising goes to work in the right business papers, with their tremendous concentration of hand-picked readers, it becomes *the most efficient machine* you can use for manufacturing sales at a profit.

Just how efficiently does business paper advertising work? If you'd like to see some examples, we'll be glad to send you a recent ABP folder on actual results. Also, if you'd like reprints of this advertisement (or the entire series) to show to others in your organization, you may have them for the asking.

THE ASSOCIATED BUSINESS PAPERS ABP MEMBER

ELECTRONICS

is one of the 129 members of The Associated Business Papers, whose chief purpose is to maintain the highest standards of editorial helpfulness—for the benefit of reader and advertiser alike.

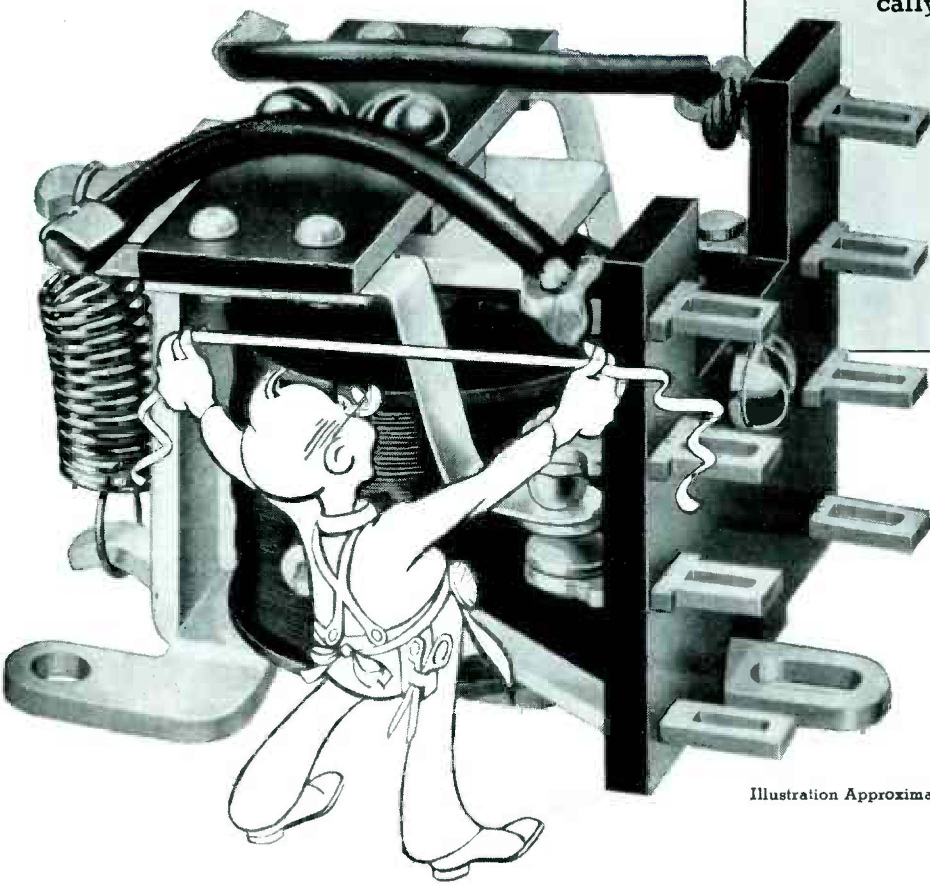
✓ Low in price ✓ Small in Size

✓ Adapted mechanically and electrically to circuit requirements

✓ Built for unsurpassed *overall* performance

✓ Prompt deliveries

✓ Designed for Underwriters' requirements



TYPE 119XBX

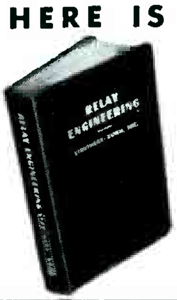
A typical Struthers-Dunn Relay type originally designed for vending machines

Illustration Approximately Twice Size

5,348 RELAY TYPES...

"tailored specifically to your needs"

HERE IS RELAY EXPERIENCE

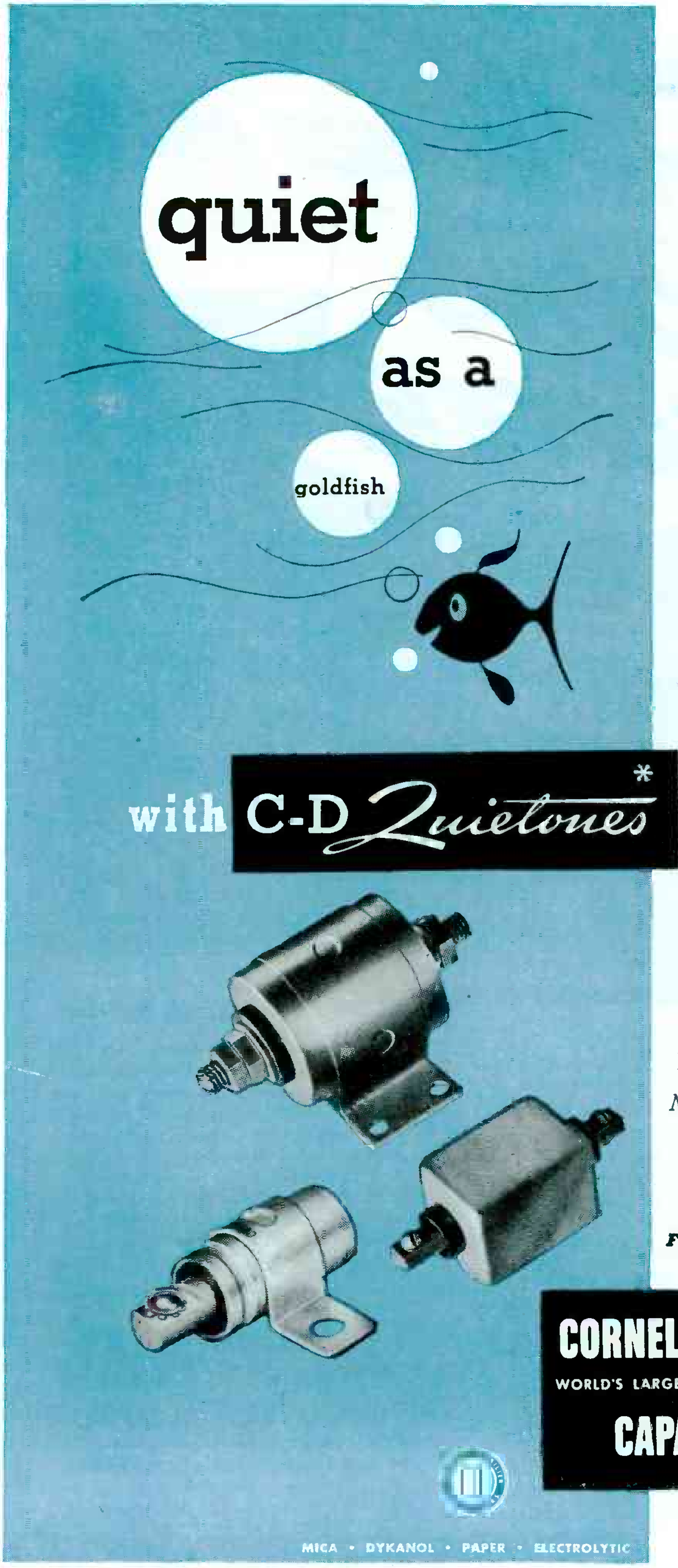


This 640-page, profusely illustrated RELAY ENGINEERING HANDBOOK brings you full benefit of 25 years of specialized relay experience — in terms of helping you select the right relay for the job, then install and maintain it properly. Over 15,000 engineers already use the Handbook. 3rd printing now available. $3 per copy.

With its vast array of 5,348 relay types to choose and adapt from, Struthers-Dunn can readily match the requirements of your circuit and your pocketbook. As long-time specialists in quality relays for critical applications, you will find our prices well in line — and you'll get all of the many advantages of relays that are specifically "tailored" for your circuit by way of good measure.

STRUTHERS-DUNN

STRUTHERS-DUNN, INC., 150 N. 13TH STREET, PHILADELPHIA 7, PA.



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. **K1,** *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.

PERSONALLY CONDUCTED THROUGH THE REVERE MILLS

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

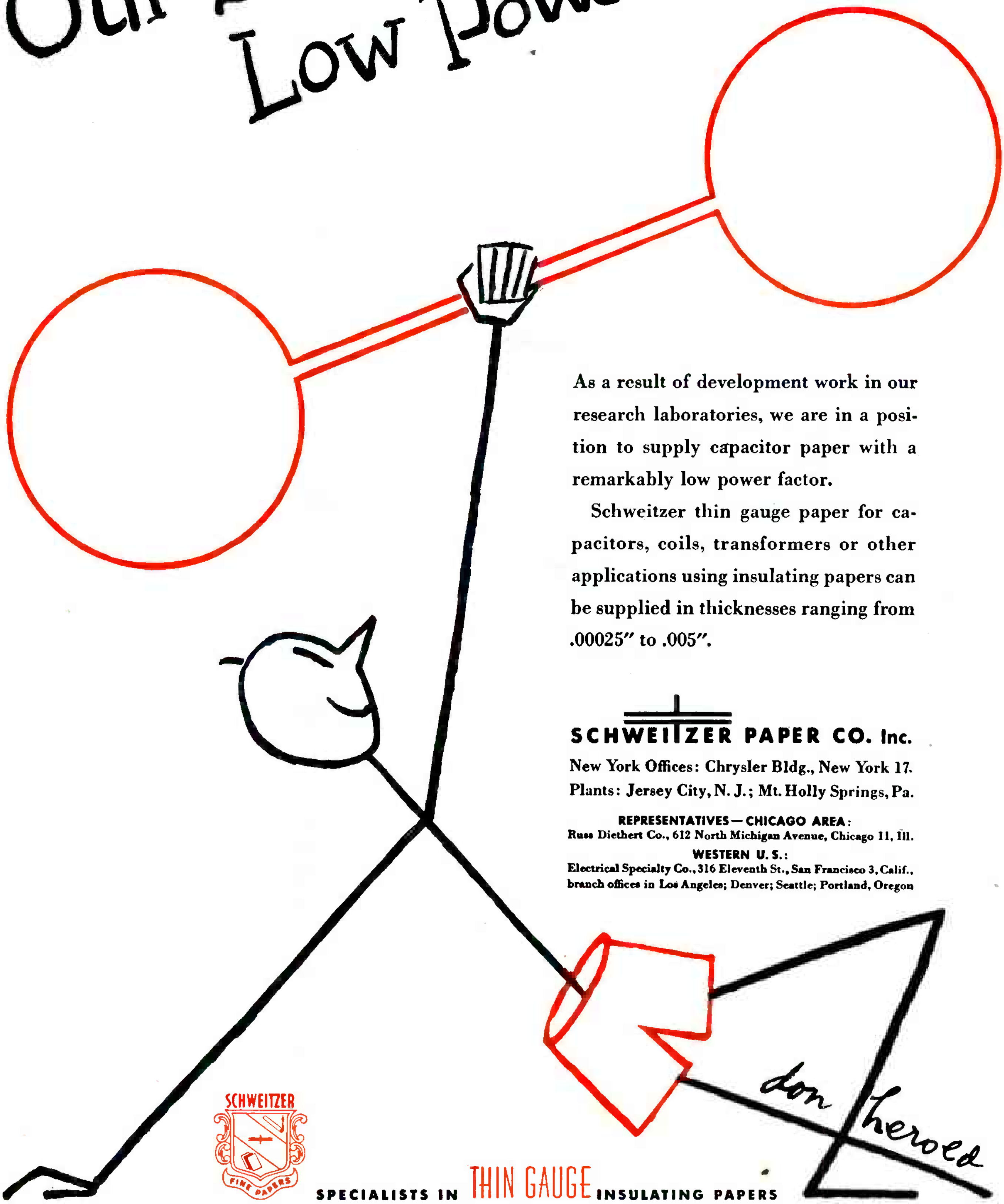
230 Park Avenue, New York 17, New York

• • •

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

Sales Offices in Principal Cities, Distributors Everywhere

Our Strength lies in our Low Power Factor



As a result of development work in our research laboratories, we are in a position to supply capacitor paper with a remarkably low power factor.

Schweitzer thin gauge paper for capacitors, coils, transformers or other applications using insulating papers can be supplied in thicknesses ranging from .00025″ to .005″.

SCHWEITZER PAPER CO. Inc.

New York Offices: Chrysler Bldg., New York 17.
Plants: Jersey City, N. J.; Mt. Holly Springs, Pa.

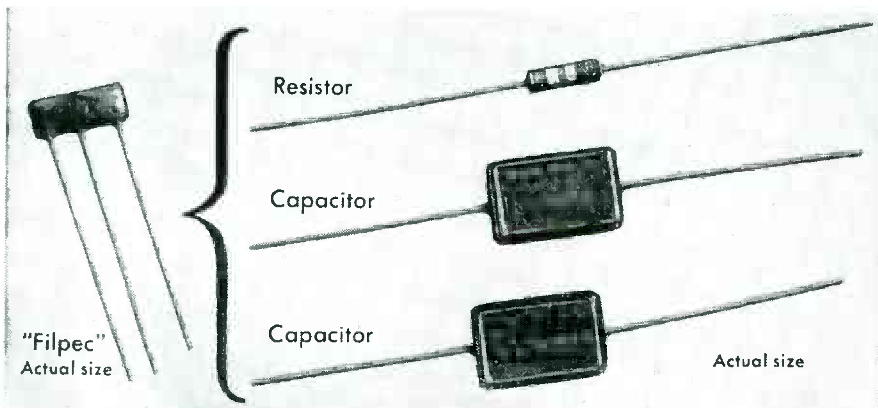
REPRESENTATIVES—CHICAGO AREA:
Russ Diethert Co., 612 North Michigan Avenue, Chicago 11, Ill.
WESTERN U. S.:
Electrical Specialty Co., 316 Eleventh St., San Francisco 3, Calif., branch offices in Los Angeles; Denver; Seattle; Portland, Oregon

SCHWEITZER FINE PAPERS

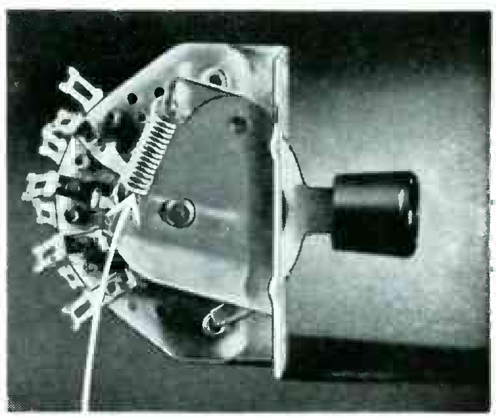
SPECIALISTS IN THIN GAUGE INSULATING PAPERS

Centralab reports to

1 **December 1947:** Lightweight, durable, with reliability and efficiency heretofore unobtainable in small units, *Ampec* is a complete, 3-stage audio amplifier — a typical application of CRL's "printed electronic circuit" (PEC). Provides all the components of an audio amplifier — tube sockets, capacitors, resistors, wiring — "printed" on one compact ceramic chassis according to your special requirements. 2.250" long, 1.156" wide. Wt. 0.63 oz. Write for Bulletin 973.



2 **November 1947:** Centralab announces new and revolutionary *Filpec* — the "printed electronic circuit" filter! As shown, *Filpec* is a brand new balanced diode load filter, lighter in weight, smaller in size than one ordinary capacitor. Resistance values: 5 ohms to 10 megohms. Write for Bulletin 976.



3 **July 1947:** New CRL *Lever Switch* features exclusive coil spring design. Guaranteed minimum life of 50,000 cycles. Write for Bulletin 970.


NO
WARM UP

RADIO
Builders and Listeners
...Both Give Top Rating

to these Cost-Controlling,

Good-Looking AMERICAN PHILLIPS SCREWS

1. TOP RATING in Production Savings: Fast, fumble-proof, automatically straight-driving . . . American Phillips Screws make possible high-volume radio production where even the slightest surface-scratch means "reject." For at highest speeds, the 4-winged American Phillips Driver can't twist out to scar work-surfaces! *Speed . . . with complete safety both for work and workers* . . . that's the double advantage that makes American Phillips Screws the *lowest-cost fastening method on any job.* Whatever product *you* assemble, you will find that American Phillips Screws pay off with SAVINGS UP TO 50%.

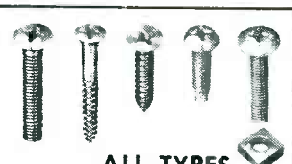
2. TOP RATING in Sales Promotion: The decorative heads of American Phillips Screws are a customer-accepted mark of quality. And they're an added assurance of serviceability under incessant use. So standardize on American Phillips Screws throughout your assembly departments. Write:

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

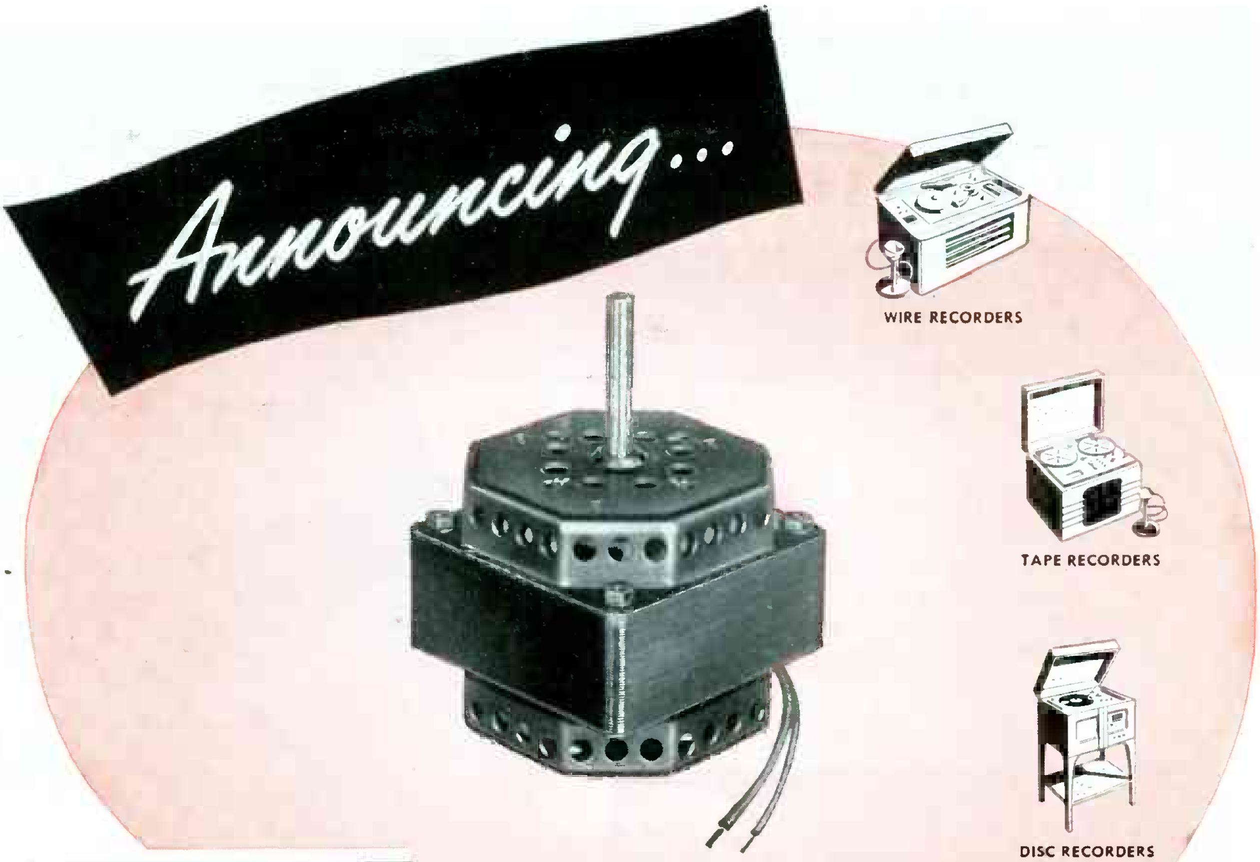
Chicago 11: 589 E. Illinois St. *Detroit 2:* 502 Stephenson Building

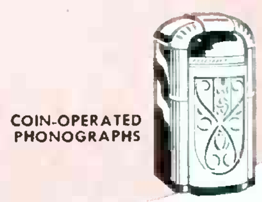
AMERICAN PHILLIPS *Screws*

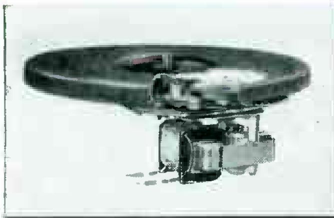


ALL TYPES

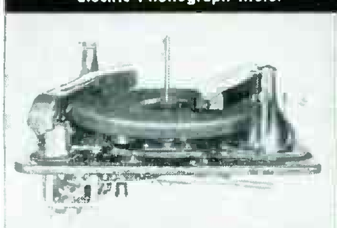
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)







Model MX Rim Drive, Constant Speed Electric Phonograph Motor



Model RC-130 Combination Record-Changer Recorder

Model R-90 Dual-Speed, Home Recording and Phonograph Assembly

a bigger, better measure of famous GI *Smooth Power*

It's the General Industries RM-4 Smooth Power phono-recorder motor—long a popular favorite for disc recorders and heavy duty phonograph units—*now* redesigned and improved to meet the power requirements of wire and tape recorders.

New features include special locating and locking means for new top and bottom covers which assures high accuracy in alignment of rotor within the stator bore . . . dual aluminum cooling fans and scientific air intakes for maximum cooling effectiveness.

Its advantages: Greater power . . . longer motor life . . . quieter operation . . . less vibration . . . cooler running characteristics . . . minimum magnetic field radiation. And, like all GI motor units, it affords split-second pick up to full constant speed—true Smooth Power performance.

Complete information and performance data upon request. Write today.

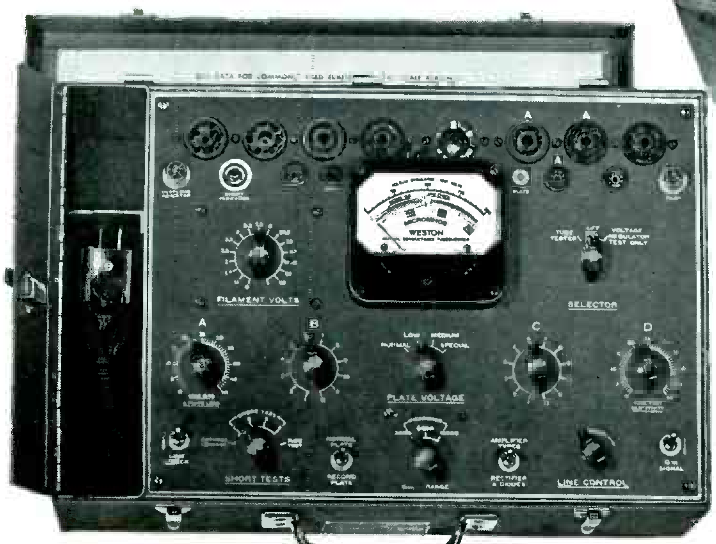
GI The GENERAL INDUSTRIES Co.

DEPT. B, ELYRIA, OHIO

INSTRUMENTS FOR

ELECTRONIC MAINTENANCE

WESTON *Electronic Analyzer*—Model 769. Incorporating: 1. A conventional Volt-Ohm-Milliammeter with self-contained power source. 2. A high-impedance electronic Volt-Ohmmeter using 115 volt, 60 cycle power. 3. A stable, probe-type, Vacuum Tube Voltmeter, for use to 300 megacycles.



WESTON *Multi-Purpose TUBECHECKER*—Model 798. This universal tubechecker offers within one instrument provision for testing: 1. Receiving tubes. 2. Voltage regulator tubes. 3. Light duty thyratron tubes such as 2A4—6D4—884—885—2051. Scale is calibrated "Good-Bad" as well as in mutual conductance readings.

Direct Reading Insulation Tester—Model 799. Compact, one-hand-operated insulation tester with .1 to 10,000 megohm range, using a test potential less than 50 volts d-c. Indicates: 1. Insulation properties. 2. Leakage resistance. 3. Conductivity of insulating materials. 4. Leakage due to moisture absorption.

These portable Westons are specifically designed for expediting electronic maintenance . . . for doing the job better—faster. All are engineered and built in the strictest traditions of Weston accuracy and dependability. For further details see your local WESTON representative, or write . . . Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON

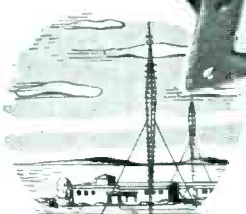
Instruments

Right . . .

FOR TODAY'S NEW CIRCUITS

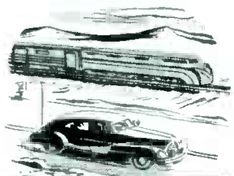
NEW CATALOG LINE OF *CT* TRANSFORMERS AND REACTORS

New and up-to-date, yet embodying all the quality, precision engineering and outstanding construction features for which Chicago Transformers have long been recognized. Ratings have been skillfully selected by men who know the latest trends in circuit design. They provide maximum flexibility in application and close matching with today's most widely used tubes. Audio transformers have 600/150-ohm impedances and contribute to product performance which not only meets but surpasses RMA and FCC standards for high quality reproduction, uniform frequency response over the required ranges, and freedom from distortion. Power transformers meet or surpass RMA standards for temperature rise and insulation test voltages. Combined in the power series are filter reactors with conveniently matched D.C. current ratings. Transformers and reactors are mounted in drawn steel cases in three variations of CT's famous "Sealed In Steel" construction. This provides protection against atmospheric moisture, efficient magnetic and electro-static shielding, strength and rigidity to withstand shock and vibration, convenience in mounting, compactness, and clean, streamlined appearance.

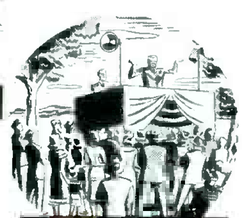


BROADCAST

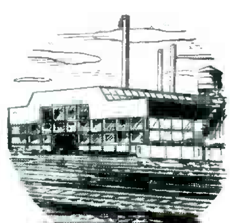
Write for Catalog



COMMUNICATIONS



PUBLIC ADDRESS



INDUSTRIAL

AMATEUR

EXPERIMENTAL

CHICAGO TRANSFORMER

DIVISION OF ESSEX WIRE CORPORATION

3501 ADDISON STREET • CHICAGO 18, ILLINOIS

NEW! A complete portable recording console THE PRESTO 90-A

Here in one easily portable unit is complete amplifier equipment to produce recordings on remote assignments that equal the best recordings in permanent installations.

Presto 90-A has 3 low-level input channels with mixers, master gain control and variable high and low frequency equalizers.

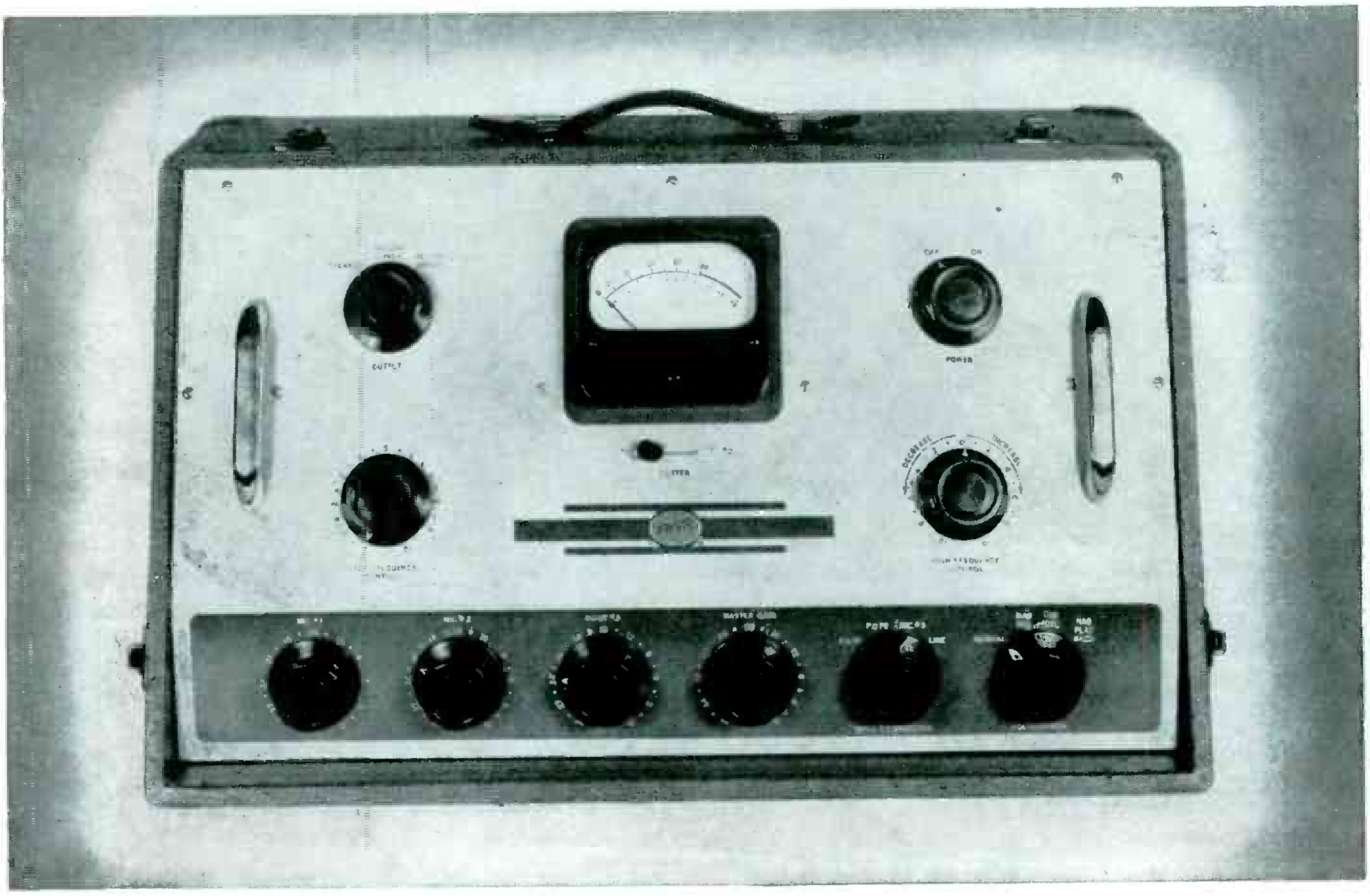
It has four fixed characteristics: flat between 30 and 15,000 CPS...NAB recording...78 r. p. m. recording...playback complimenting NAB recording.

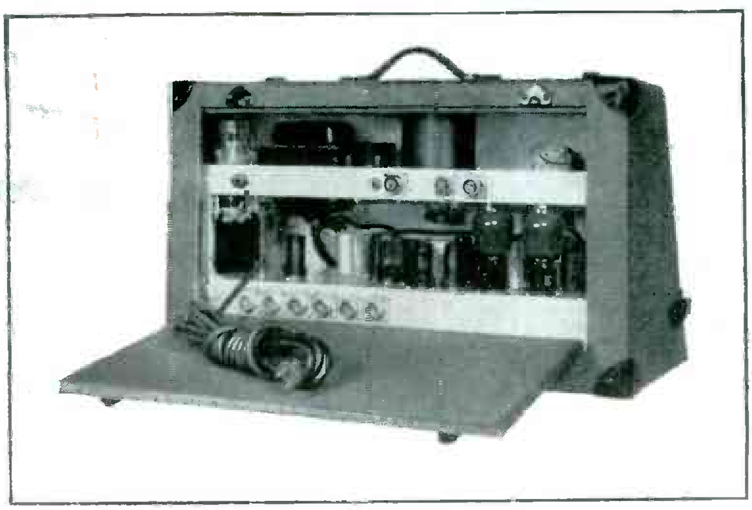
Other features include: line input and output, V.U. meter, switching for one or two recorders, over-all gain—115 db, power—10 watts undistorted.

In quality of parts and workmanship and in flexibility of operation, the Presto 90-A is the equal of the finest studio equipment.

Presto engineers are proud to present this new recording console as a forward step in recording equipment.

Immediate delivery can be made from stock.





PRESTO

RECORDING CORPORATION

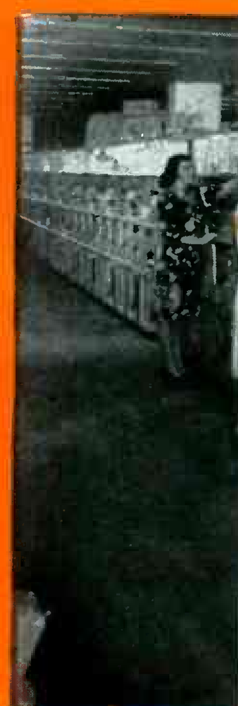
248 WEST 55TH STREET, NEW YORK 19, N. Y.

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.

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.

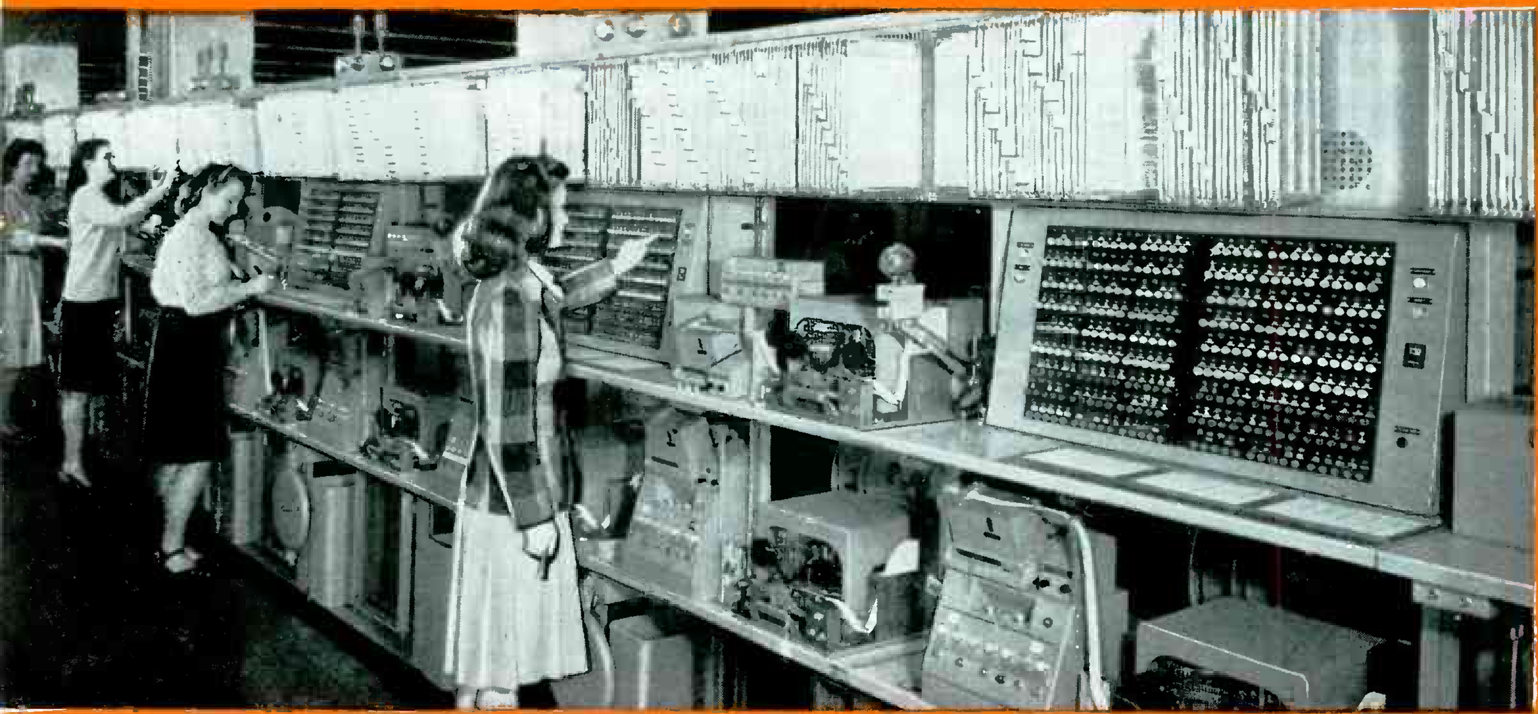
Western Union engineers have developed the Push-Button Switching System, which is being installed at strategic points throughout the country . . . to speed up the more than a half-million telegrams handled daily. With it, telegrams will be typed only once—at the point of origin.

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.

PROFESSIONAL PERFORMANCE — that keeps the original sound alive!

Make Each Record a

"Personal Appearance"!

— with precision control of recording quality

Listen critically: Your station is on the air. There's your announcer's voice . . . the opening music . . . the song . . . the chatter. Is it a 'live' or a 'recorded' program? Not even your trained ears should be able to tell!

Today, truly professional recording reproduces all of the quality and natural beauty of music or speech with full naturalness. It keeps the original sound alive.

You can sum up the reasons for the unexcelled 'live' performance of the Fairchild Unit 523 Studio Recorder in one simple statement: It provides a maximum flexibility of mechanical operation that permits the operator to secure unexcelled quality of reproduction. Fairchild provides instant, infinite variation of pitch from 80 to 160 lines-per-inch by means of a unique planetary-driven lead screw. Operation is controlled by a single, easily accessible knob, as illustrated at the left. This makes it possible to record a very loud passage at 90 lines-per-inch and to follow it with soft passages at 120 or 130 lines-per-inch without dial twisting or the danger of overcutting the next groove.

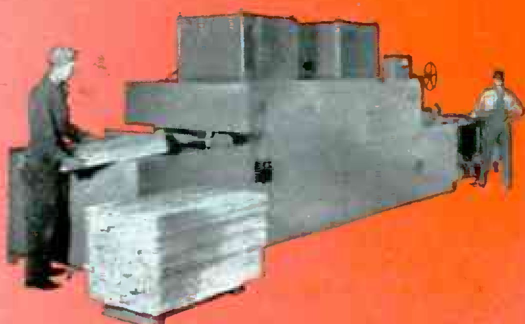
Timing is accurate to a split-second. Operation is 'WOW'-free. Turntable noise, rumble and vibration are non-existent. And the performance of the Fairchild Unit 541 Magnetic Cutterhead — which is standard equipment on the Unit 523 Studio Recorder — has been engineered for full dynamic range; minimum distortion content and broad frequency range. Want more details? Address: 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

Studio Recorders
Magnetic Cutterheads
Transcription Turntables
Portable Recorders
Lateral Dynamic Pickups
Unitized Amplifiers

Fairchild CAMERA AND INSTRUMENT CORPORATION

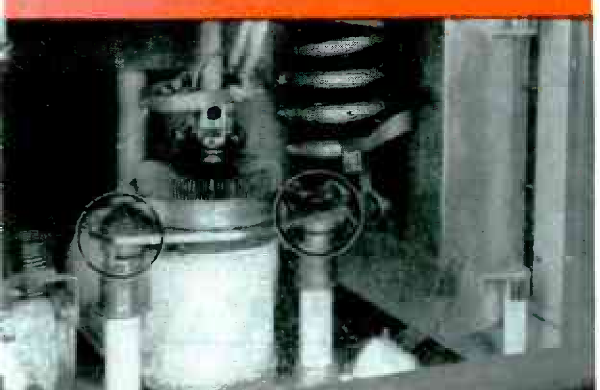
AM FM SOUND EQUIPMENT

GIRDLER *Isolates Blower* VIBRATION *with* LORD VIBRATION CONTROL SYSTEM



Above—Thermex Model 10-H high frequency heat generator used for high speed wood-glue bonding. Lord Mountings isolate blower vibration from sensitive equipment.

Below—Lord Vibration Control System in Thermex Model 10-H also includes Mountings for oscillator tube. Complete protection prolongs tube life—cuts operating costs.



***LORD** Mountings Used by The Girdler Corporation in Thermex High Frequency Heating Equipment to Isolate Blower Vibration—Protect Oscillator Tube—For Greater Efficiency, Service Life . . .*

Greater efficiency—longer service life—smooth, quiet performance are obtained in Thermex high frequency heating units by thorough isolation of vibration. Protection of sensitive electronic equipment from vibration is so important that The Girdler Corporation, Thermex Div., specifies a *complete* Lord Vibration Control System in their product.

The Lord Vibration Control System in this Thermex unit provides two-way protection . . . first, by isolating blower vibration, and secondly—for complete protection—isolating the sensitive oscillator tube from external vibratory disturbances. Four Lord Shear-Type Bonded-Rubber Mountings under the blower and motor assembly prevent its vibration from damaging the oscillator tube. Three more Lord Mountings support the oscillator tube, effectively guarding it against shock and vibration from nearby machinery.

Whether you manufacture electronic equipment or any other product, you can increase your sales by eliminating costly, destructive vibration. It will pay you to consult Lord . . . make us your headquarters for product improvement through Lord Vibration Control Systems.

LORD

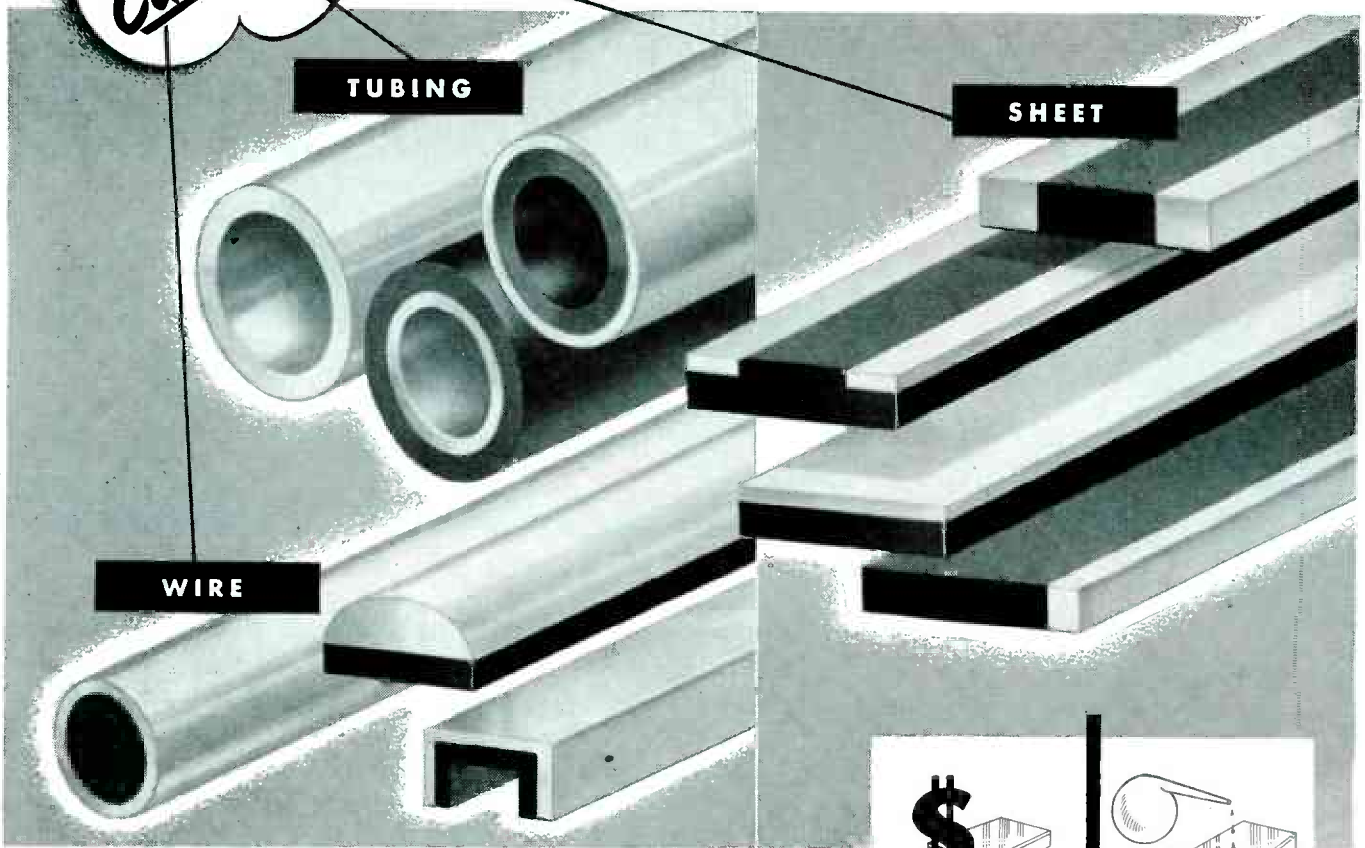
MAKE GOOD PRODUCTS *BETTER*

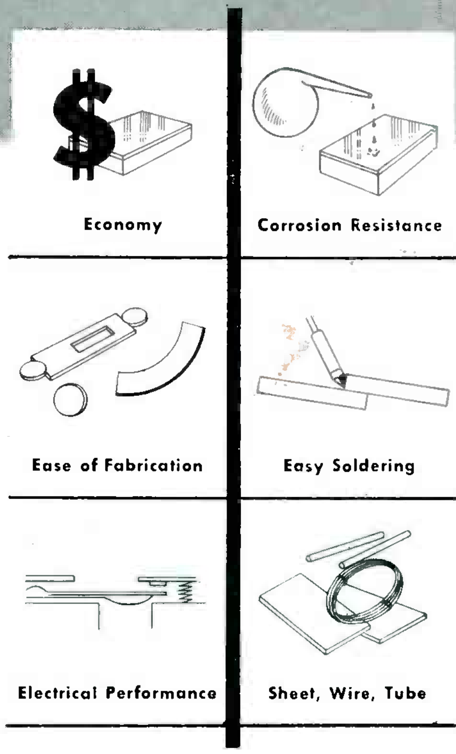
with *Vibration Control*

LORD MANUFACTURING CO. · ERIE, PA.

Field Offices: Detroit · Chicago · New York · Washington, D. C.
Providence, R. I. · Burbank, Cal. · Philadelphia, Pa.
Canadian Representative: Railway & Power Engineering Corp., Ltd.

Here's a Way to CUT COSTS Yet Maintain High Performance Quality





. . . use GENERAL PLATE Laminated Metals

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.

Here's how — by permanently bonding a thin layer of precious metal to relatively inexpensive base metal, General Plate Laminated Metal gives you all the advantages of precious metal performance at a fraction of the cost of solid precious metal. In addition, the base metal adds strength, while the combination is more workable, easier to fabricate, easier to solder, braze or weld.

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ITS JOB: to detect and measure

INFINITESIMAL CURRENTS

New GL-5674 6-Electrode Electrometer Tube

DEPENDABLE DOWN TO 5×10^{-16} AMPERES!

ELECTRICAL CHARACTERISTICS

Filament voltage	3.8 v
current	0.090 amp
Input capacitance	6.8 mmfd
Max Ratings, Absolute Values	
Anode voltage	10 v
Anode current, per anode	100 mu a
Space-charge-grid voltage	6 v
Typical Operating Conditions	
Anode voltage	6 v
Anode current, per anode	20 mu a
Space-charge-grid voltage	5 v
Control-grid voltage	—3.5 v
Balance-grid voltage	—3.5 v
Control-grid current	5 X 10^{-15} amp

NOTE: When a 10^{11} ohm grid resistor and a 10^{-10} ampere-per-millimeter galvanometer are used, sensitivity of approximately 75,000 millimeters per volt is obtainable.

● Presentday research—in nuclear physics, in medicine, in industry—calls for precisely this tube. General Electric has originated Type GL-5674 to meet the demand for an electrometer pliotron which combines *great sensitivity* with *stable operation*.

● Stability is vital in view of the many extraneous influences that affect readings of extremely small currents—such factors as fluctuations in tube-filament emission due to the smallness of the electron flow, variations in battery voltage, temperature changes, and external impulses from nearby electrical fields.

● Type GL-5674, properly applied, offsets these influences by using two control grids and two anodes (operating with a common filament and space-charge grid), connected in a Wheatstone-bridge circuit. Variations in emission, and other sporadic or continuous causes of instability, thus are balanced out. In consequence, G.E.'s new pliotron will measure accurately down to 5 x 10^{-16} amperes. This is such an extremely small current that the noise level of the grid resistor becomes a limiting factor.

● Complete information about this great new pliotron gladly will be supplied to scientists and engineers interested in its application to radiation detection, delicate photoelectric measurements, or other fields. Write to *General Electric Company, Electronics Department, Schenectady 5, N. Y.*

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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.

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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

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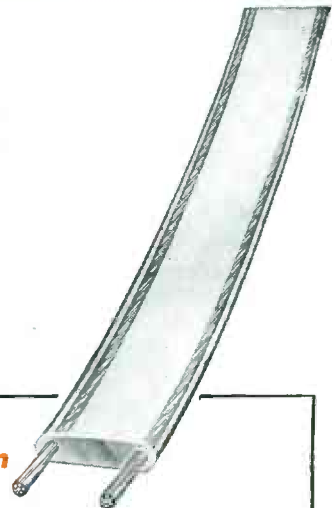
CONFUSING? OR AMUSING?

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. 47439

**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.

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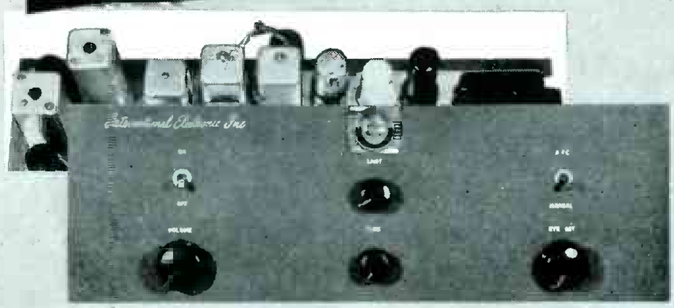
Completely eliminates static!

● These two new Hings Detectors absolutely and positively eliminate static and interference in reception for the first time. Where others have tried before with "squelch" and "limiter" circuits, International Electronic has succeeded completely through two entirely new systems of detection—the Noise Neutralizing Detector for AM, and Triggered Detector for CW and CS!

These new instruments mean revolutionary improvement in any type of point-to-point communication . . . are particularly indispensable to police and aircraft networks, ship-to-shore and overseas communication, to automatic printers, tape recorders, alarms and similar operations. They again make practical the use of low-frequency and high-frequency transmission.

Hings Noise Neutralizing Detector for Voice and AM



for VOICE and AM

The Hings Noise Neutralizing Detector for AM ("NND" for convenience in reference) brings you all of these vital advantages:

- Neutralizes all noises such as static and ignition completely.
- Permits greater signal-to-noise ratio and vastly improved selectivity.
- Introduces a new operating threshold for AM.
- Permits standby operation of receiver with maximum sensitivity and without atmospheric interference.
- NND is controlled in its phase and amplitude by a second self-generated carrier. Damage to incoming signal and intelligence from impulse saturation or shock is literally repaired.
- Gives clean reproduction through interference for facsimile.
- Eliminates static streaks from television.
- Maintains fidelity of modulation.
- Incorporates self-contained AVC.

Hings Triggered Detector for CW and CS

for CW and CS

The Hings Triggered Detector for CW and CS ("TD" for sake of brevity) offers the following tremendously important features:

- Permits completely silent standby with both tone and DC reproduction of any signal period.
- Provides selectivity of better than 300 cycles in heavy static without any circuit noise.
- Permits direct operation of automatic equipment or relays.
- Allows tone-selection to suit the operator.
- Internally generated signal is controlled by incoming signal and not by noise shocks.
- Stands noise many thousands of times the amplitude of the signal.
- Suitable for selecting desired CW signal from interfering signals.
- Supplies direct or inverted keying energy.
- For automatic printers, marker spaces can be varied.
- Recommended for handling as high as 150 words per minute.

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Both the Hings NND and the TD are supplied in standard rack mounting, suitable for operation with any communications receiver. They are provided with self-contained audio-system and power supply, and connect to the IF circuit of the normal receiver. When ordering specify the IF frequency of the receiver with which the Hings Detectors are to operate. *Send for illustrated booklet describing operation and stating engineering details. Engineering services are available for applying the Hings NND and TD to present commercial receivers.*

Fixed Frequency R.F. Panels for use with NND and TD will be available shortly.

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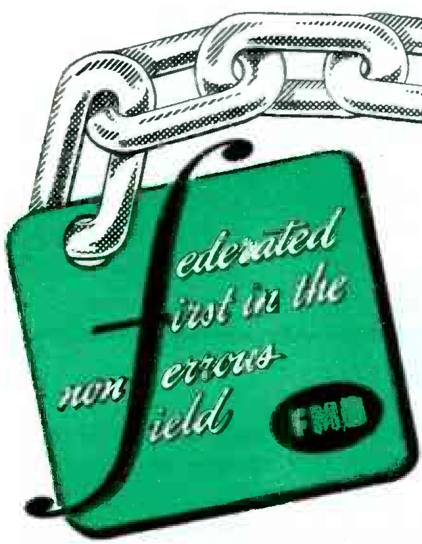

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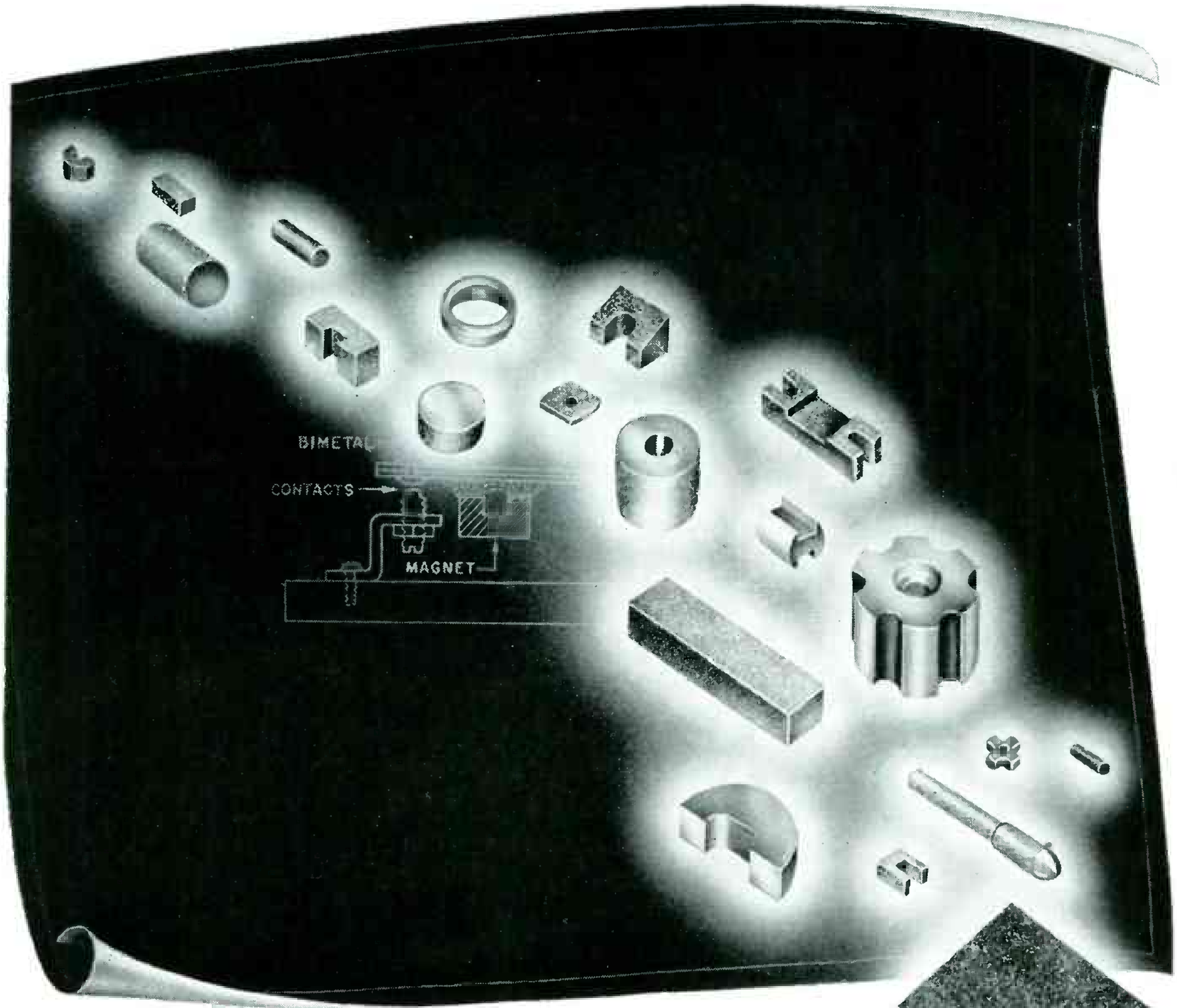

IT PAYS TO DESIGN FOR SINTERED ALNICO II MAGNETS

Costwise as well as from a general efficiency standpoint, permanent magnets of Stackpole *Sintered* Alnico II often offer real advantages—especially where odd shapes and small sizes (to approximately 2 oz. weight) are required. Smoother surfaces for easier brazing or soldering, closer tolerances, greater mechanical strength and higher uniformity plus low cost form an unsurpassed combination.

Dies for many standard rectangular and cylindrical shapes are available. Beyond these, however, it is entirely practical to adapt magnets of many unusual shapes to economical sintered production simply by avoiding reentrant angles and having holes, slots and offsets aligned in the direction of molding pressure. Designed in this manner, odd shapes may readily be built into relatively inexpensive dies from which thousands of permanent magnets can be molded without extra machining and forming operations.

SAMPLES!

Stackpole can produce specific samples of Sintered Alnico II magnets without dies. This service is freely available to prospective users who send full details of required shapes, sizes, and quantities.

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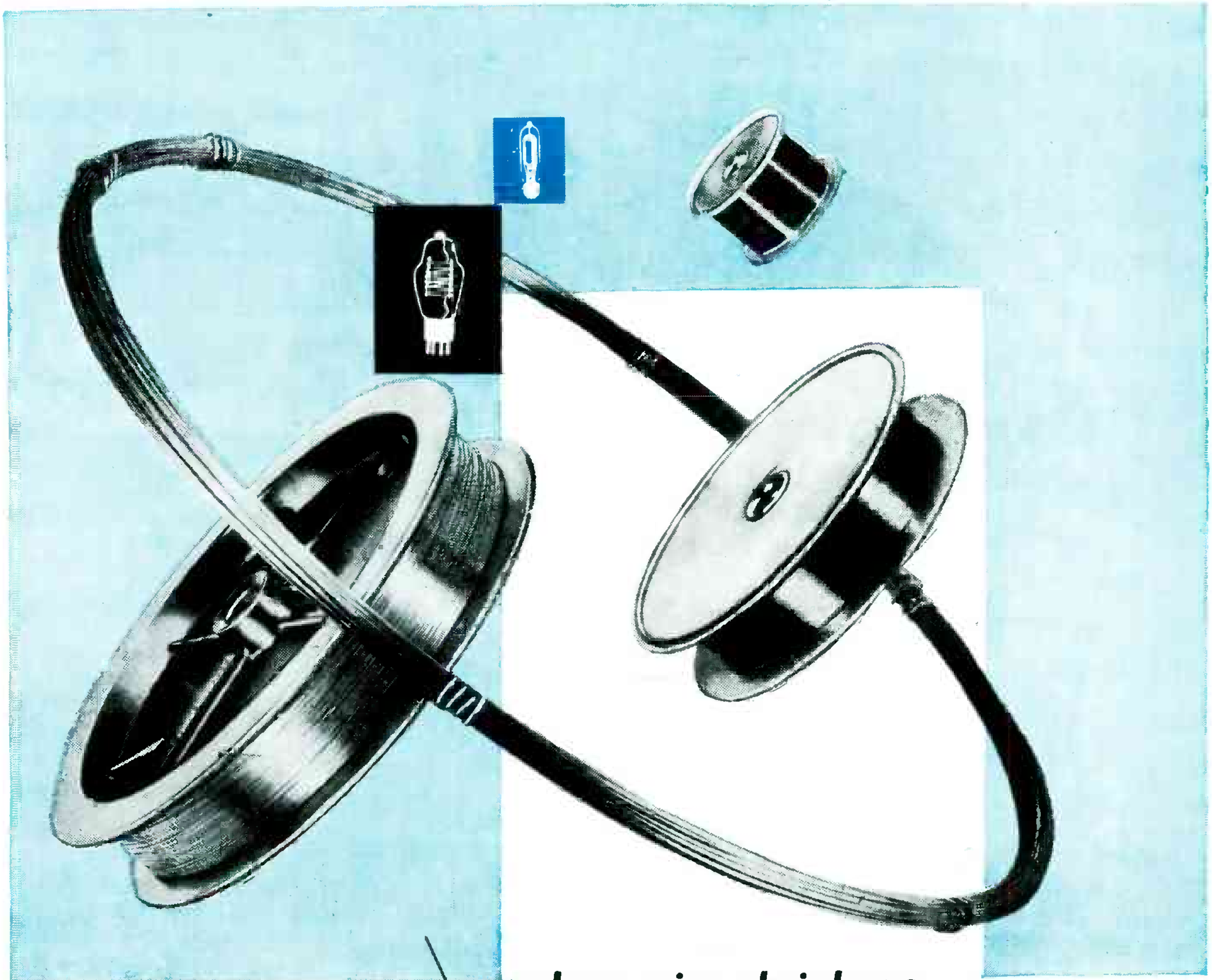

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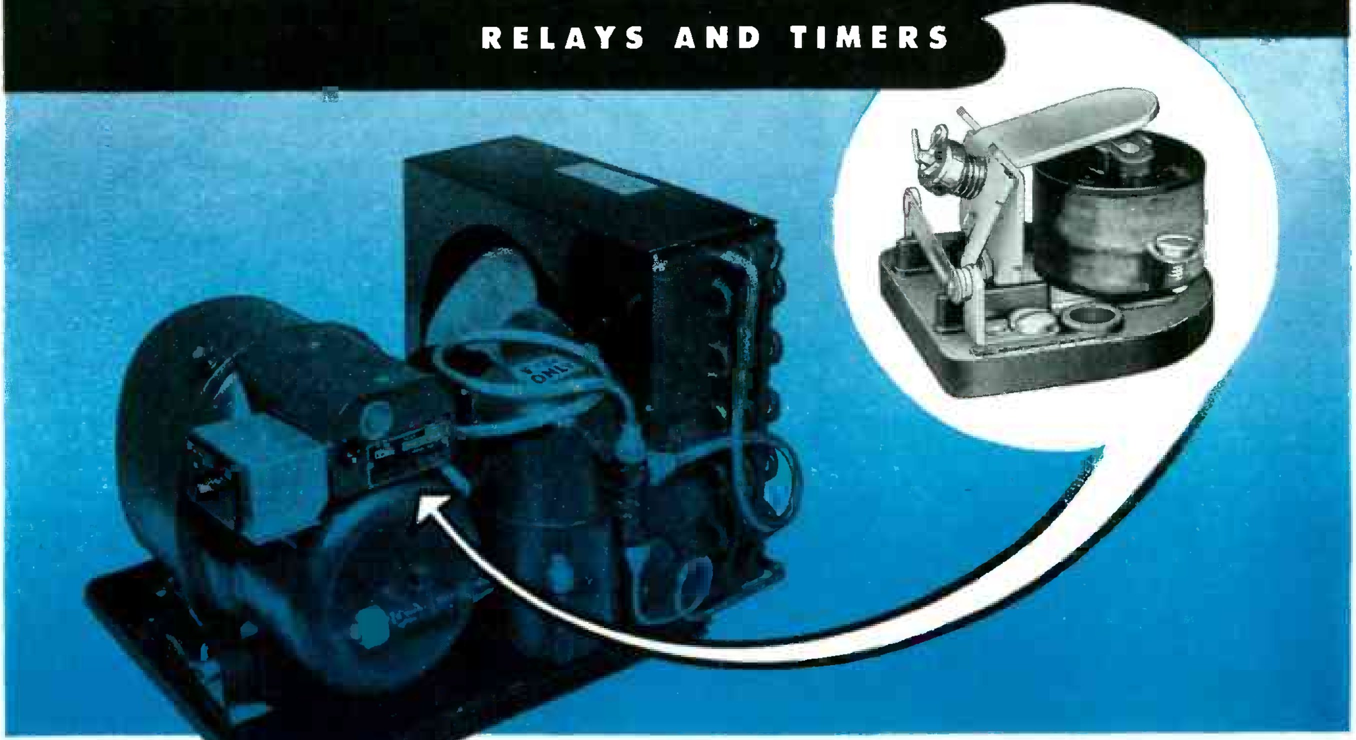

SERVEL

SUPERMETIC hermetically sealed condensing units for electrical refrigeration depend on small but rugged P & B motor-starting relays instead of centrifugal switches for positive cut out of the starting coil.

This motor-starting relay is a pertinent example of Potter & Brumfield performance engineering as a solution to difficult switching problems.

Servel, Inc., of Evansville, Indiana, found that neither centrifugal switches nor ordinary motor-starting relays would stand up in their new Supermetic electric refrigeration units. They presented the problem—which included a number of new complexities—to Potter & Brumfield engineers.

The resulting relay met all Servel requirements (including Servel's demand for unfailing dependability through a full year of rigid field tests after laboratory approval)—and is now in fully satisfactory service on thousands of the Servel units. In addition to its proved performance, the relay has the further virtues of mechanical simplicity and low fabrication cost.

For just such practical performance engineering, Potter & Brumfield engineers are always at your service. We solicit your inquiries on all types of relay problems.

Potter & Brumfield also offers a standard line of relays which are fully illustrated and described in a comprehensive 22-page catalog. Midget, power, leaf, shock-proof, plate-circuit, telephone and many other types are offered in stock assemblies. Write for your copy of the catalog.

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POLITICAL ACTION—
Labor's Blind Alley

THE approach of the 1948 elections brings organized labor in America to a fork in the road.

Straight ahead lies the familiar route of free collective bargaining. Except for an occasional side trip, labor has been traveling it for years. On this road the role of government is to act as traffic cop, removing obstructions for all travelers.

The fork is the road of political action—the road to special privilege for labor. On it government is called upon to clear a special right of way for organized labor—to push aside all others.

Which of these two roads will organized labor take?

Most American labor leaders are now urging their followers toward political action. Their first objective is to "get" all members of Congress who voted for the Taft-Hartley Act. AFL plans to raise a $5 million political combat fund through contributions and a per capita tax on its membership. CIO is soliciting $1 donations for political action from its 6,000,000 members.

For their own sake, however, as well as for the welfare of the country as a whole, the rank and file of organized labor will do well to stop, look and listen before they turn their unions into political action squads. If they examine the facts for themselves, they will make two significant discoveries:

I. Political action is a blind alley for labor.

II. The Taft-Hartley Act is an essential bulwark of free collective bargaining.

A brief discussion of these two statements will show what they mean to organized labor.

I

Political action is a blind alley for labor.

If there is any doubt about that statement, a good way to dispel the doubt is to look at European countries where organized labor has been following a political action line.

Britain, where the Labor Party is in power, is such a country. How is labor faring there? Measured by the good things money buys, the average hourly wage in Britain is less than two-thirds of what it is in the United States. Part of the difference may be accounted for by the fact that the British Isles are poorer in natural resources than the United States. Another reason is the war damage to Britain's plants.

But there are two other big reasons why the British wage earner is far behind the American worker in enjoying the good things of life:

1. The *incentive to produce* has been dulled by vote-catching programs which promise economic security and a levelling of incomes. Lulled by promises of cradle-to-the-grave security and discouraged by high taxes, the British have descended to a state neatly described by the London *Economist:*

"Nobody gains anything from activity or suffers anything from inactivity."

2. To run a program like Britain's requires more and more government functionaries. Civilian employees of the British government have increased by 50% since before the war, putting one worker out of ten on the government payroll. More and more people stop producing and spend their time instead cutting up what others produce. The result is smaller production, higher taxes and lower real wages.

The British Labor Party must accept most of the responsibility for this sorry state of affairs. It is due primarily to a program of political action by organized labor which promised the individual worker security and equality of income—*but which can not deliver either because the incentive to work is gone.*

The lesson for American wage earners is clear. Political action by unions to enforce the economic fallacy of more-and-more-for-less-and-less will end by impoverishing the working man—and bringing the nation to ruin.

Unions exist for collective bargaining, not for politicking.

II

The Taft-Hartley Act is an essential bulwark of free collective bargaining.

Bargaining works satisfactorily only when both parties—management and labor—think they are getting a fairly even break.

Management was very sure that the Wagner Act, as administered from 1935 to 1947, was giving employers the short end of the stick. Furthermore, management's feeling of frustration was no whim. It was justified by case after case where rights were granted to organized labor with no counterbalancing recognition of the rights of management, of individual workers or of the public.

The Taft-Hartley Act goes a long way toward establishing equality in employer-union relations. It may fall short of doing a perfect job. *As a subsequent editorial in this series will show, it leaves virtually untouched the public menace of industry-wide bargaining and labor monopoly. And it leaves unprotected what should be the individual's right to hold a job without joining any particular organization.* But it *does* provide some major safeguards for collective bargaining by striking at abuses.

Organized labor, therefore, has no cause to damn the members of Congress who voted for the Taft-Hartley Act. True, the law will check what has been an uninterrupted march of the labor union bosses toward absolute power. It will do so just as laws in the past—The Sherman Anti-Trust Act, for example—have checked management when it was too greedy. And, as the first section of this editorial points out, the time has come to check the march of the big labor bosses.

Fundamentally, the Taft-Hartley Act gives free collective bargaining a new lease on life. The old lease was running out because the Wagner Act stacked the cards against employers, against individual workers, and against the public.

The road to free collective bargaining is now clear of many of the most menacing obstructions. It is the only road for labor to take in its own self interest. Union workers who let their leaders lure them down the blind alley of political action will do so at their own peril—and at the peril of this great industrial nation.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

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******Type* "BOHO" is D.P.D.T. relay sealed with standard octal plug. Contact rating of 5 to 10 amperes and coil capacity of 115 v. D.C. at 2.5 watts and 220 volts; 25 and 60 cycles at 4.5 volt-amperes.

**Type* "CN" is S.P.S.T. double break relay with 50 ampere contacts and coil capacity of 115 v. D.C. at 3.5 watts and 220 volts; 60 cycles at 10.5 volt-amperes.

**Type* "BN" is 6 P.D.T. relay with 15 ampere contacts and coil capacity of 115 v. D.C. at 3.5 watts (not available in A.C.).

**Type* "BG" is S.P.D.T. relay with 2 ampere contacts and coil capacity of 25 v. D.C. at 50 milliwatts (not available in A.C.)

**Type* "BO" is D.P.D.T. relay with 15 ampere contacts and coil capacity of 115 v. D.C. at 2.5 watts and 220 volts; 25 and 60 cycles at 4.5 volt-amperes.

**Type* "F" is S.P.D.T. with 2 ampere contacts and coil capacity of 85 v. D. C. at 1.5 watts (not available in A.C.).

**Type* "SK" from S.P.S.T. up to 4 P.D.T. with 1 ampere contacts and coil capacity of 60 v. D.C. at 750 milliwatts (for 4 P.D.T. relay) not available in A.C.

Allied Control representatives are located throughout the United States. A short note to our home office will give you the name of our nearest representative.

AL-119

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BUSINESS BRIEFS

By W. W. MacDONALD

Business Briefs has been appearing in ELECTRONICS just one year. We dreamed up the title at considerable pain and, so help us, thought it was original. But so little is.

Dave Ritchie of Houston, Texas, has been using the name since 1936 in connection with a monthly house organ containing condensations of marketing, selling and other news for clients, friends, and prospects of his advertising agency. He has recently started to syndicate it for use as a house organ by others.

Says Dave: "Confidentially, I think we are both to be congratulated on our choice of the words." Which seems fair enough to us.

Broadcast Station Revenue increased approximately 8 percent in 1946 over 1945, according to an FCC report just released. Eight a-m networks and 1,025 a-m stations reported a $322,552,771 take. Expenses were up 14 percent to $246,086,525 however, so that income before Federal tax was $76,466,246, a decline of 8.5 percent.

The increase in industry revenue was due largely to non-network time sales, up 13 percent over 1945. Networks showed less than 1 percent increase. About one-third of the revenue and one-fourth of the income in the business accrued to the networks and their owned-and-operated stations.

Citizens Radio Service walkie-talkie developed by a mid-western manufacturer and awaiting FCC class-B type approval is attracting consumer inquiries by the gross, despite the fact that news concerning it has so far travelled around the country exclusively by word-of-mouth. One mail-order house alone is said to have placed an order for 600 units at about $175 per pair.

New Electronic Tools, rather than further refinements of existing ones, are what industry needs, according to GE's Bill White, upon whom we called in Schenectady during the month. He showed us one example, a microwave transmitter-receiver reminiscent of early radar gear that makes a fascinating burglar alarm, and told us about another that duplicates one of man's senses but about which we can say no more at this writing.

Labor Costs are 69 percent higher today in radio receiver manufacturing plants than they were in 1939, according to RMA's Bond Geddes. Average hourly rate of pay was 58.1 cents in 1939, 68 cents in 1941, and is now $1.15.

Speaking Of Cost, manufacturers of super-high-quality components are crying, now that military orders have declined. The price war is on again, particularly in the radio business.

The parts boys are faced with the alternatives of cutting corners and going after volume or sticking to their guns and being satisfied with smaller, more highly specialized businesses. The decision is often a tough one, because many of those inclined toward the latter course have big war-developed plants.

Receiving Tube Sales by RMA member companies totalled 145,540,732 in the first nine months of 1947. Of this total 93,997,110 went into new equipment, 32,734,888 were sold for replacement use, 18,212,126 were exported, and 596,608 were purchased by government agencies.

To Gordon Volkenant of Minneapolis-Honeywell, whose recent speech and demonstration before the Sales Executives Club of New York proves that an engineer can sell electronics to executives if he talks their language, we are indebted for a neat phrase: *"unnecessary device for an unimportant function."*

Never have we heard one that more aptly describes many of the projects undertaken in this sometimes-too-fascinating field at the ex-

PYROVAC... A NEW EIMAC PLATE MATERIAL

The story's out . . . Pyrovac, a new Eimac plate material, the culmination of ten years research and millions of hours of life test data, is now in standard production—at no extra cost.

Pyrovac is truly as important a milestone of vacuum tube development as the thoriated tungsten filament. Pyrovac plates, like the thoriated tungsten filament, open a new vista for vacuum tube life performance.

This new material combines the advantages of tantalum to overloads, molybdenum's strength, weight and conductivity, and carbon's ability to dissipate heat . . . with none of the disadvantages of these materials. Tubes with Pyrovac plates are mechanically rugged, require no additional getters and they do not gas even under extreme overloads.

The life span of tubes with Pyrovac plates far exceeds that of tubes incorporating plates of conventional materials. For example, under conditions where a tube gave 3000 hours of service the same tube type with a Pyrovac plate gave 15,000 hours of life, a 400 percent increase!

Pyrovac plates are capable of handling overloads in excess of 1000%. For instance, the 4-65A plate pictured above was radiating 900 watts of heat, a 1280% overload . . . without indication that the eventual life of the tube or its characteristics were affected. We don't suggest you dissipate 900 watts of heat in your Eimac 4-65A's (you could probably do it), but this example establishes proof that Pyrovac is a superior plate material destined to become the anode standard of the vacuum tube industry.

Pyrovac plates were first incorporated in the Eimac 4-250A in the early part of 1946 and followed in the 4-125A. As a result there has been universal acceptance of these tubes in all fields of electronic endeavor. . . . Further proof of the superiority of this new plate material. In the ensuing period of

Type 4-125A

Type 4-250A

time all Eimac internal anode type tubes have been converted to Pyrovac plates as rapidly as production facilities would allow.

For your assurance to obtain the most in performance and satisfaction for your vacuum-tube-dollar, insist on Eimac tubes . . the criterion of good design in any electronic equipment.

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Follow the Leaders to
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The Power for R-F

pense of more deserving engineering jobs.

Printed Circuits Symposium note published in this column in December (p 74) pulled many letters asking for more information. To others interested in the subject we're recommending the National Bureau of Standards circular "Printed Circuit Techniques", by Brunetti and Curtis, available through the Government Printing Office, and the Proceedings of the Symposium itself, soon to be made available through the same source.

Brunetti advises that another symposium to be staged in Washington in the spring will cover miniature power supplies, with the principal emphasis on batteries.

Taxi Radio Interference is becoming a serious problem in several cities, where signals from similar services in nearby towns are regularly heard. Some sort of cooperative sharing of channels seems indicated, particularly since such a plan would also enable other cab operators, at present out in the cold with respect to radio, to participate.

Selective Calling Systems are in for a face-lifting that should make them more acceptable to people who have held out for something that works faster.

At least two companies are near ready with dial-less equipment utilizing tones, or tones and pulses, to simplify and speed up operation, and phone companies interested in common-carrier radio service are working on the idea too. Details in our feature pages in a month or two.

Mobile Radio Applications are growing at such a rate it is surprising that we haven't already heard about smart boys setting up wayside repair stations.

It will come.

Out-Of-Town Papers were invited to copy an item we saw in a newspaper the other day, and we ourselves rush to take advange of this kind offer. The item read as follows: "Ten noisiest cities in the

United States are Reno, Philadelphia, Boston, Las Vegas, Chicago, Washington, San Francisco, Dallas, Detroit and St. Louis, according to Duotone sound engineers.

One of Our Readers described a camera shutter-speed calibrator in ELECTRONICS back in May 1944 (p 164). Now he has his patents and says he would like to sell them outright or license some manufacturer on a royalty basis.

The device would be at its best in retail repair shops. Address on request to "Business Briefs."

Exports of all types of radio equipment totalled $33,000,000 in the second quarter of 1947, according to the U. S. Department of Commerce. First-quarter exports were valued at $28,600,000.

Tele Receiver Sales in the metropolitan New York area will run about 63 percent table-top types and 37 percent consoles in 1948, according to a DuMont survey among 64 dealers. Some 57 percent of the sets will probably have television alone, 21 percent should include a-m and f-m radio, and the remaining 22 percent will in all liklihood contain a record player as well.

Men are obviously dominating most purchases.

IRE Winter Meeting registration last March at New York totalled 11,895 (we estimated 12,000 on p 80, July 1947), with the following breakdown:

5,706	non-members
2,687	Associates
856	Senior members
829	Members
812	non-members*
524	applications pending
351	Students
130	Fellows

* Registered as members

Refinancing of electronic equipment manufacturing firms appears to be at its peak. We ourselves have been instrumental in getting several buyers and sellers together. There is, it appears, plenty of business on some books, but not much cash.

Birds' Nests in the vicinity of the Owens-Corning plant at Newark, Ohio are largely fabricated of Fiberglas Wool.

CROSS TALK

► **ALARM** . . . In the course of testing the Hazeltine Fremodyne circuit (p 83, this issue) we have had occasion for some soul searching concerning present trends in receiver design. The alarm is generated by the large values of signal radiated by many receivers, particularly the inexpensive ones. The Fremodyne (25 to 65 millivolts radiated by the local oscillator) is no worse in this respect than many another f-m receiver or television receiver which uses no r-f stage. So we are not singling out any particular receiver in this respect, but we do feel impelled to question the value of all such receivers. If the local oscillator frequency of an f-m receiver is below the f-m band (as it is in some models, despite admonitions of their designers), the local oscillator radiation falls in the television channels. And 65 millivolts fed to a dipole can raise hob with a block full of television sets. If the oscillator frequency is above the band it falls on airport frequencies which, while not so vulnerable to its effects, are nevertheless involved in the safety of human freight. A well-designed r-f stage costs money, but it goes a long way toward curing this evil. It should be used on all sets, even the cheapest ones. There is no excuse whatever, cost included, for a local oscillator on the low side of the f-m band.

The poor audio quality of some of the receiver designs concerns us also, but not so much. A manufacturer takes his chance in the market, with an increasingly critical public, if his set has too much distortion or noise or both. But when his set affects adversely the performance of other equipment, in the hands of the public, and particularly if it affects the safety of airport operation, the horse has an entirely different hue. We view this latter tendency with great alarm. If ever there was a chance for practical statesmanship in radio engineering, the mitigation of this evil is it.

► **BOILERS, AGAIN** . . . Our editorial inquiry some months ago concerning the propriety of television for monitoring the water level in high pressure boilers has stirred up such a vigorous defense of the method that we are bound, in all fairness, to state the case in its favor. A television system, for all its complexity and need of careful maintenance, has one compelling advantage as a monitor: it cannot give a wrong answer. The television picture either shows the water level correctly as revealed in the gauge, or it shows nothing at all. If the television system is backed up by a system of mirrors which will permit an alternative method of monitoring to be used on short notice, the television system interposes no danger. Other, simpler systems of monitoring now available are not similarly foolproof. So television, plus a quickly available backstop, is a good answer to a vexing problem.

► **PRIZE** . . . It has been many years (not since the Davisson award in 1937) that a physicist has been awarded the Nobel Prize for work in the radio-and-electronic field. We are particularly happy, therefore, to note the recent award of this honor to Sir Edward Appleton, whose discovery of the ionosphere in 1924 and subsequent studies in this field put long distance transmission of radio waves on a firm quantitative basis. We are pleased to note another award to Sir Edward, not so generally publicized, the Medal of Merit which he received for his contributions to radar and for promoting cooperation between British and American scientists during the second world war. No one in Great Britain did more to perfect the harmonious interplay of thought and action between the two Allied groups working on radar, loran and related arts.

► **WALKIES** . . . A spokesman for the FCC asks us to enlist the cooperation of readers in the fight against unauthorized use of walkie-talkie sets and other surplus transmitters. These cannot usually be licensed for civilian use, but this fact is often not understood by the purchaser in advance of his purchase. This situation is so well known to those who work in the electronics business that advice to beware such equipment hardly applies directly. But we can help indirectly, by warning less-knowing friends that careful inquiry concerning licenses should be made in advance of purchase.

Bandwidth vs Noise

THE BASIC QUESTION in communications is the relative value of various schemes of modulation, amplitude modulation, frequency modulation, pulse-time modulation and pulse-code modulation, to name but a few. New light on this question was shed at a symposium of four papers presented Nov. 12 by the New York Section of the IRE. At this meeting, C. E. Shannon of the Bell Telephone Laboratories presented an extension of the theory of communication in the form of a general relation between the bandwidth used by a system, its capacity to transmit information, and the signal-noise ratio present. Using this relationship, three other speakers (B. D. Loughlin of Hazeltine, A. G. Clavier of Federal, and J. R. Pierce of BTL) drew conclusions concerning the relative efficiency of a-m, f-m, ptm and pcm systems as carriers of information.

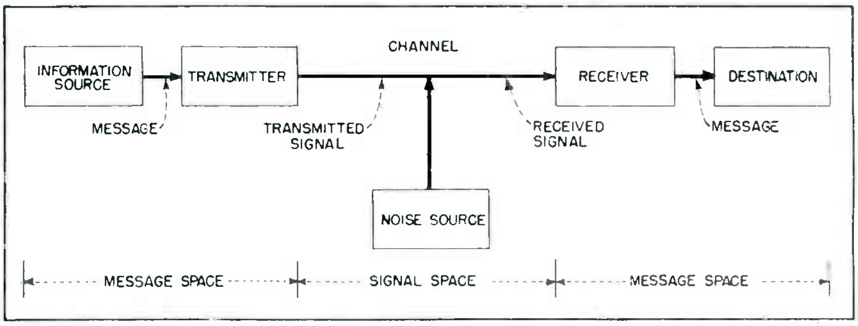

FIG. 1—Essential elements of a communication system, used by Shannon as a basis for treatment of bandwidth-noise problem. The transformation from message to signal is accomplished by some form of modulation

Influence of Noise

The first statement of the new law to appear in print was published in an editorial[1] in ELECTRONICS quoting W. G. Tuller. In essence, the new law is a reformulation of the Hartley law,[2] which says that the amount of information which can be transmitted in a given time is proportional to the bandwidth occupied by the communication channel. The revised law says that the amount of information which can be transmitted in a given time is also determined by the logarithm of the signal-noise ratio plus one.

The original Hartley law, as applied to television, for example, states that a 525-line, 30-frame image, having equal vertical and horizontal resolution, must occupy a channel at least 4.5 mc wide. The new law states that, if we are willing to increase the signal relative to the noise, at whatever cost, the bandwidth can be reduced below 4.5 mc, without reducing the total amount of pictorial information conveyed in a given time.

This relation between bandwidth and noise is not a new subject. Prior to 1935, it was believed that the information-carrying capacity of a circuit was dependent upon its bandwidth, and there the theory stopped. But in that year, before a technical world hardly ready to accept the concept, E. H. Armstrong proved that the signal-noise ratio of a broadcasting station could be improved materially by assigning a wide band to it.[3] His method was frequency modulation, whereby a spectrum 150 kc wide was occupied by a broadcast station operating with a 15-kc modulating signal, or about 5 times as wide as would be required by a double-sideband amplitude-modulation station.

The effect can be expressed, in somewhat idealized form, as follows: if the bandwidth utilized by an f-m station is doubled, other factors remaining unchanged, an improvement of 6 db in signal-noise ratio can be ideally achieved. Thus for each doubling of the bandwidth, 6 db is *added* to the signal-noise ratio.

The new law shows that this improved performance of an f-m system over an a-m one is still far from the ideal case. The ideal system, the best permissible under the new concept, is one in which the number of db improvement in signal-noise (for high signal-noise ratios) is *directly proportional* to the bandwidth employed. In other words, the number of db improvement is *multiplied* (rather than added, as in the f-m case) when the bandwidth is increased. Thus in the ideal system, doubling a given bandwidth may add a 10 db improvement in signal-noise ratio. If the band is then doubled again, the improvement is 10 times 10, or 100 db, a vast improvement, relative to the additive system typified by f-m. It turns out that the pulse-code modulation system,[4] alone of the schemes now known, is a multiplicative system. From a strictly theoretical point of view, pcm is thus the preferable system to use,

NEW WORLDS TO CONQUER

Modulation is not just a means of superimposing a message onto a readily transmitted carrier; it is also a means of protecting the message from noise during transmission. Just how effectively modulation accomplishes this second objective determines its utility.

Current basic investigations using the powerful mathematical-physical concepts of quantum mechanics, outlined in this article, show that the ratio of received message power to thermal noise power is related to bandwidth; the greater the signal power, the narrower the bandwidth required to maintain a given quality of transmission.

The basic communication problem is to find modulation methods that make these theoretical improvements possible. The opportunity is open to conquer new worlds in communications technology

in Communication Systems

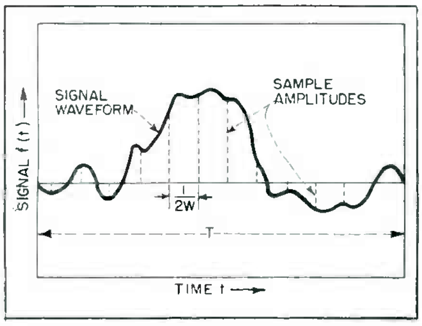

FIG. 2—Signal waveform can be specified by sampling the amplitude at regularly spaced intervals

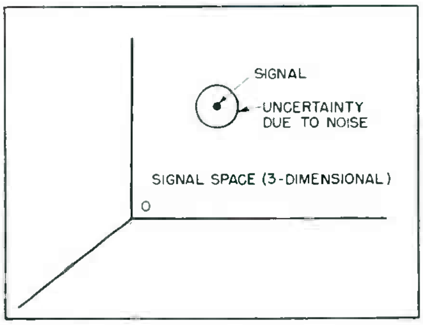

FIG. 3—Representation of a signal by a point in a three-dimensional signal space. The noise surrounds the signal point

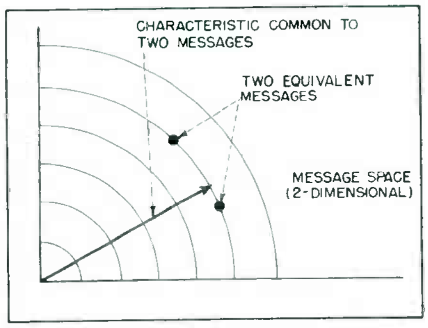

FIG. 4—Representation of equivalent messages as a point in a two-dimensional message space

Reporting an IRE symposium on the reformulation of the Hartley Law. New theory places limit on the extent to which bandwidth can be traded for signal-to-noise ratio, shows extent to which a-m, f-m, ptm and pcm make use of communication channel

when economy in the use of the ether spectrum is the primary consideration. If other economic factors (such as cost of equipment) are present, as they are in broadcasting, pcm may lose its advantage.

The new law (which has not yet received a name, but in which Tuller, Shannon, Sullivan and Wiener, of MIT, BTL, CalTech and MIT respectively, have had a hand) takes the following simple form

$$C = W \log_2 (1 + P/N) \qquad (1$$

Here C is the capacity of the channel to carry information per unit time (strictly speaking, the number of binary digits which can be transmitted in unit time), W is the bandwidth of the communication channel, and P/N is the signal-noise ratio in power units. The law states that if the capacity of the channel is to be increased, this may be done by increasing the bandwidth W, or equally well (cost not considered) by increasing the signal power relative to the noise. Alternatively, if we are satisfied with a given capacity, we may trade off bandwidth for signal-noise ratio. We may reduce the bandwidth W, if we are willing and able to increase the signal-noise ratio (by adding transmitter power or reducing noise). Or we may increase the bandwidth, and thereby permit a reduction in transmitter power, or an increase in noise, without harm to the capacity (e.g. quality of reproduction) of the circuit.

All this trading is possible in an ideal system, of which Eq. 1 is descriptive. Nonideal systems exist, in which increasing the bandwidth may *increase* the noise, as in the nonlimited a-m system. But if the system is clever enough to take full advantage of the ideal law, then bandwidth and signal-noise may be traded as indicated in Eq. 1. Pcm is one such clever system.

Underlying Logic

The proof of the law is not a simple matter, since it involves multidimensional spaces not familiar to the communication engineer. But the thread of the argument may nevertheless be followed from the reasoning presented by Shannon, which is herewith reported as given at the IRE meeting.

Figure 1 shows a typical communication system in which the initial information, in the form of a message, is transformed, by a transmitter using some form of modulation, into a signal. While the signal is in the communication channel, noise is imposed upon it. Noise is defined as a statistical variation imposed on, but not correlated in any way with, the signal. The receiver transforms the signal-plus-noise back into a message which is perceived at the destination.

We now assign a bandwidth W cps to the communication channel, and put the channel to use for a period of T seconds. We inquire into what sorts of signals may be handled within this bandwidth and within this time. While it is impossible to construct exactly any signal function (except zero) which has no spectrum components outside the bandwidth W and no temporal existence outside the time T, some fair approximations may be so constructed.

A generalized example is shown in Fig. 2. Here we have a signal waveform plotted against time. Such a signal (of duration T seconds) may be passed through the system having W bandwidth, if its narrowest hump (half-wave component) is no narrower than $1/(2W)$ seconds. Moreover, if we sample the amplitude at intervals of time equal to $1/(2W)$, the sample amplitudes, taken throughout the duration of the signal, serve to specify the signal uniquely. Since we have taken T as the duration of the signal, it follows that there are $T/(1/(2W)) = 2WT$ sample amplitudes in the whole length of the signal function.

To take a concrete example, if a video waveform depicts a television program for an hour (3,600 seconds) over a bandwith of 4,000,000 cps, there are $2 \times 3{,}600 \times 4{,}000{,}000 = 28.8$ billion sample amplitudes in the signal. If we knew all these sample amplitudes, we could reconstruct the program exactly, even though we did not have the actual video waveform for reference. It thus takes $2WT$ different quantities to specify uniquely all the different types of signals which might be sent over a channel of bandwidth W cps during T seconds.

Coordinates of Communication

Whenever such a large and general description of a quantity is encountered, it has proved most informative to adopt geometric methods of thinking. So, (and here is a big step so far as engineers are concerned) each possible signal capable of transmission through the system is imagined as a *point* in multidimensional space. Since a point is specified in space by its coordinates, and since the signal point (for the complete program) has $2WT$ different numbers required to specify it, it follows that the appropriate space has $2WT$ dimensions. In the television case previously cited, the space has 28.8 billion dimensions.

While such a space cannot be visualized (any more than four-dimensional space can be visualized), its properties may be deduced by the symbolized logic of mathematics, and examples may be visualized by reducing the problem to one, two, or three dimensions. For example, if we have a signal point in multidimensional space, it has the following coordinates: x_1, x_2, x_3 . . . . . x_{2WT} and its average energy is proportional to the sum of the squares of its coordinates. This energy is proportional to the square of the distance of the signal point

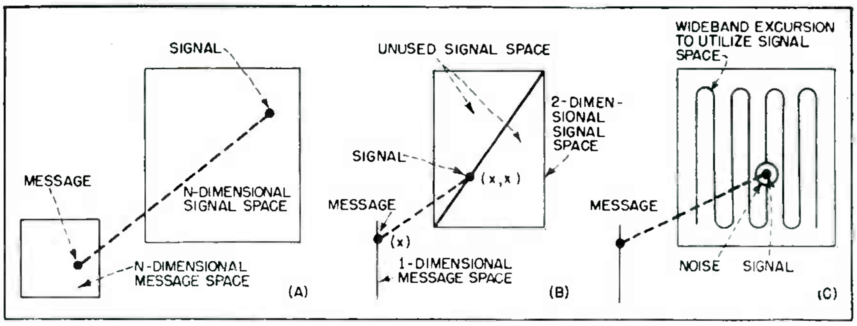

FIG. 5—Mapping is the process of transformation from message space to signal space. (A) Single-sideband a-m in two dimensions, (B) Double-sideband a-m from one to two dimensions, (C) Filling in unused space in double-sideband case, by utilizing a wideband modulation system

from the origin of the space, regardless of the number of dimensions we consider. So we have a convenient relation between the ordinates which describe the signal and the average energy of the signal.

To take a three-dimensional case (a 3-cps channel in use for one second, for example), consider Fig. 3. All the possible signals which may be transmitted are represented as points in three dimensional space. Surrounding each such possible signal is a region of uncertainty (the boundary of which becomes sharper as the number of dimensions increases), which represents the effects of noise.

In other words, the noise adds to or subtracts from the ordinates specifying the signal point in a random way which makes it impossible to know exactly where the signal point is after the noise has been added in the transmission system. But, if we know the average value of the noise energy, which we recall is proportional to the square of a distance connecting points in the space, we know the radius of the roughly spherical region within which the signal point is located. The same concept applies in a space of any number of dimensions, even though the shapes may not be visualized. So we have a *signal-space* inhabited by points representing possible signals, each point surrounded by a region of uncertainty which represents the random effects of noise.

We now consider the *message* before its translation into a signal. The message, for example, may be the audio waveform before application to a frequency-modulated transmitter, the f-m wave radiated being the corresponding signal. Each message has a spectrum of frequencies contained within a band W_1 cps (usually equal to or smaller than the channel bandwidth W). Moreover the message lasts a time T_1 seconds, which may be shorter or longer than the signal duration T. Acting on the same logic as in the signal space, we imagine a *message space* of $2W_1T_1$ dimensions. Each point in this space represents a possible message having the given message spectrum W_1 and message duration T_1. In Fig. 4 we depict a two-dimensional space (a message having a 2-cps spectrum which lasts one second, for example).

Moreover, we may imagine groups of messages which are indistinguishable from one another when perceived at the destination of the system. For example, we may shift the phase of the harmonic components of a speech waveform without changing the sound of the speech as perceived by the ear. If we represent all such indistinguishable messages as points on an arc of a circle centered on the origin, we may specify all such messages by a single quantity, the radial distance from the origin to the arc, as shown in Fig. 4. In this case the message space is reduced to one effective dimension.

Function of Modulation

Having, by dint of some exercise of the imagination, dreamed up two spaces, one containing the message, the other the corresponding signal, we now inquire concerning the translation process from message to signal at the transmitter and vice versa at the receiver. This translation, in geometric terms, is known as *mapping* the one space into the other. An example is given in Fig.

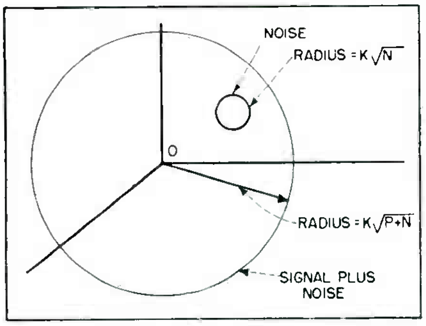

FIG. 6—Derivation of revised Hartley law is based on a spherical signal space, with radius squared proportional to sum of signal power plus noise power

5A. If the transmitter employs single-sideband a-m, the mapping procedure is a one-to-one translation, changing only the position on a frequency scale. If double-sideband a-m is used, two sidebands are produced for each modulating harmonic component, so a message space of N dimensions is thereby translated into a signal space of $2N$ dimensions.

The simplest possible case is show in Fig. 5B. Here a message space of one dimension, the line shown, contains a message represented by the point whose coordinate is x. When translated by a double sideband a-m system into a signal, the signal space becomes two dimensional, as shown, but, since the sidebands are symmetrically disposed about the carrier, the same number describes each, and the corresponding signal point has coordinates x,x. Hence all signals lie on the diagonal line shown. So all possible messages in double sideband a-m are translated from a line to a line. All the signal space outside the line is unused in the double-sideband a-m system. This is the reason why this system of modulation cannot make the fullest possible use of the channel bandwidth.

In Fig. 5C, the wavy line represents a translation (corresponding to that introduced by pulse-code modulation, for example), which makes fuller use of the signal space available, and hence is more efficient than a-m as a modulation system. Efficient modulation systems all operate in this manner, although the shapes cannot be visualized in the multidimensional case.

In Fig. 5C, surrounding the message point is a circle representing the uncertainty introduced by noise. If the wavy lines are placed too close, so that the noise circle overlaps two lines, then the effect of the noise is multiplied. This overlapping means that the wideband system, typified by the wavy line, has a threshold value of signal, below which the effect of noise becomes rapidly worse, more rapidly than in the simple a-m case. This effect has been observed in wideband f-m, pcm and ptm systems. The theory shows that this is a general property of all wideband systems.

System Capacity

Finally, we come to the derivation of the modified Hartley law, Eq. 1. Dr. Shannon illustrated the three-dimensional case shown in Fig. 6. The transmitter power is P watts, and the random noise (white noise) is N watts. The channel has a bandwidth W cps; the signal duration is T seconds. At the receiver, after the signal and noise have become mixed, the signal space is represented as a sphere whose radius squared is proportional to $(P + N)$. To find out how many signal points may be distinguished within this space, we fill it with small spheres representing the noise, each of radius squared proportional to (N). The maximum number of noise spheres which will fit into the multidimensional signal space is then the generalized volume of the message space $K\sqrt{P + N}^{2TW}$ divided by the generalized volume of the noise spheres $K\sqrt{N}^{2TW}$. We thus obtain the number of messages M which may be distinguished at the receiver

$$M = \frac{K\sqrt{P + N}^{2WT}}{K\sqrt{N}^{2WT}} = \left[\frac{P + N}{N}\right]^{TW} = (1 + P/N)^{TW} \qquad (2)$$

We can rewrite Eq. 2 in logarithm form, using for convenience the log to the base 2

$$\log_2 M = TW \log_2 (1 + P/N) \qquad (3)$$

Taking a cue from the pcm system, Dr. Shannon then introduced the binary digit system.[4] If S binary digits are available, the number of messages that can be carried by these digits is $M = 2^S$, from which $S = \log_2 M$. Then, Eq. 3 becomes

$$S = TW \log_2 (1 + P/N) \qquad (4)$$

But S/T, the number of binary digits transmitted per second, is the capacity C of the channel to carry binary digits, so

$$C = W \log_2 (1 + P/N) \qquad (5)$$

which is the law to be proved. Whew! While the law was proved for a system transmitting messages by the binary digit code, it can be shown to apply generally to all classes of systems.

Dr. Shannon pointed out that, while bandwidth can be saved (in the ideal system which makes full use of the signal space) at the expense of signal-noise ratio, the saving is very expensive, because of the fact that the logarithm changes very slowly with changes in the power P. Thus it might be necessary, in a particular case, to increase the transmitter power two times to secure a 10 percent reduction in bandwidth without harm to the signal. But, if one can afford it, one can do it.

A final form of the equation which shows the multiplicative nature of the decibel improvement, previously mentioned, is

$$C = KW\, 10 \log_{10} (1 + P/N) = K\, W\, n \qquad (6)$$

where $n = 10 \log_{10} (1 + P/N)$ is the number of db expressing the signal-noise ratio plus 1, and K is a proportionality constant.

A lively discussion followed the meeting, participated in by Harold Wheeler, who stated his opinion that the number one should be eliminated from the argument of the logarithm. W. G. Tuller, and Herbert Sullivan also participated in the discussion. A summary of the analysis presented by A. G. Clavier, comparing the transmission efficiencies of various modulation schemes,[5] showed that, for operation well above (60 db) the noise, the utilization efficiency of pcm is independent of bandwidth, and that the only known system in which utilization efficiency increases with bandwidth is pulsed frequency modulation.—D.G.F.

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(3) E. H. Armstrong, A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation, *Proc. IRE*, p 689, May 1936.
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(5) Effect of Modulation on Transmission Efficiency, Electronics, p 136, Jan 1948.

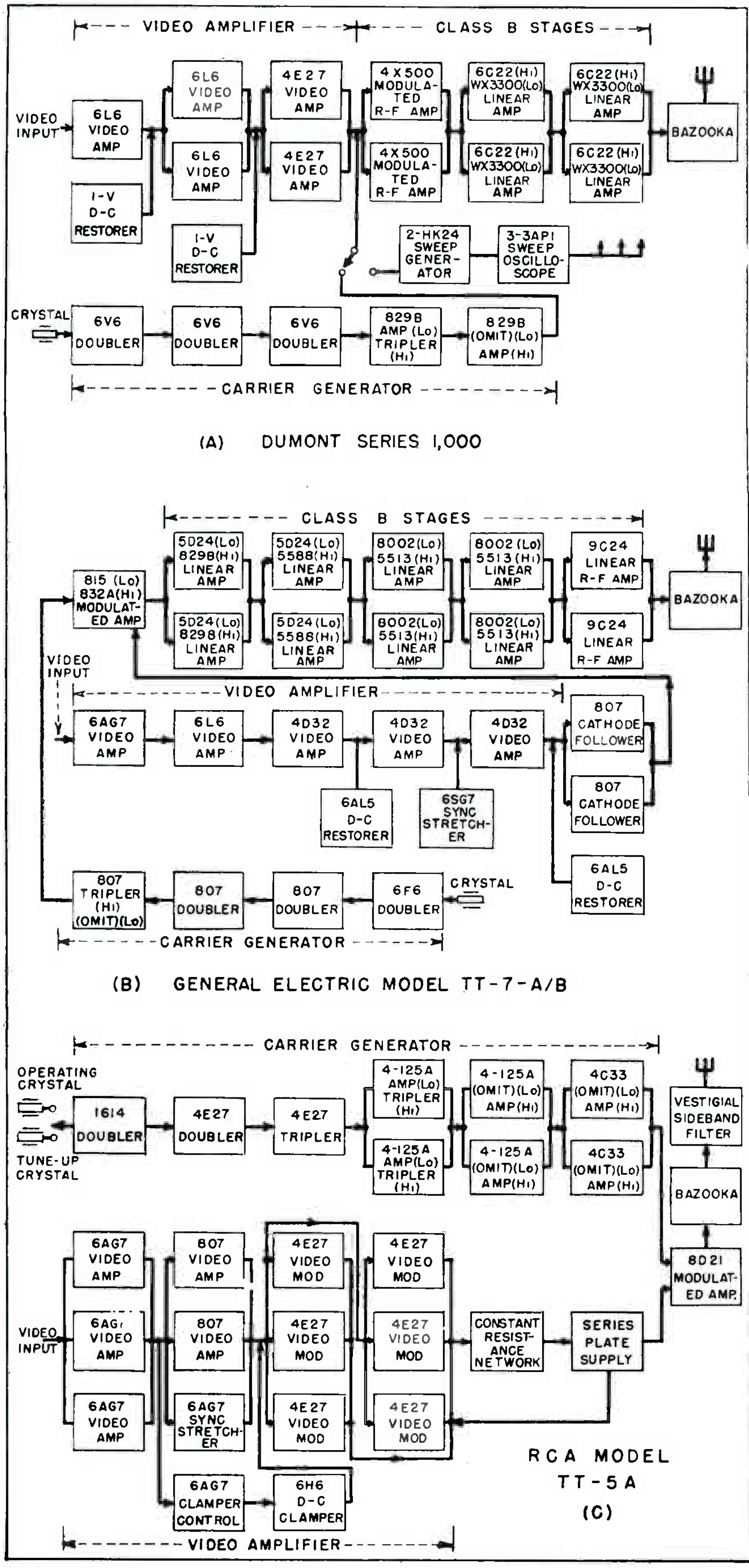


FIG. 1—Block diagrams showing the essential tubes in the DuMont, GE, and RCA five-kilowatt visual transmitters

THREE MANUFACTURERS are currently offering video transmitters for the commercial television channels between 54 and 216 mc. This article is a survey, based on conversations with the engineers who designed the transmitters, conducted to determine why certain decisions were made in their development.

So far as output is concerned, all three makes produce the same result, that is, a vestigial sideband signal of 5 kw peak power (3.5 kw in one case on the high-frequency channels). But the manner in which this result is obtained differs widely among the three manufacturers. The differences appear in the level at which the video modulation is introduced, in the method of removing the unwanted portion of the vestigial sideband, and in the method of cooling the tubes in the power output stage.

In talking with the various groups concerned, the editors found a not-unexpected rivalry and a natural tendency of one designer to question the wisdom of the rival designers' choice of circuits and methods. Taking full advantage of this situation, questions were passed from one group to the other during the interviews and many interesting answers obtained.

Before describing the transmitters in detail, some of the outstanding differences should be mentioned. All three groups employ crystal control and frequency multipliers to establish the carrier frequency. Here the similarity ends.

The RCA transmitter employs narrow-band multipliers up to the final stage and employs high-level modulation at the grid of the final

Design Trends in Television Transmitters

Video transmitters offered commercially by DuMont, General Electric, and RCA reflect basically different approaches to the problems of modulation, sideband suppression, and power tube cooling. The whys and wherefores are reviewed in this survey of available equipment

stage. The undesired portion of the lower sideband is removed by a high-level filter in the antenna circuit.

The G-E transmitter multiplies to carrier frequency at low level and the modulation is introduced at about one watt carrier power. The 5-kw level is achieved by amplification in five linear stages. The high-power stages are of the grounded-grid wideband variety, the pass band of each stage being so positioned with respect to the carrier frequency that the unwanted portion of the vestigial sideband is removed, in accordance with the RMA specifications, before application to the antenna.

The DuMont designers have adopted a position midway between low-level and high-level modulation. Grid modulation is introduced in the 500-watt stage, followed by two class-B linear grounded-grid stages. All three stages are aligned to remove the unwanted portion of the vestigial sideband. The final stage employs air-cooled tubes. In the high-band version of the DuMont transmitter, the power output obtainable is 3.5 kw.

The arguments for and against these arrangements are as follows: The high-level transmitter typified by RCA's offering is easy to tune, since each of the amplifier stages is a narrow-band unit, tunable merely by reference to meter readings. The low-level transmitter on the other hand uses several wideband stages, each of which must be tuned by reference to a sweep-pattern on a c-r oscilloscope. On the reverse side of the argument, the high-level transmitter needs a high level of video voltage for modulation and requires a vestigial sideband filter after the final stage, which in itself is expensive and consumes some of the output power which might otherwise be radiated.

The choice of cooling methods of the final stage is also full of pros and cons. Air-cooling, used by DuMont, is simple and inexpensive. Simple water-cooled tubes such as are used in the G-E transmitter can be made smaller and hence somewhat more efficient than air-cooled tubes. The all-out water-cooled tube used by RCA applies cooling water not only to the plate, but also to the grids and filament seals. This makes for a very small tube, highly effi-

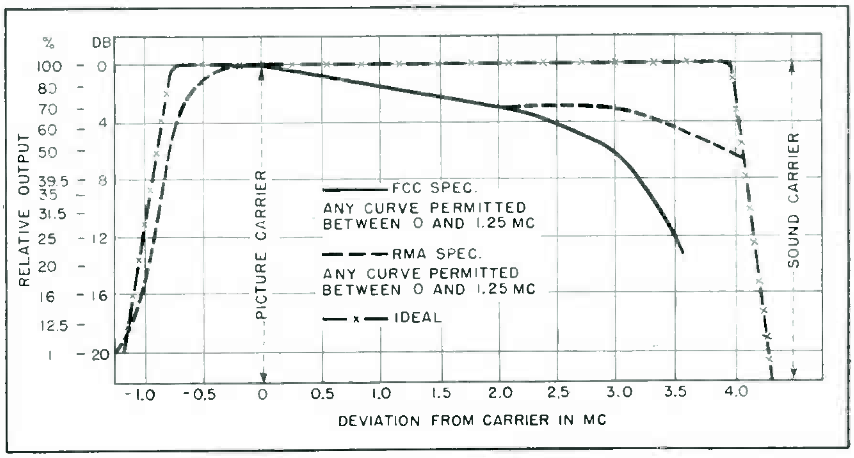


FIG. 2—Transmission channel specified by RMA and FCC standards. A portion of the lower sideband is not transmitted

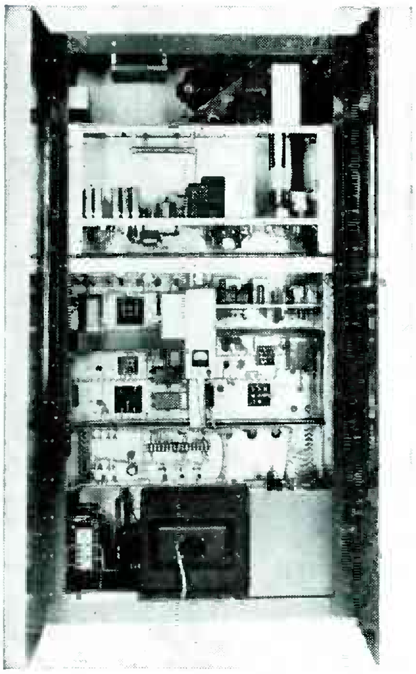


FIG. 3—Rear view of modulator and low-power stages of DuMont transmitter. The 500-watt stage is at the upper right, under blower

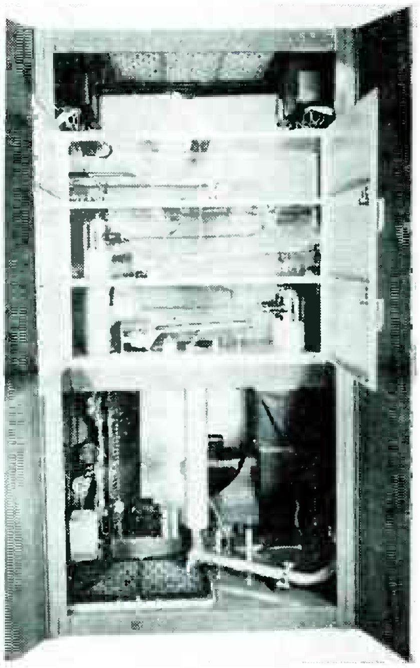


FIG. 4—Rear of DuMont 5-kw amplifier, containing two class-B linear air-cooled stages. The complete tube lineup is shown in Fig. 1A

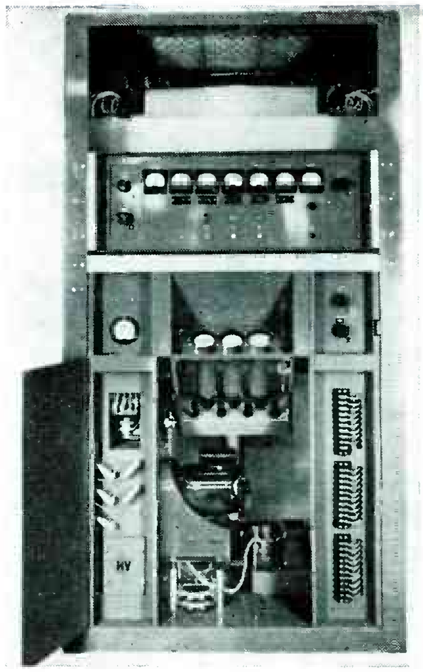


FIG. 5—Front view of DuMont 5-kw amplifier, showing three built-in oscilloscopes, on a sloping center panel, for aligning wide-band stages

cient even at frequencies higher than 216 mc, but requires a distilled water cooling system from which dirt has been rigorously excluded (since dirt particles might clog up the narrow passage through the grids).

It would appear that such basic differences would make a difference in the cost of the transmitter, but this factor does not differ markedly in the three units. The answer is that competition is a great leveler in such matters, and that a sizable production run, over which engineering and development charges are spread, may permit an expensive design to be sold competitively.

DuMont Visual Transmitter (Series 1000)

Considering the three types in alphabetical order, the DuMont transmitter line-up is illustrated in Fig. 1A. The crystal frequency is doubled in the crystal stage, followed by two additional doublers for the low band (channels 2 to 6, 54 to 88 mc) and an additional tripler for the high band (channels 7 to 13, 174 to 216 mc). The carrier frequency thus established, the signal is passed through an amplifier which raises the level to about 60 watts. At this level the carrier is combined with the video modulation and applied to the grids of the modulated amplifier stage (two type 4X500A's in push-pull).

The video amplifier accepts the composite video signal at the standard RMA level of 1.0 to 2.5 volts, and amplifies it in three video stages, the last of which employs two 4E27 tubes in parallel and develops about 50 watts peak video power across 500 ohms (150 volts peak video voltage). The d-c component of the video signal is restored by type 1-V diodes at the grids of the 6L6 and 4E27 stages. Thereafter the d-c component is preserved by conductive coupling between the 4E27 plates and the modulated amplifier grids. Since the latter grids operate with normal negative bias, the 4E27 plates are negative with respect to ground. This requires that the 4E27 cathodes be operated at a negative voltage, below ground by an amount equal to the normal plate voltage. This negative voltage is supplied by a separate power supply.

The output of the modulated amplifier is a video-modulated signal of about 500 watts peak power, with a total bandwidth of about 7 mc. In the low-band version of the transmitter, this power level is amplified to 5 kw peak by passage through two class-B linear stages employing type WX3300 air-cooled tubes. The bandwidth of these amplifiers is between 4 and 5 mc, and the band-pass curve is positioned so that the picture carrier frequency lies to the left of the center, as shown in Fig. 2. Thus the lower portion of the lower sideband is removed, as required by the vestigial sideband standard. In the high-band version of the transmitter, the type WX3300 tubes are replaced by type 6C22, and the peak power output at the output of the final stage is 3.5 kw.

The tuning of the class-B stages is accomplished by adjustment of three parameters: the length of the tank-circuit lines, the lumped capacitance at the ends of the halfwave lines, and the loading reflected from the following stage (first stage) or antenna (second stage). Both class-B stages are operated in the

FIG. 6—One of the class-B stages of the G-E transmitter, showing method of removing air-cooled tube from anode tank. The circuit is tuned by an L-shaped flipper

FIG. 7—Water-cooled final stage of the G-E transmitter. The 9C24 tubes consume heavy filament current, as indicated by the size of the leads

grounded-grid connection, since this reduces neutralization difficulties and adds a portion of the driving power to the output of the stage.

The push-pull output of the final stage is converted to single-ended connection (necessary for the coaxial transmission line to the antenna) by passage through a balanced-to-unbalanced converter (bazooka). This consists of a sleeve around the outer conductor of the coaxial line, at the lower end. Inside the sleeve is a plunger, adjustable to the particular carrier frequency in use. A crystal diode recovers a small portion of the output for measuring power output and indicating the waveform of the carrier envelope.

Internal views of the video-modulated amplifier assembly and power amplifier are shown in Fig. 3 and 4. Primary aims in the DuMont design have been to make all units accessible for servicing without removal from the cabinet, and to keep the circuits as simple and straightforward as possible. The choice of low-level modulation was made to save the cost of a high-level video amplifier, to eliminate the need for a vestigial sideband filter in the output and to secure the highest possible economy in the production of output power. As previously mentioned, this choice admittedly entails more difficulty in tuning the transmitter than if high-level modulation were used. To simplify the tuning adjustments, the DuMont transmitter has three built-in c-r oscilloscopes (Fig. 5) which permit simultaneous monitoring of the sweep-frequency pattern at the input and output of each wideband stage. A built-in frequency-sweep (wobbulator) is also provided, so that all essential test equipment required for lining up the wideband stages is included. It is possible to check the alignment of all class-B stages merely by throwing one switch.

The choice of low-level modulation and suppression of the lower sideband by means of fundamental coupled circuit methods is a result of serious consideration by the DuMont engineers. The choice was made on experience gained since 1939 with W2XWV and later with WABD, particularly with respect to problems of initial installation, ease of maintenance, and the ease with which inexperienced personnel may operate the equipment.

The built-in sweep generator and individual oscilloscopes make the tuning procedure a simple operation. Initially, the transmitter is tuned with loose coupling, producing a sharply tuned resonance curve. As the coupling between stages is tightened, a double-hump resonance curve appears. Each of the secondary stages of the coupled circuits is provided with an adjustable position to vary the loading. When the loading is increased on the secondary of each stage, the bandwidth becomes greater, and the double-hump resonance curve reverts to a flat-topped response characteristic. With this method of varying the coupling and loading, the required bandwidth may be readily attained.

It is desirable to tune each stage so that the minimum bandwidth required is available, to provide high transfer of energy between stages and to attenuate the lower sideband more sharply. This tuning procedure may be begun from either the input end or the output end. Once coupling has been properly adjusted, it is a matter of minutes to make any modification necessary in tuning. Provision has been made to inject a small portion of the r-f exciter voltage for use as marker frequencies.

The grounded-grid amplifier circuit presents its own loading impedance. It is therefore unnecessary to load down the transmission lines, resulting in a considerable increase in effective power.

General Electric Model TT-7-A/B

The G-E transmitter line-up is shown in Fig. 1B. The crystal stage triples the crystal frequency and is followed by two doublers for the low bands, with an additional tripler for the high bands. Modulation is accomplished at the plate of a type 815 tube (low band) or type 832A (high band), the grid of which is driven at carrier frequency. The peak video voltage applied to the plate of the modulated stage is only 80 volts, so the modulation level (about one watt, peak) is substantially lower than that of the DuMont system.

The video chain in the G-E transmitter consists of five stages and a cathode follower, with a diode d-c restorer at the grid of the next to last stage. One of the video amplifiers acts as a sync-stretcher—that is, it extends the amplitude of the sync pulses relative to the remainder of the video waveform, thus permitting the required 25 percent sync pulse amplitude to be maintained at the transmitter output, despite compression in the amplifier stages and even if the input signal has substandard sync amplitude. The final video stage is conductively coupled to the modulator tube and is operated with negative cathode voltage, as previously described.

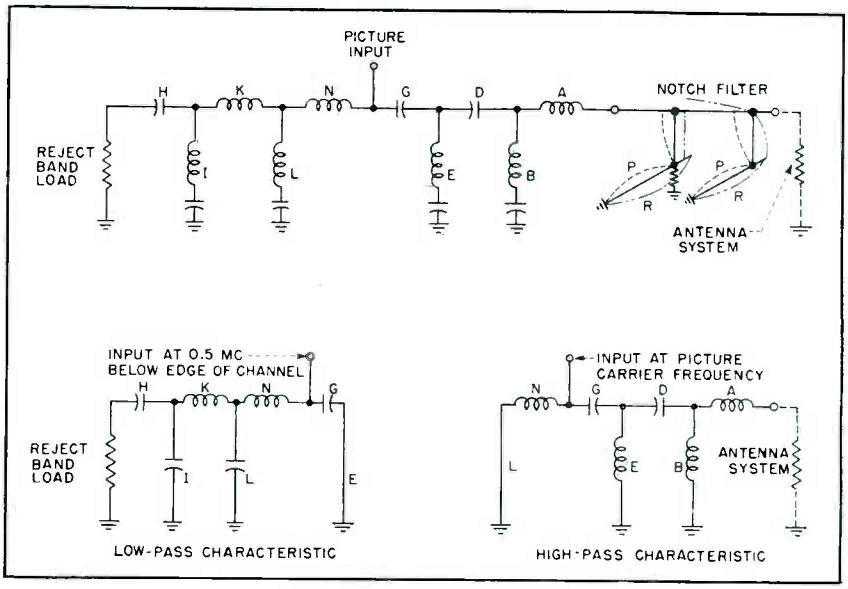


FIG. 9—Equivalent circuit of the high-level vestigial sideband filter used in RCA design. Made of $3\frac{1}{8}$ inch coaxial elements, it will pass a 50-kw signal

The output of the modulated amplifier (low-band version) is amplified in five linear push-pull class-B wideband stages, two stages type 5D24 (or 4-250A), two type 5513, and one type 9C24. The first two are air-cooled, the last three water-cooled. In the high-band version five stages are used. The tubes are types 829B, 5588, 5513, 5513, and 9C24 respectively, the last-named being water-cooled.

To assist in tuning the wideband stages, a built-in sweep generator is included, and the output of the final stage is viewed on an external c-r oscilloscope. The overall bandwidth of the five stages is 4.75 mc, positioned with respect to the carrier as shown in Fig. 2. The sweep generator operates at carrier frequency and sweeps through a range of approximately 12 mc. The sweep is applied to terminal jacks, permanently coupled to the plate tank of each wideband stage. The output applied to the oscilloscope vertical deflection plates is derived from a crystal diode connected within the bazooka in the antenna circuit. The stages are tuned working backward from the output tank, all adjustments of tuning and loading being made from front-panel controls. Alignment of all stages can be completed if necessary, according to the testimony of G-E engineers, in approximately five minutes.

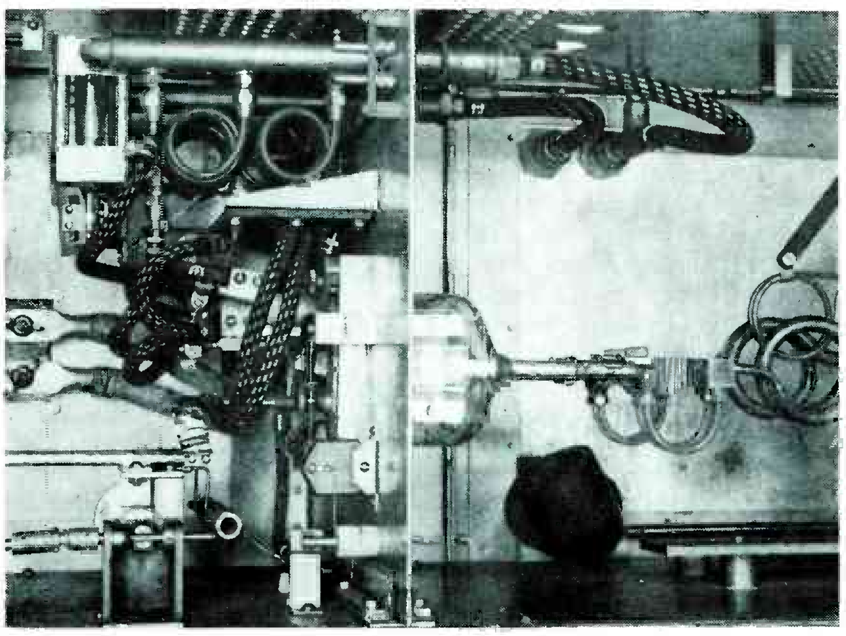


FIG. 8—The final stage of the RCA transmitter. The 8D21 tetrode has water-cooled anodes, screen grids, and control grids, and only 2 $\mu\mu$f plate-to-plate output capacitance. All water connections are of the clip-on type

The factors dictating the choice of the low-level design in the G-E case run parallel to those cited for the DuMont transmitter, so far as avoiding the cost of the video amplifier and sideband filter are concerned. Additional arguments are as follows: Low-level plate modulation makes possible a highly linear modulation characteristic. The use of a cross-connected dual tetrode modulated stage keeps the residual r-f (fed through the modulator at the low point of the modulation cycle) to a small value and hence permits a high modulation capability (maximum white, 5 to 10 percent). Views of the G-E transmitter are shown in Fig. 6 and 7.

The G-E design is based fundamentally on the experience gained since 1939 with station WRGB, a 40-kw transmitter near Schenectady, which also uses low-level modulation. The post-war improvements include the use of the stable and efficient grounded-grid circuit and the rugged disk-seal 9C24 water-cooled final amplifier tube.

Answering objections to the large number of class-B stages, the G-E engineers point out that any variation in the response of one stage introduces a small effect on the output. A similar variation in a high-level-modulated stage would produce a more serious degradation of picture quality. For the same reason, it is possible to remove any tube in the G-E transmitter and go back on the air without retuning, thus evidently reducing off-the-air time.

The grounded-grid circuit is a great favorite with the G-E designers, for three reasons: First, the low imput impedance provides the necessary wideband circuit loading without wasting power. Second, the circuit is remarkably stable. Throughout the development of the high-power grounded-grid stages, parasitic oscillations have never appeared. Third, the low impedance permits easy adjustment of tuning and loading from front-panel adjustments.

In the event higher power is required, additional class-B stages can be added readily, since the same technique of circuit adjustment would apply to them as to the existing lower-power stages.

The final stage employs a water-cooled double tetrode, type 8D21, of unusual design, shown in Fig. 8. Distilled water, supplied at a rate of about 1.7 gallons per minute, is forced through the plate, as well as through both control and screen grid, which are hollow. Water is also applied to the filament seals. This thorough-going cooling system permits the tube to be operated at the very high plate dissipation of 370 watts per square centimeter of anode surface. Consequently the elements, and their electrical capacitance, are much smaller than those of comparable air-cooled and conventional water-cooled tubes. The plate-circuit efficiency is correspondingly high. The tube can operate equally well on all channels up to 216 mc (in fact, full power output has been produced at 285 mc). A self-contained circulating water cooler and filter is used to supply water to the tube and its grid resistor and to the vestigial sideband filter and dummy antenna load, which are integral parts of the transmitter.

The video amplifier consists of three stages, three 6AG7's in parallel, two 807's in parallel (with a 6AG7 sync stretcher) and six 4E27's in parallel, respectively. The pulse stretcher increases the pulse amplitude in the second stage, and a tetrode-controlled dual-diode clamper circuit reinserts the d-c component at the grids of the 4E27's. The final video stage provides about 100 watts of video power on the average.

The load resistance of the final video amplifier is of unusual form, known as a constant-resistance network. Basically the network consists of two arms in parallel, L and R in series in one arm, and C and R in series in the other, such that $R = \sqrt{L/C}$. Such a network displays a constant resistive impedance over a very wide band of frequencies, much wider in fact than the 4.5-mc bandwidth of the modulating signal. The actual form employed in the transmitter consists of several L and C sections, each of which satisfies the relation given above, but with the LC product of each chosen to resonate at different portions of the video band. The two resistors are placed at the bottom of the network (next to video ground), and may be of the wire-wound (inductive) type since they

RCA Transmitter TT-5A

The tube line-up of the RCA 5-kw transmitter is shown in Fig. 1C. Comparison with the DuMont and G-E diagrams in the same figure shows that the RCA design represents a radically different approach. Three crystals are provided. Two serve the usual OPERATE and SPARE functions. The third is a TUNE-UP unit used only during tuning of the final stage, as described later. The crystal stage doubles, and is followed by a doubler and tripler stage. In the low-band version, the next stage is a straight-through amplifier. In the high-band version this latter stage operates as a tripler and two other stages are added to provide the necessary driving power. The next-to-last stage, a pair of 4C33's, provides about 400 watts of driving power for the final stage.

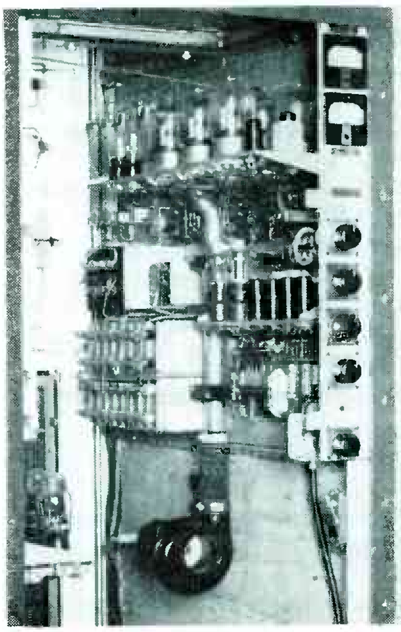


FIG. 10—Video amplifier of the RCA transmitter. The six 4E27 tubes, which develop 626 volts peak-to-peak video, are on top rack

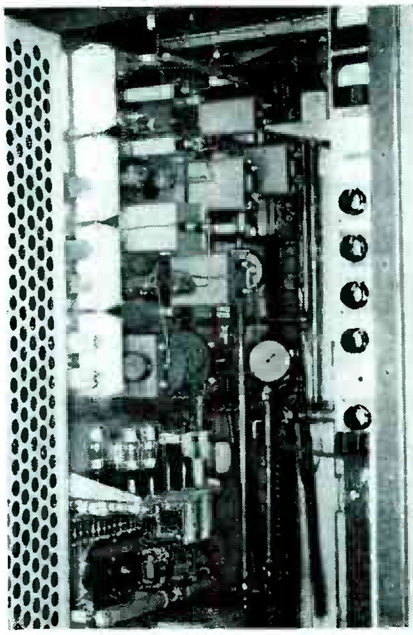


FIG. 11—Elements of the constant-resistance network used as a load for the high level modulator stage of the RCA equipment

have no effect on high-frequency performance. The high power dissipation required of the final video amplifier is thus conveniently accomplished without loss of high-frequency response. Voltage stabilization is applied to all video stages to keep the black level constant.

The video voltage (about 625 volts peak to peak) is applied conductively to the grids of the final r-f stage, which operate at normal negative bias. To apply positive voltage to the plates of the 4E27 modulators, it is necessary to insert a series power supply of 1,100 volts within the constant-resistance network. This power supply is inserted below the high-frequency sections of the network and hence does not add to the capacitive load at the modulator output. The final r-f stage operates at 5,000 volts plate potential. The modulation capability is 90 percent, which exceeds the maximum FCC requirement (85 percent, that is, maximum white 15 percent or less of peak amplitude).

The vestigial sideband filter is essentially three filter sections constructed of coaxial line. The equivalent circuit is given in Fig. 9. Two of the sections are m-derived units, one for passing a portion of the lower sideband energy to a water-cooled terminating resistor, the other for sharpening the cutoff at the edge of the upper sideband. The third filter section is a notch filter for removing any picture-signal energy at the frequency of the sound channel of the next lower television channel. The notch filter also dissipates its energy in a water-cooled resistor. All elements of the sideband filter are constructed of 3⅛ inch 72-ohm coaxial line. This is large enough to pass a 50-kw signal, in the event that a power amplifier is later added to the transmitter. The large size also lowers the insertion loss of the filter to 3.38 percent at 100 mc. Two types of sideband filter are supplied, for low-band or high-band use. Each type is pretuned at the factory for the particular channel assigned to the transmitter. The water flow required by the resistors in the filter is about two gallons per minute.

The tuning procedure of this RCA transmitter is, as previously mentioned, somewhat simpler than in the low-level type of equipment, since only the output tank of the 8D21 stage requires wideband adjustment. Two methods of tuning may be used. In this simpler method, the tune-up crystal is inserted in the crystal stage and the following r-f stages are tuned by the conventional meter-reading method. The carrier frequency thus obtained is approximately 1.6 mc higher than the assigned carrier frequency, and falls in the center of the channel passband. The final stage is then tuned symmetrically by the tuning and loading of its grid circuit and output tank, until it displays predetermined meter readings.

When this preliminary tune-up procedure is complete, the OPERATE crystal is switched into position and the r-f amplifier chain (except the output of the final stage) is retuned to the assigned carrier frequency. This process takes but a few minutes and is accomplished without the use of an oscilloscopic sweep pattern.

The foregoing method does not provide a means of recording the characteristic. For proof of performance, and where precise measurements are required, a second method is used wherein an ordinary video sweep generator is patched into the regular transmitter input. A built-in diode following the sideband filter rectifies the sweep modulation, which may be viewed on a low-frequency scope, and the presentation compared directly to the RMA standards of minimum response. Required adjustments are made on 8D21 anode and output circuits while viewing the scope. This method yields the overall transmitter characteristic, including that of the video system.

The circuits and methods adopted by the RCA engineers are based on many factors, including the experience gained since 1936 with transmitters installed at NBC. High-level modulation was adopted because the picture quality is affected only by the video amplifiers, which require no adjustments in service, one r-f stage, and the vestigial filter. In the low-level case, misadjustment of any of the class-B stages has a definite effect on picture quality, and may even (if balance is lost) reinsert the unwanted portion of the vestigial sideband.

As a further protection against loss of picture quality, the modulated r-f stage uses a tube specially designed for grid modulation over the wide bands required for television. While this tube is admittedly expensive, it possesses a very high degree of stability against regeneration, even a small amount of which is fatal to picture quality, and it offers the rated output of 5 kw at conservative ratings.

The RCA engineers interviewed agree that high-level modulation is practical, at present, only for transmitters of 5 kw or lower power output. If higher power is required in the future, it will probably prove most economical to add a class-B linear stage to the present equipment, since several thousand volts of video signal would be required to grid-modulate a 50-kw stage, and this would require an exorbitantly large investment in the video amplifier and modulator. But for the 5-kw level, the RCA technicians insist that high-level modulation produces the best result, particularly with respect to maintaining picture quality over long periods of time, including tube replacements. They argue that maintenance of picture quality is well worth the additional costs which may be involved, especially since the cost of programming is the predominant factor in running a television station.

Summary

In summary, the points of view represented by the three transmitter designs are vigorously upheld by the respective design groups. One system may attract wider support than the others, but at present there is little evidence as to which system will eventually win out. The writer's opinion is that all three designs are capable of producing results so closely the same that other parts of the transmission system, particularly camera pick-up equipment and network connections, are likely to impose the limit on the overall performance of the broadcasting plant. Only the experience of future months can prove or disprove the competitive claims regarding ease of maintenance and running costs.—D.G.F.

FREMODYNE F-M Receivers

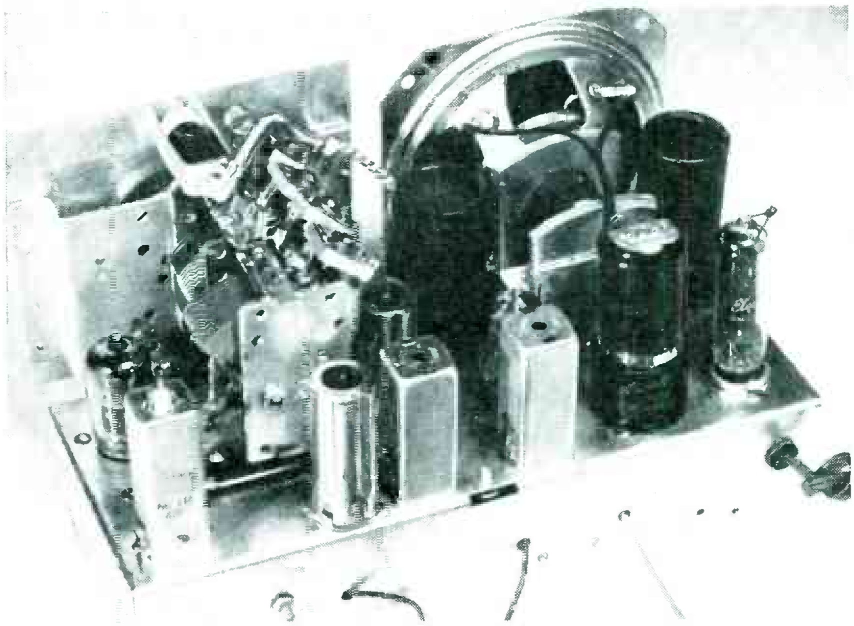
Description and evaluation of measurements made on a novel superregenerative superheterodyne circuit offered for low-cost mass-produced f-m receivers. Figures are given for sensitivity, quieting-sensitivity, distortion, audio response, selectivity, and radiation

THE MOST inexpensive approach, to date, to the production of an f-m broadcast receiver is the "Fremodyne" circuit, licensed by Hazeltine Electronics Corporation to some 125 manufacturers, 5 of whom are currently in production. Because of its potential impact upon every aspect of f-m broadcast listening, the editors of ELECTRONICS canvassed the manufacturing licensees and found that two of them already had receivers or converters. One a-c/d-c table model receiver for f-m and a-m was purchased, another of the same make was borrowed, f-m converter supplied gratis by another manufacturer.

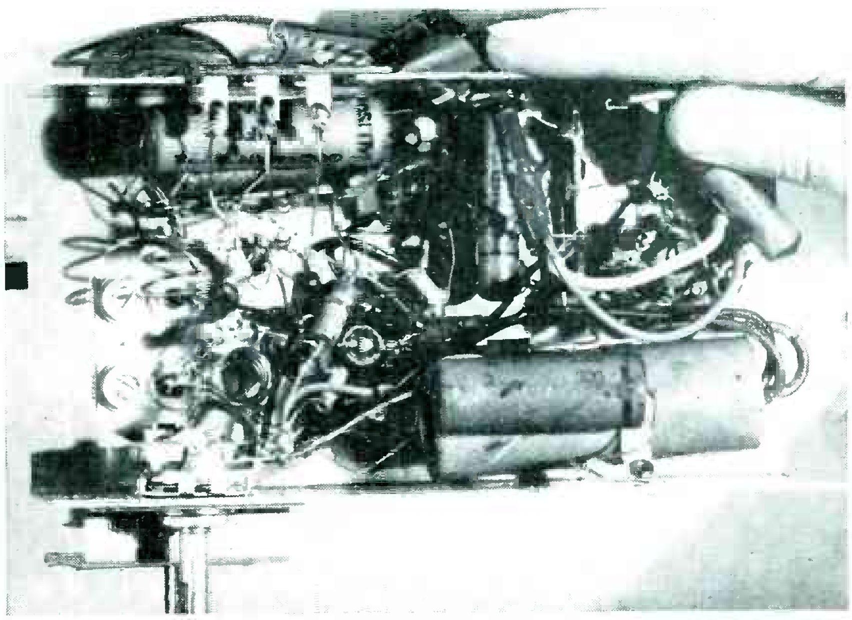
Using standard testing equipment as well as qualitative listening tests, the editors subjected two available versions of the Fremodyne circuit to a series of fundamental tests that will be of significant interest to designers in the f-m field. The tests conducted included sensitivity (signal-noise ratio), quieting-sensitivity (quieting of receiver noise by an unmodulated carrier), distortion, relative audio response, selectivity (response to adjacent and co-channel interference), and radiated interference, although the terms used are not synonymous with those definitions as applied in standard RMA receiver tests.

It should be emphasized that, for reasons to be given, certain arbitrary criteria of judgment were adopted. An extension of the testing method to two conventional types of f-m receivers is intended to aid in interpreting the test results.

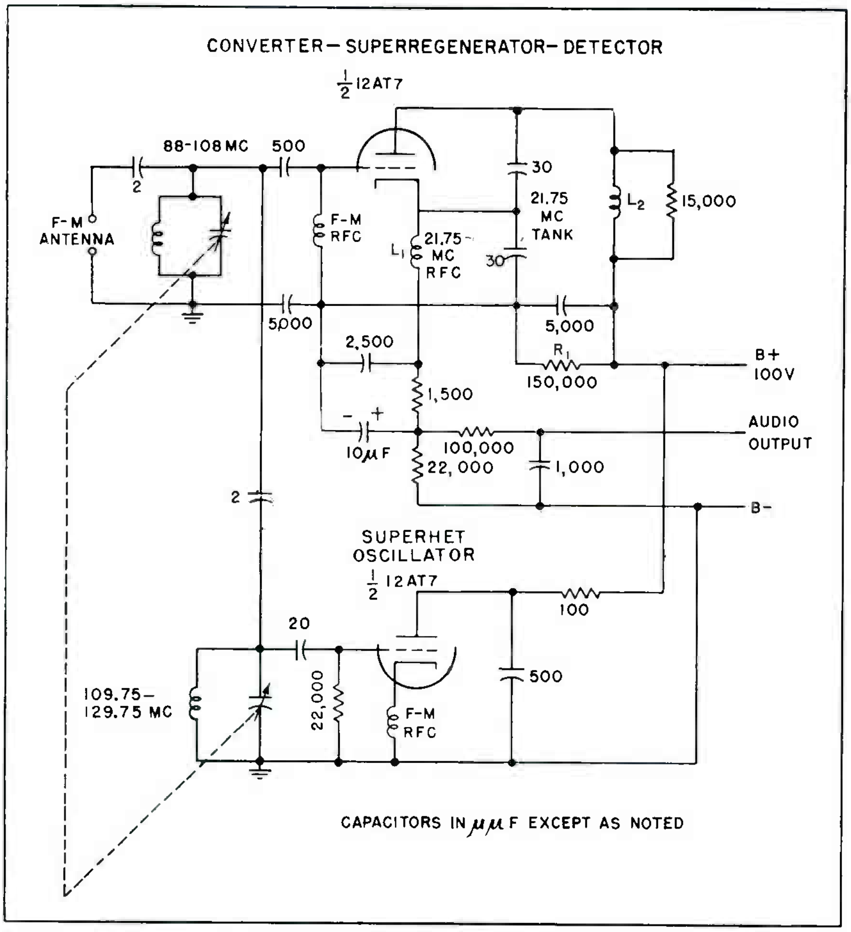
Described by Hazeltine as a superregenerative superheterodyne,



Combination a-m and f-m receiver using the superregenerative superheterodyne circuit. Local and signal tuning coils and padders can be seen above tuning gang at left



Under-chassis view of a Fremodyne f-m converter with r-f circuit at left. Later models use the same basic circuit but have an additional audio amplifier tube



Schematic diagram of the basic Fremodyne circuit

the basic Fremodyne circuit shown consists of a double triode tube, one section of which is used as a local oscillator of the Colpitts type displaced 21.75 megacycles above (or below) the incoming signal frequency.

The local oscillator (lower section in the diagram) output is fed onto the grid of the other triode section (upper section) along with the antenna input. This upper grid circuit is tuned to the signal frequency. The plate tank of the upper section forms a Colpitts oscillator using L_2 and the two 30 $\mu\mu$f capacitors tuned to 21.75 mc. The same triode section operates as a superheterodyne converter and i-f amplifier. It is also a self-quenching superregenerative detector with a quenching frequency in the region of 17 to 22 kc (Hazeltine recommends a quench frequency of 30 kc) by virtue of the 150,000-ohm resistor R_1 returned to B plus. By these means, the oscillator frequency which gives the strongest radiated signal, is displaced from the carrier frequency. Since the detector operates at one frequency, a fixed optimum amount of quench is easily obtained without a separate control. The quench waveshape is controlled by a 1,500-ohm resistor and 2,500 $\mu\mu$f capacitor.

Audio signal is recovered across a 22,000-ohm resistor in the lead from cathode to B minus.

Engineers will find that the circuit behaves in every respect like a simple single-tube self-quenched superregenerative receiver that they may have used at one time or another in receiving f-m signals. As with conventional a-m detectors, slope detection of f-m signals is possible if slight mistuning from the center of the carrier frequency can be satisfactorily achieved and the degradation of the audio quality can be tolerated.

It must be recognized that tests of a superregenerative circuit as an f-m receiver are to some extent arbitrary insofar as distortion, signal-noise ratio and quieting measurements are concerned. Tuning for maximum quieting of the receiver by an incoming carrier gives inacceptable audio output that is rich in second-harmonic distortion. As the receiver is tuned farther down one slope or the other of the detection curve in order to obviate distortion the noise increases. The practice adopted during the tests was always to tune the receiver on the high-frequency side of the incoming signal at the optimum point between distortion and noise.

Testing Equipment

Signal-noise and distortion measurements were made using equipment connected as indicated in the block diagram of Fig. 1.

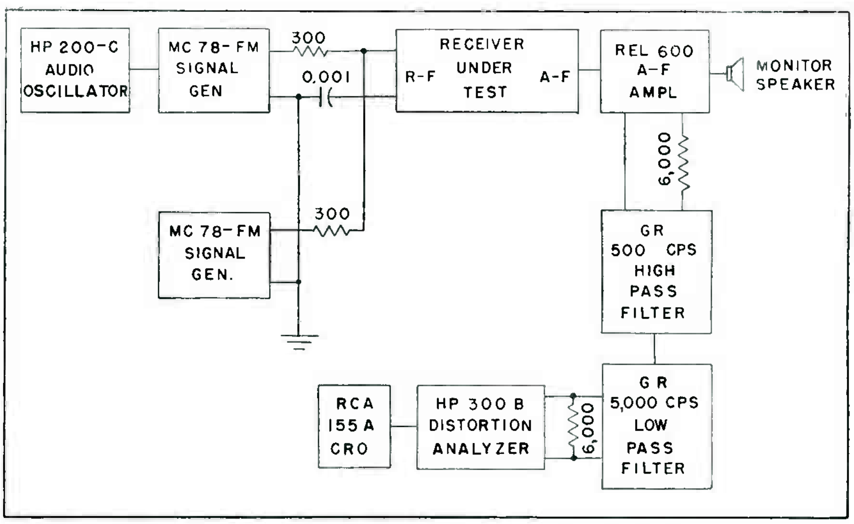


FIG. 1—Block diagram of the testing equipment used and the interconnections

The signal generators were Measurements Corp. model 78-FM for the frequency range covered by the f-m broadcast band, with provision for internal or external frequency modulation of the carrier. The audio oscillator was a Hewlett-Packard type 200-C. Audio output in every case was taken after the de-emphasis network included in the receiver but ahead of any audio amplifier so that the superregenerative circuit was measured alone. Suitable gain was provided by a Radio Engineering Labs. audio amplifier model 600. The loudspeaker was connected to a separate output from the amplifier for monitoring purposes. Owing to hum and quenching frequency noise only the pass band between 500 and 5,000 cycles was measured, except as later noted. Filtering was accomplished with General Radio 500-cycle high-pass and 5,000-cycle low-pass sections. The distortion analyzer was a Hewlett-Packard model 330B instrument and the oscilloscope an RCA type 155A.

Fremodyne sets 1 and 3, discussed hereafter, are a-m/f-m, a-c/d-c receivers of a type shown in the block diagram of Fig. 2. Set 2 as tested comprises only the Fremodyne circuit and power supply; it was designed for use as an f-m converter for existing a-m receivers. Both sets as now manufactured have a line-cord antenna and also make provision for connecting an external antenna, although the line-cord connection was omitted in set 2, in the particular sample tested.

Set 4 is a Zenith model 8HO23 a-m/f-m, high-and-low-band receiver of conventional f-m design, that has been in use for some months without readjustments. It contains a stage of trf, converter, two i-f's, limiter and discriminator. Set 5 is a special receiver, Radio Engineering Laboratories model 646, designed for optimum f-m reception and is in no way comparable to a low-priced home receiver. It has a trf stage, converter, three i-f's, two limiters, discriminator.

Measurements were made of the signal-to-noise (actually signal-plus-noise to noise) ratio at 90 mc using, with one exception, 50 kc deviation with 1,000-cycle modulation. The higher audio frequency was necessary, rather than the more standard 400 cycles, because of the 500-to-5,000 cycle pass band used in the tests. A more considerable deviation than 22.5 kc was desirable in order to obtain a tuning point midway between distortion and noise that would have significance from a listener's point of view. It also served to facilitate duplication of tuning settings during the tests, because they occurred on a straight portion of the detection slope.

Initial tests of Fremodyne set 2 using 400 cycles at 75 kc deviation were essentially preliminary and seemed too severe. Time was not available to repeat them at 1,000 cycles using the lower deviation of 50 kc standardized for the other receivers. The figures as presented are corrected for attenuation of the 400-cycle signal by the 500-cycle high-pass filter. Fremodyne set 3 developed a bad hum after several hours of operation so that only the check points shown, measured before hum began, are felt to be representative.

F-M Receiver Characteristics

The results plotted in Fig. 3 make use of the phenomenon that the desirable characteristics of an f-m receiver include an avc action (the audio output must not change appreciably with changes in signal

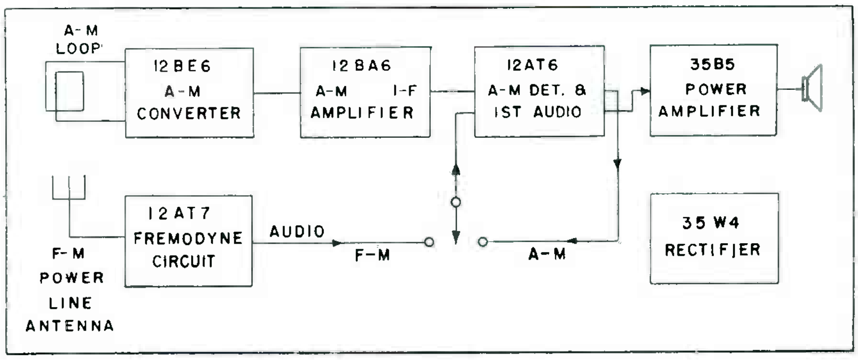


FIG. 2—Block diagram of an f-m/a-m receiver in which the audio system is common to both the Fremodyne and a conventional superheterodyne receiver circuit

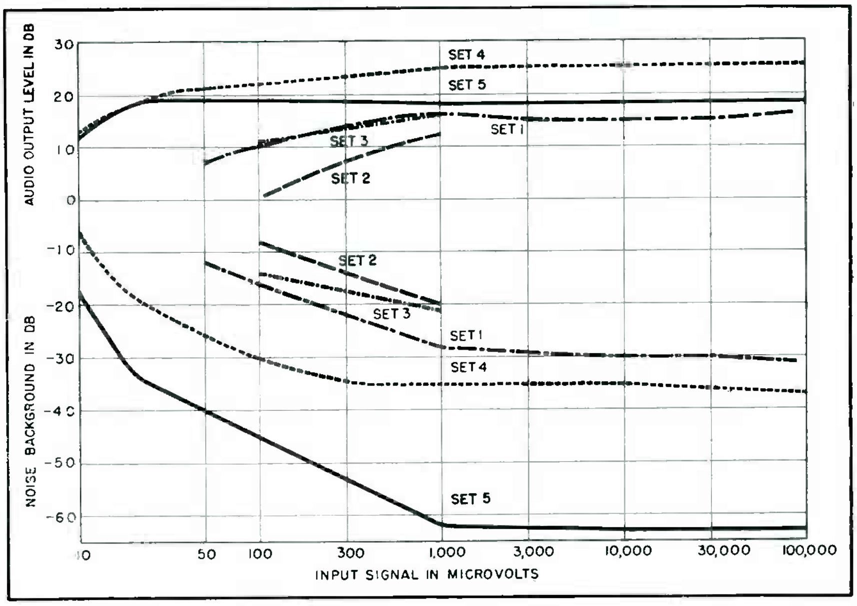


FIG. 3—Audio-output level and receiver noise background separately plotted against input signal strength. Signal-noise performance of an f-m receiver is more clearly indicated by the area enclosed between the curves than by the curves considered separately

strength) as well as an increasing quieting of set noise with increased signal. The horizontal zero axis represents the noise in the absence of signal and so serves merely as a reference, except at the zero-zero point. Quieting in db below the noise level is plotted against unmodulated input signal and can be considered the noise background as encountered by the listener.

The audio level curves (ideally straight horizontal lines with the exception of a short positive slope near the zero-zero point) are computed by subtracting the quieting figures in db from those representing the signal-to-noise ratio at the same signal input. The general shape of the curves is the same for all the receivers tested and the three Fremodynes group fairly closely. What is not immediately so apparent from this presentation is the rather wide difference in performance when we consider not only the separate displacements from the reference axis, but the sum or spread between the two characteristics, audio level and noise background. The average of the two best Fremodynes varies from 26 db at 100 μv to 47 db at 85,000 μv input, while the Zenith (set 4) varies between 52 and 62 db over the same signal input range.

Inspection of the signal generator connection (Fig. 1) will show that while the curves are comparable among the receivers for this test, the effective source actually has an impedance of about 150 ohms and voltages of half the values shown. In other words a receiver that gives 45 db of quieting (noise background scale) at 100 microvolts in this test can be expected to give the same quieting with only 50 microvolts from a single standard signal generator connected to the receiver through approximately 150 ohms.

Percentage distortion for varying signal inputs modulated at 1,000 cycles with 50 kc deviation is shown in Fig. 4. The initial negative slope of each curve represents the inclusion of a large amount of noise at low signal input (owing to lack of quieting) and is, therefore, not particularly significant. The extremely high distortion encountered in set 2 is, undoubtedly, owing to the use of 75 kc deviation (at 400 cycles) rather than the 50 kc later standardized for the other receivers. It is included as a matter of interest but should not be regarded as having comparison significance.

Interference Measurements

Adjacent and cochannel interference measurements centering about 90 mc are given in Table I. It should be noted that tuning of the Fremodyne receivers was fixed on the high-frequency side. Because of the off-center tuning the results of the high and low adjacent channel interference are not comparable. The test setup used is that of Fig. 1. The modulating signal was, with the exception of set 2, 1,000 cycles at 50 kc deviation. Set 2 was tested against 400-cycle modulation at 75-kc deviation. Despite this fact, there is a good correspondence in the order of magnitude of the results.

In the conventional receivers an interfering signal when increased beyond a certain point "captures" the receiver, whereas in the Fremodyne there is merely an increase in the interference. For instance, cochannel interference of a modulated signal was noticed in set 4 at 600 microvolts, but when the interfering signal was increased to 1,000 microvolts the desired signal was obliterated and the receiver was completely captured by the interfering signal.

When the desired signal was unmodulated and the interfering signal modulated, the criterion of interference was a 3 db rise in the background noise. This amount of

Table I—Adjacent and Cochannel Interference

(Modulated interference to unmodulated signal of 1,000 μv)

Interfering Signal	Interfering Signal Strength in μv (for 3db rise in background noise)				
	Set 1	Set 2	Set 3	Set 4	Set 5
Cochannel	50	35	25	25	130
200 kc low	5,000	20,000	10,000	4,000	900
400 kc low	60,000	100,000	85,000	30,000	—
200 kc high	150	180	400	2,500	5,000
400 kc high	40,000	40,000	30,000	15,000	—

(Unmodulated interference to modulated signal of 1,000 μv)

Interfering Signal	Interfering Signal Strength in μv (see text)				
	Set 1	Set 2	Set 3	Set 4	Set 5
Cochannel	15	20	20	600	200
200 kc low	2,000	5,000	4,000	10,000	40,000
400 kc low	50,000	>100,000	>100,000	100,000	>100,000
200 kc high	400	250	2,000	2,500	8,000
400 kc high	30,000	>100,000	>100,000	80,000	>100,000

Table II—Radiation Interference in Microvolts

(Receiver under test tuned to 100 mc. Interference frequency shown in left-hand column)

Freq.	Set 1	Set 2	Set 3	Set 4	Set 5
54				5,500	
64.3					
78.25		30,000			
87	1,000				
100	2,000		4,000		
100.5		600			
101		4,000			
101.6		650			
107.3		1,000			
108			2,500	6,500	
109.5	2,000				
111.1					1,000
121.8	300				
122	25,000		20,000		

rise is, of course, a more severe test to the receivers with low background. In the unmodulated interference to a modulated signal the standard was an arbitrary disturbance of the cathode-ray pattern of the audio. It was always judged by the same individual over the short period of the test.

Audio Response

Relative audio response, including the de-emphasis circuit, was measured on two receivers, modifying the measuring setup (Fig. 1) by substituting a General Radio 15,000-cycle low-pass filter for the band-pass filter.

The results, corrected for the de-emphasis characteristic, are shown in Fig. 5. The signal input to both sets was 1,000 microvolts using 1,000 cycle tone modulation with 50-kc deviation. Test was not made on set 3 because of hum trouble that developed. The tests show that although the sets have a flat audio output response from about 100 to 1,000 cycles, divergence from uniformity starts increasing rapidly on either side of these limits. Even more important, distortion due to beating with the quench frequency begins at about 4,000 cycles in set 1 and between 6,000 and 8,000 cycles in set 2, so that the flat portions of the curves are the only useful ones. The intermodulation effect probably results from the low quench frequency.

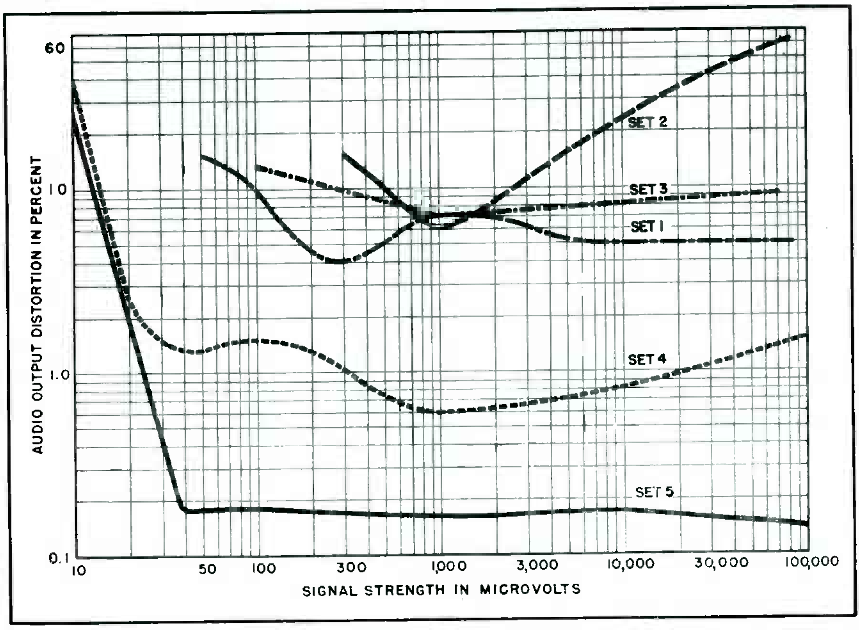


FIG. 4—Percentage audio output distortion plotted against input signal strength. (Curve for set 2 is not comparable to others. See text). Initial negative slope is caused by noise

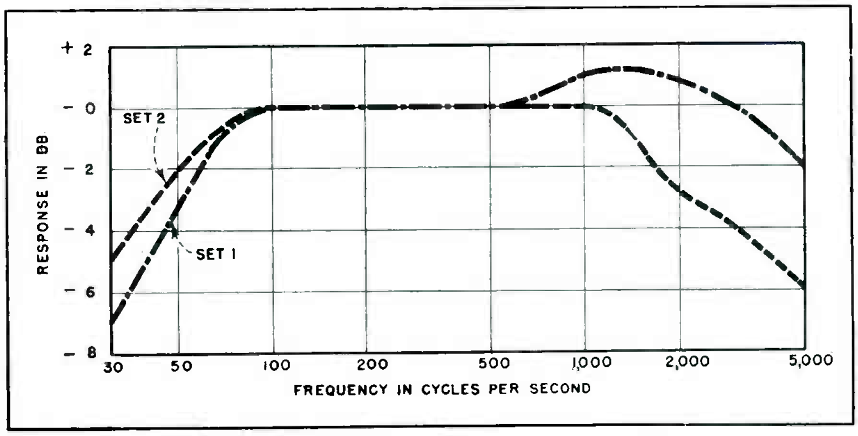


FIG. 5—Relative audio response for sets 1 and 2

Radiated Signals

Of significance both to the set owner and to those receiving signals in the same or adjacent bands is the amount of power radiated by a receiver. The antenna, or antenna and ground, terminals of the Fremodyne circuit were connected through a 10-foot length of 70-ohm coaxial cable to the antenna terminals of a Hallicrafters S-27 receiver and the dials set to 100 mc. Then the S-27 receiver was tuned for points of strongest signal emanating from the receiver under test and the signal strength calibrated with a Measurements Corp. generator. As might be expected, the greatest signal intensity occurred at the frequency of the local oscillator. Other wide-band interference was also found, peaking at the frequencies and with the strengths listed in Table II. Radiated signals of less than 300 microvolts intensity are not included. Strong noise signals peaking at 21.75 mc in a band over 3 mc wide could also be picked up on a Hallicrafters S-28 receiver about 10 feet away and not physically connected to the test receiver.

Qualitative Listening Tests

In the editorial offices of ELECTRONICS on the 30th floor of the McGraw-Hill Building near Times Square, it was found possible to pick up 16 f-m broadcast stations using only the line cord antenna used in Fremodyne sets 2 and 3.

Although the audio quality of the programs as received in the f-m position is inferior to that from a-m stations carrying the same material, the relative freedom from fluorescent lighting, elevator contactor and other noise makes the f-m section preferable for continued listening. Cochannel listening with two similar receivers spaced about 25 feet apart along corridors is impossible, and even at about 100 feet there is some squealing and hash across the dial of either receiver.—A. A. McK.

Complete nondestructive thickness gage, with indicating headphones and crystal transducer probe

Portable Ultrasonic Thickness Gage

Thickness of empty or full pipes and tanks, or metal sheets, is quickly measured to 1 percent accuracy. A frequency-modulated oscillator provides an audible indication of plate current peaks when the oscillator is tuned to fundamental or harmonic thickness resonance with material under test. Indicating dial shows steel thickness directly

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THE USE of ultrasonic vibrations for nondestructive thickness measurement and flaw detection received an impetus during the war years that has resulted in development of practical equipment of great importance to industry. All of these commercial devices employ electronic means of generating the ultrasonic signal and detecting changes in its transmission or reflection within the material under observation. The reflection may be from the far side or from a flaw.

The Audigage, to be described, differs somewhat from other thickness-measuring equipment. It may be conveniently thought of as a device for setting a metal sheet or wall into thickness vibration, provided with a means of detecting the frequency of resonance from which the thickness of the known material can be determined. Operationally, it is unique in being portable and in using an audible signal to indicate resonance.

The instrument was designed primarily to be used in connection with thickness determination of tanks, pipes, process vessels, and other structures that may be readily accessible from only one side. It will quickly and reliably provide information that might otherwise have to be obtained by drilling into the wall and measuring its thickness. In other applications the

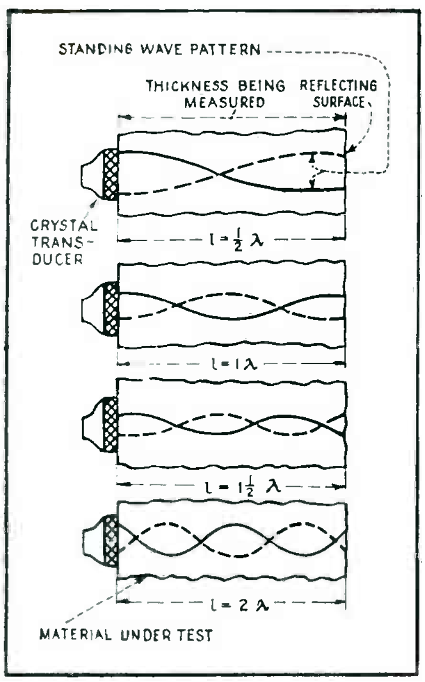

FIG. 1—Representative standing-wave patterns of ultrasonic vibrations in material

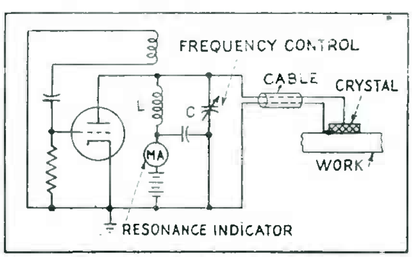

FIG. 2—Basic circuit for a variable-frequency ultrasonic thickness tester

Thickness gage being used to check condition of filled gasoline tank and outlet pipe

use of the instrument will save costly dismantling of equipment for inspection. If temperatures are not excessive, thickness measurements can often be made without the necessity of shutting down operations.

Physical Principles

The ultrasonic resonance principle of thickness measurement depends upon two fundamental characteristics of sound waves. First, they travel through metal at a velocity that is a function of its density and of its elastic constants.[1] This velocity is not appreciably influenced by small variations in temperature. The relationship is expressed

$$V_1 = \left(\frac{E}{\rho}\,\frac{1-m}{(1+m)(1-2m)}\right)^{1/2}$$

when V_1 = velocity of longitudinal waves in cm per sec

E = Young's modulus in dynes per sq cm

ρ = density in grams per cu cm

m = Poisson's ratio

In the second place, sound waves are reflected by surfaces separating two areas such as metal and water that have different acoustical impedances. Standing waves can be set up within the wall of a pipe, or within a metal plate, just as standing waves are set up within the air column of an organ pipe, as shown in Fig. 1. The frequency of the standing waves depends upon the thickness of the material and the velocity of sound in the material, just as the frequency of the organ pipe depends upon its length and the velocity of sound in air.

Fundamental and Harmonic Operation

The fundamental frequency at which thickness resonance vibration will be produced is given by the relation

$$f_1 = c/2t$$

where f_1 = frequency in cycles per second

c = velocity of sound in the material in inches per second

t = thickness in inches

Thickness resonance occurs also at all harmonics of the fundamental frequency such as $f_2 = 2f_1$, $f_3 = 3f_1 \ldots f_n = nf_1$.

The frequency difference between two adjacent harmonics is numerically equal to the fundamental frequency. When the fundamental frequency is known, the thickness can then be determined from the equation $t = c/2f_1$.

When two adjacent harmonics are known, the equation used is

$$t = \frac{c}{2\,(f_n - f_{n-1})}$$

Limitation and Accuracy

The ultrasonic principle of thickness measurement does not provide an average thickness reading over a large area. It will only provide indications for the thickness components which are directly under the area of the crystal. If there are excessive variations in the thickness under the crystal area it will not be possible to obtain thickness readings.

In the case of nonparallelism between an inner and outer surface, reduction of the crystal area may provide better results. For a crystal with sides 0.5 inch by 0.5 inch, operating at a frequency of one megacycle, a change in thickness of 0.2 inch in the thickness direction for each inch in the plane of the work will be the maximum slope that can be measured. If the slope is in excess of this amount the thickness indications will overlap. This means that a first-harmonic resonance condition for the smallest thickness component under the crystal will occur at the same frequency which will produce a second harmonic resonance condition for the largest thickness component under the crystal.

The maximum slope which can be measured is expressed approximately by the formula

$$m = \frac{0.1}{f\,l}$$

where m = maximum slope in inches per inch

= maximum ultrasonic frequency

used for the thickness measurement

l = dimension of the crystal in the direction of changing slope

In the case of pitting caused by corrosion the results that can be expected are not so easy to predict because the area at the bottom of a pit may be small or large depending upon the type of corrosion. If the area at the bottom of a pit is about equal to the crystal area, or larger, it will be possible to measure the minimum wall thickness. The worst possible condition can be obtained by machining rows of sharp edged V-shaped grooves in a flat plate. The maximum peak-to-valley depth of groove in the reflecting surface for which thickness readings can be obtained is expressed approximately by the formula

$$d = \frac{0.1}{f} \text{ where}$$

d = peak-to-valley depth of grooves in inches

f = maximum ultrasonic frequency used for the thickness measurements.

Corrosion and erosion will usually produce a relatively uniform thinning over a given small area which is included in any one thickness reading. For example, one side of a pipe will often corrode or erode much faster than the opposite side. However, the variation in thickness will be small within any small area. Therefore, thickness readings can be made at points around the circumference and local thinning will be detected.

For materials of uniform thickness, it is possible to obtain accuracies of better than one percent. In applications where it is necessary to measure corroded materials an accuracy of 2 to 5 percent can normally be expected.

Materials such as scale, coke, and other deposits that may form on an inner surface of a tank or pipe are poor conductors of ultrasonic waves. Therefore, it is possible to measure the true wall thickness of a tank without introducing errors owing to other materials which may be in contact with one surface. Most liquids are good conductors of ultrasonic waves. However, the acoustic properties of liquids will ordinarily differ considerably from the wall of the container. Therefore a large part of the ultrasonic energy will be reflected at the boundary of the liquid and the container wall. The wall thickness of the container can be measured accurately even though a liquid is in intimate contact with one surface. Since some of the ultrasonic energy will enter the liquid there may be a weak thickness indication owing to the resonance of the wave in the total distance through the liquid in the container. This phenomenon will have an effect upon the character or pitch of the audible sound obtained because of thickness resonance of the container wall, and thus provide the experienced operator with useful information on the condition of the inaccessible surface.

By using acoustic indications, advantage is taken of the fact that the ear is much faster in response than a sensitive d-c instrument which would otherwise constitute the simplest indicator. In addition, an operator is free to use his eyes for other duties such as reading the thickness dial or insuring proper placement of the transducer probe.[2,3]

Electronic Principles

The instrument under discussion performs two functions—the transmission of sound waves of varying

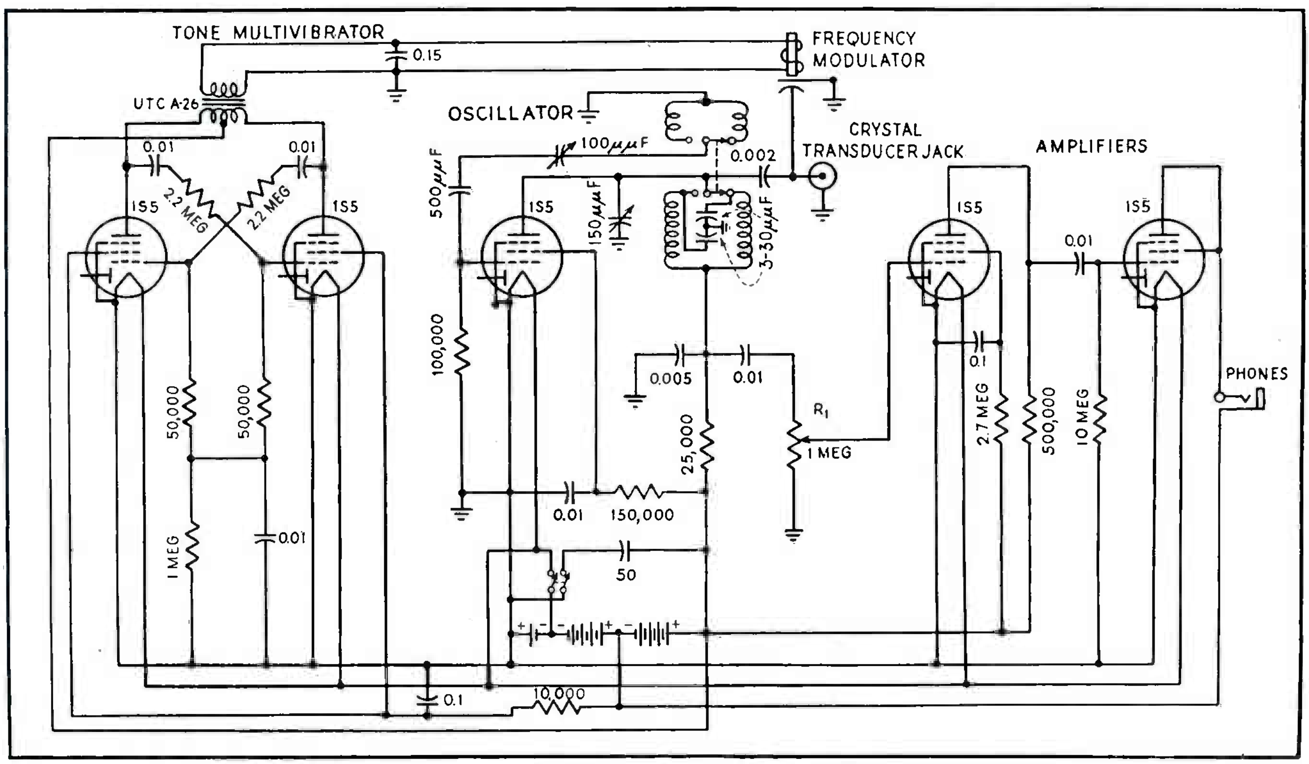

FIG. 3—Circuit diagram of the Audigage model FMSS-4 instrument

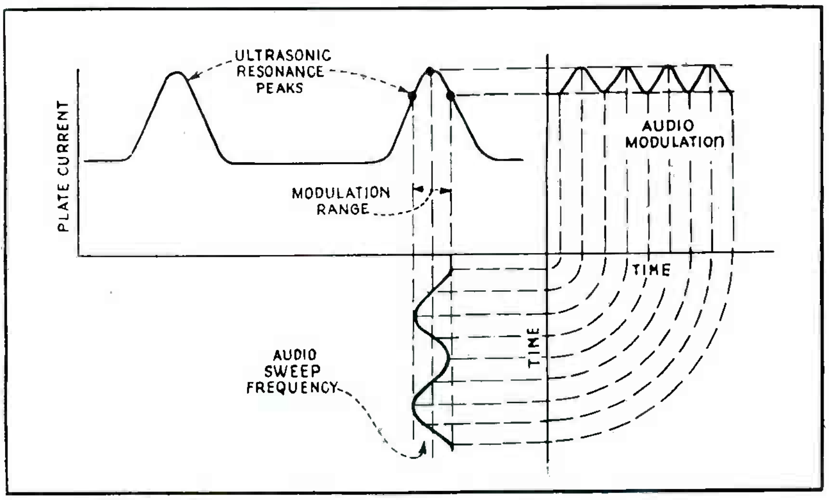

FIG. 4—Approximate representation of the audible indication resulting when a frequency-modulated ultrasonic wave is tuned to resonance with material under test

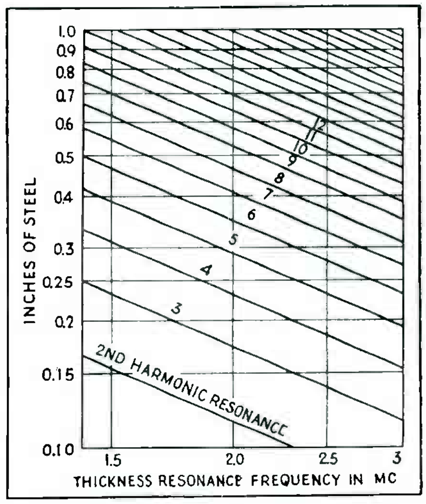

FIG. 5—Harmonic resonance chart, used when thickness is approximately known

frequencies into the material and the detection of the presence of standing waves. The principles underlying the development are those used in the Sonigage[4] of the General Motors Research Laboratory.

A basic circuit, shown in Fig. 2, comprises a variable-frequency self-excited oscillator that generates an alternating voltage which is applied to an X-cut quartz crystal. When the crystal is held against the material to be tested, with a film of oil or other suitable coupling fluid between the crystal and the work, an ultrasonic wave is transmitted into the material. If the oscillator is tuned to a frequency that is an integral multiple of the fundamental frequency of the wave in the thickness of the material, there will be a sharp increase in the amplitude of the vibration in the part of the wall directly under the crystal. This is a resonant condition and because of the internal damping in the material there will be an increase in the energy dissipated. The effect on the oscillator is the same as adding a resistive component across the LC circuit.

An increase in the oscillator plate current results. This increase, which may vary between a few percent and 25 percent, is detected by the instrument. The oscillator frequency at which the increase occurs is read on a calibrated scale.

Several methods can be used to indicate the increase in the plate current due to thickness resonance. The simplest means is a sensitive d-c instrument in the oscillator plate circuit. Such an instrument is, however, inherently slow in response. To insure that all thickness indications are observed it would be necessary to tune over the frequency range slowly while carefully watching the instrument pointer. The circuit actually used, shown in Fig. 3 is only slightly more complex and provides several desirable features. The oscillator that drives the crystal is frequency-modulated over a small increment at an audio-frequency rate. When a thickness resonance is located within the modulated frequency range a current oscillating at an audio-frequency rate is flowing through the input resistor R_1 of the amplifier. This signal is amplified to provide an audible indication by means of a set of headphones. An approximate graphical presentation of this effect is shown in Fig. 4.

The oscillator, frequency modulator and amplifier, powered by small batteries are all contained in a case and weigh less than 10 pounds. The frequency range was determined by the thickness range and by the material to be measured. A range from 0.125 inch to 12 inches on steel was selected; the corresponding frequency range is 1.4 to 2.8 megacycles. The graph in Fig. 5 shows how the instrument is used to measure at harmonic frequencies.

The X-cut quartz crystal is cemented to a plastic holder and connected to the instrument by a flexible coaxial cable. The crystal is ground to a natural frequency that is somewhat higher than the maximum frequency generated by the oscillator in order to avoid resonance effects.

The area of the crystal is determined by the lowest applied frequency. The crystal dimensions perpendicular to the X-axis should be equivalent to several wavelengths of the ultrasonic wave in the material to be measured. This dimensioning is necessary to produce a beam of ultrasound with the required directional properties. Crystals with a 0.25-square inch area have been used satisfactorily at one megacycle, where the crystal dimensions are equal to about two wavelengths of the wave in steel. Better sensitivity and sharper indications are obtained if crystal dimensions of five or six wavelengths can be used. In practice, a size of one inch square has generally been found satisfactory.

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FIELD TESTS for

Experimental units developed for field testing the Citizens Radio Service are described. A simple equation, for calculating the expected coverage of two-way systems having various characteristics, was experimentally checked with this equipment

By
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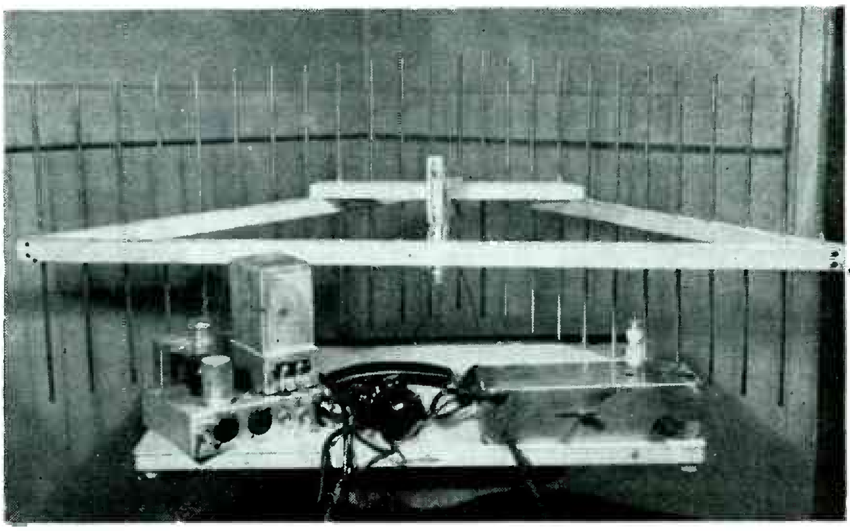

FIG. 2—Directional antenna, power pack, and transmitter-receiver of the two-watt experimental station for 465 mc

THE SUBJECT of ultra-high-frequency radio propagation has been covered in the technical literature, and has recently been summarized.[1] In considering the performance of Citizens Radio systems,[2] the theory can be reduced to a simple semiempirical formulation which gives results of practical usefulness.

From the power limitations, the nature of the service, and analysis of the more common expected applications, we can make the following assumptions or restrictions:

All computations can be made at 465 megacycles.

Power will be of the order of 10 to 25 watts for class A fixed stations, 1 to 5 watts for mobile stations, 0.1 to 1 watt for semiportable stations, and 10 to 50 milliwatts for personal sets.

Antenna heights will usually be small compared to the distance covered, so conditions approaching free space transmission will seldom be encountered. This will be especially true for mobile and portable sets. (Exceptions would include use in aircraft.)

The combination of low power and low antennas should result in a reduced range such that corrections for earth curvature would be minor. The problem is complicated by the greater probability of intervening man-made obstacles or vegetation between low antennas. One can at best introduce an empirical correction to include the resulting attenuation to the correct order of magnitude.

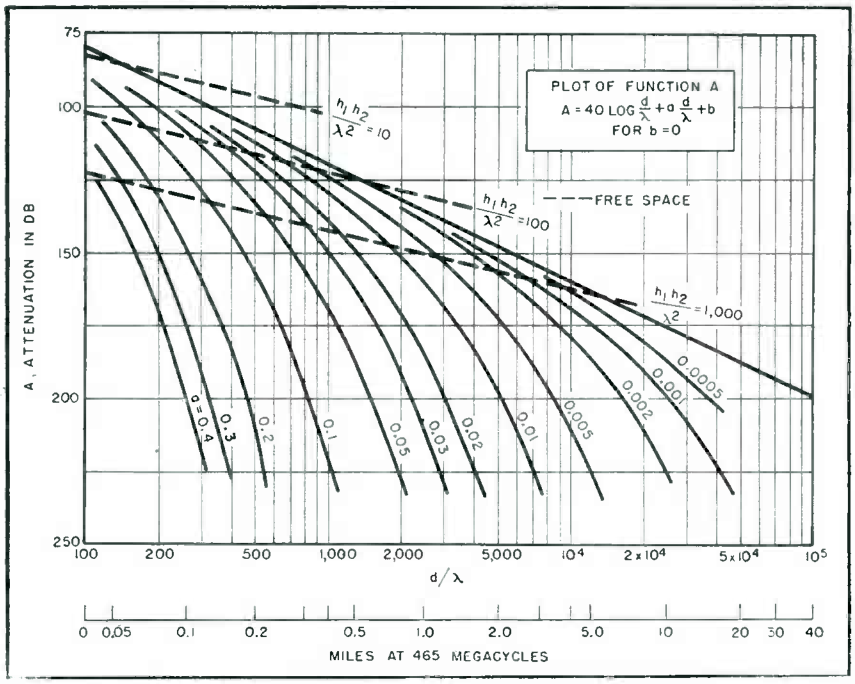

FIG. 1—Curves plotted for two terms of the propagation equation. Values can be taken from the curves

From a paper presented at the 1947 National Electronics Conference in Chicago.

CITIZENS BAND

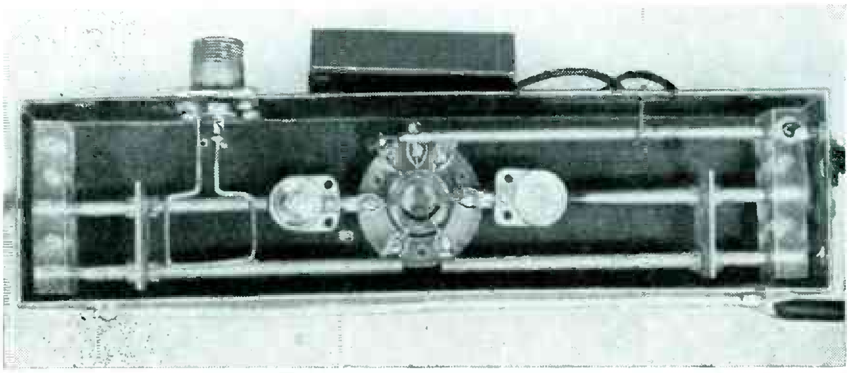

FIG. 3—Construction of lines in the two-watt plate-modulated oscillator

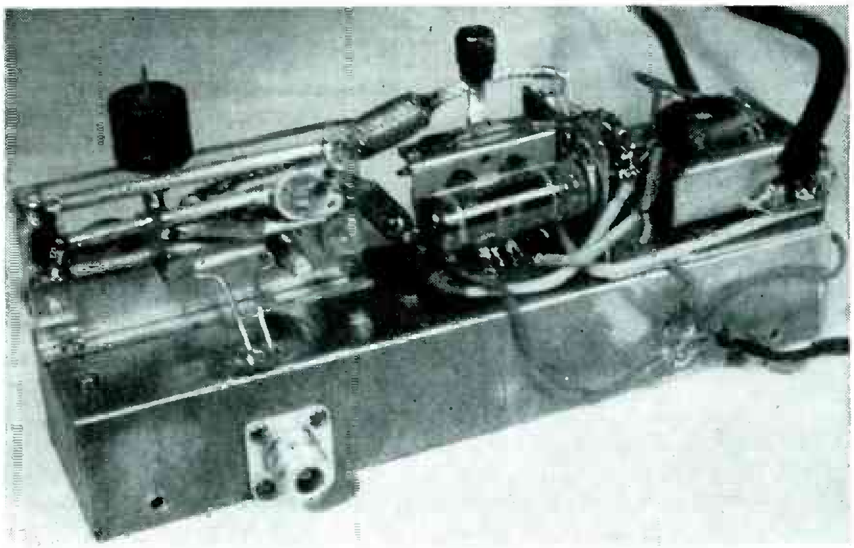

FIG. 4—Superregenerative receiver and audio amplifier-modulator

By expressing the contribution of each element of the system as a gain or loss in decibels, maximum convenience is achieved. When all elements including transmitter and receiver are considered, the sum of all such contributions will total zero at the maximum distance of intelligible communication. This maximum distance will be taken as the measure of performance of the system.

Useful Equation

With the above assumptions, one can arrive at the following semi-empirical expression:

$$T + R + 20 \log \left(\frac{h_1 h_2}{\lambda^2}\right) = 40 \log \left(\frac{d}{\lambda}\right) + a \left(\frac{d}{\lambda}\right) + b$$

In the above equation

T = Transmitting station gain factor in db.
R = Receiving station gain factor in db.
h_1, h_2 = Heights of transmitting and receiving antennas respectively, above ground or reference plane.
λ = Wavelength in free space, in same units as h_1 and h_2. (At 465 mc, λ = 2.12 feet)
a = Empirical attenuation constant.
b = Empirical attenuation constant.
d = Maximum useful communication range, in same units as h_1, h_2, and λ.

The station gain factors are computed as follows:

$$T = T_t + T_a - T_c$$
$$R = R_r + R_a - R_c$$

where

T = Transmitter carrier power output, in db above one watt.
R = Receiver power sensitivity for a 10-db signal to noise ratio, in db below one watt. (Measured at modulation level normally used in transmitter.)
T_a, R_a = Transmitting and receiving antenna gains in direction of transmission, expressed in db over an isotropic radiator.
T_c, R_c = Coupling and mismatch loss between equipment and antenna in db.

With the exception of the two attenuation terms involving constants a and b, the propagation equation follows directly from the commonly used approximation for transmission over a plane earth.

Constants

The attenuation constants a and b as used here do not have direct theoretical justification. In fact, the dimension of a in decibels/distance in wavelengths is chosen purely for convenience in plotting curves to a single ordinate. Their use, if included in calculations, must be governed by a certain amount of common sense and experience. Since they are each intended to correct for a different class of conditions, only one or the other will ordinarily be used in a given calculation.

The constant a is introduced to indicate the order of attenuation produced by a more or less uniform distribution of buildings or vegetation between low antennas. At 465 megacycles, certain ranges of values for a have been determined which give good results. In perfectly flat open country, it may be neglected. In ordinary open country with scattered vegetation, a value of 0.0005 db/wavelength gives good results out to about 15 miles, indicating that earth curvature effects are also partially compensated. In dense woods, values between 0.04 and 0.08 db/wavelength may be used. In downtown sections of cities or in industrial plants, where communication directly through large structures is attempted, the average attenuation will be found to be be-

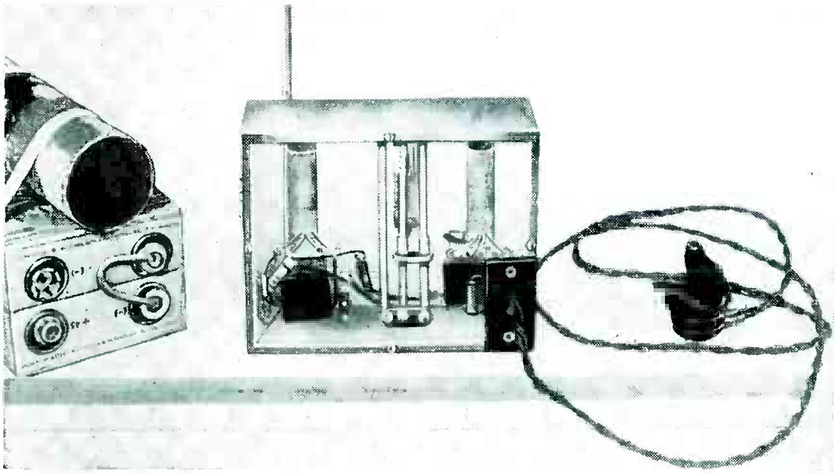

FIG. 5—Midget receiver with separate quench oscillator to provide square pulses to the detector grid

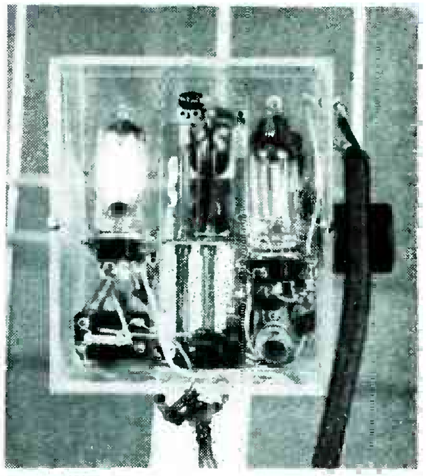

FIG. 6—Closeup of early receiver using miniature tubes

tween 0.2 and 0.4 db per wavelength.

The constant b serves an entirely different purpose. Consider the case where one antenna is located above surrounding buildings, and the other near street level some distance away. Normal optical transmission will occur from the elevated antenna over the tops of the buildings to the vicinity of the receiving antenna. Here, random reflections will transfer a certain amount of signal energy down to street level, but with a loss of anywhere up to about 30 db. Under these conditions, one can obtain a first approximation by using a value for b of about 15 db. Other cases may arise where some obstacle introduces a fixed attenuation of known order of magnitude.

Unpredictable effects of considerable magnitude will be encountered. At distances well within the maximum range, variations in signal level of 20 or 30 db will not seriously impair communications, but at greater distances such variations may represent the difference between intelligibility and complete absence of audible signal. Shadow effects from large solid structures in the line of sight, or standing-wave patterns set up by reflecting surfaces, can cause just such variations, and it is necessary to move the antenna to a position of best signal strength. In some cases a movement of one or two feet is sufficient, indicating that a single antenna should be used for both transmitting and receiving to insure reciprocity.

For convenience, the first two terms on the right of the propagation equation are plotted in Fig. 1.

Examples

To illustrate the method, and indicate what can be expected from typical Citizens Radio systems, consider combinations of the following equipments:

Transmitter 1, personal: 30 milliwatts power, $T_t = -15$ db.

Transmitter 2, portable-mobile: 1 watt power, $T_t = 0$ db.

Transmitter 3, fixed: 15 watts power, $T_t = 12$ db.

Receiver: 7 microvolts sensitivity at 50 ohms impedance, $R_r = 120$ db.

Non-directional antenna, simple half-wave dipole = Gain +2 db.

Directional antenna, dipole with 90-degree corner reflector = Gain +12 db.

Antennas for the first two transmitters are 3.2 wavelengths (7 feet) above ground, or a height gain of $20 \log 3.2 = 10$ db. The antenna for the fixed transmitter is 75 feet above ground, giving a gain of 30 db, which is partially offset by a 3-db coaxial cable loss.

Figures of performance in terms of maximum useful distance are tabulated in the accompanying tables for various combinations of units. Values of a are 0.0005 for open country, and 0.04 for dense woods. Values in parenthesis are the average of experimental data.

The value of a directional antenna as a field accessory for portable use is obvious. The tables do not apply to the downtown sections of large cities, where results are so variable as to preclude any useful interpretation. Communication may be good between low-power portable sets for a few blocks if they are in direct optical view of each other; but where buildings intervene, the attenuation will be very great. Numerous weak signal areas due to reflections and shadows are very annoying to an operator; consequently, one could hardly expect operation in such areas to be of value to the general public.

This statement may be modified somewhat in the case of certain special applications. The points of weak signal due to multiple reflections from surrounding structures seldom have anything approaching a complete null. Rather, a signal from a low-power portable transmitter, radiated from an antenna which may be unfavorably placed, will at a short distance become so weak that standing wave variations may take it down below the receiver noise level. Where a more powerful transmitter with a favorably placed antenna can be used, as in the case of multiple address or paging systems, one will find most of the immediately surrounding territory filled up with signal.

Effect of Obstacles

In one test, a transmitting antenna was located about 50 feet above the street on a long support projecting from a window. The antenna was about 25 feet below the average roof level of surrounding buildings. Power was about 0.2 watt. Intelligible signals could be heard on the same street for about a half mile in either direction, but as soon as a corner was turned even one block away, the signal disappeared.

High Antenna

In another series of tests at a different location, about 10 watts of signal were fed to a directional antenna mounted on top of a 75-foot tower. The antenna, a dipole with a 90-degree corner reflector, is mounted on a rotatable platform, and is high above immediately surrounding structures. The surrounding area is densely built up with brick homes, apartment buildings and light industrial plants, most of which are two or three stories in height. A receiver and a 1-watt transmitter were mounted in a car having a quarter-wave vertical antenna on the roof.

In driving away from the fixed station following an arbitrary route along the streets, one is out of direct view of the tower most of the time. In certain general directions, an intelligible signal is received up to about 7 miles, with only minor occurrence of dead spots. Within about three miles, no noticeable loss of intelligibility is found under streetcar wires, bridges or the elevated structure. At one point about a mile south of the tower, signals can be understood in the center of a 300-foot long steel viaduct under a railroad yard.

A summary of field tests shows that coverage is nearly complete within about a three-mile radius. Beyond this radius, coverage to a car is good to about a 7-mile radius except where one is anywhere in the shadow of a tall and bulky structure such as a gas storage tank to the southwest. Beyond the 7-mile radius, reception is generally poor or non-existent except for line-of-sight.

These results will not be duplicated in downtown areas, but they do indicate that substantially complete coverage of industrial properties or large public gatherings for paging purposes can be accomplished with a suitable transmitter and antenna.

In rural areas where the ground is fairly level, much less variation from the predicted performance is found. It is in such areas, or in smaller towns, where Citizens Radio should find its chief application. Any particular combination of equipment will have its own maximum expected range of communication, but at distances within that particular range, reliable communication should be expected.

Farmers, ranchers and various types of field parties should find many uses. Hunters will find their use of Citizens Radio somewhat restricted because of the high attenuation of dense woods, but on the other hand, lake fishermen or yachtsmen will obtain good results. The performance in hilly or mountainous country has not been directly investigated.

Figure 2 shows a transmitter-receiver combination which may be operated from a six-volt storage battery or from an a-c power supply. The transmitter consists of a plate-modulated oscillator using a type 6F4 acorn triode in the center of an effective half-wave line with both ends short circuited. A power output of two watts is obtainable with better than 50 percent plate efficiency. By reducing plate voltage, power outputs of one-half watt or one watt may be selected.

The receiver is a self-quenched superregenerative detector with an input sensitivity of 7 microvolts for a 10-db signal-to-noise ratio. Input coupling was adjusted for maximum performance when the source had an impedance of 50 ohms. The receiver tube is a Raytheon 605-A miniature triode.

A common audio-frequency amplifier is used for both transmitter and receiver. Tuned circuits consist of short-circuited sections of two-wire transmission lines. Interconnection cables at radio frequency are type RG-8/U coaxial line with type N fittings. Figures 3 and 4 show views of the transmitter-receiver unit.

Figure 5 shows a midget battery-operated receiver used in tests re-

Table I—Two Personal Sets

Antenna Type	Total Gain	Range in Miles Open Country	Range in Miles Dense Woods
Nondirectional..........	129 db	0.6 (0.5)	0.2 (0.15)
Directional.............	149 db	2.0	0.3

Table II—Two Portable-Mobile Stations with Type 2 Transmitters (1 Watt)

Antenna Type	Total Gain	Range in Miles Open Country	Range in Miles Dense Woods
Nondirectional..........	144 db	1.5	0.25
One Directional........ / One Nondirectional.....	154 db	2.6 (2.8)	0.35 (0.4)
Directional.............	164 db	4.0	0.43

Table III—Between Type 3 Transmitter with 75-Foot High Directional Antenna, and Mobile Installation with Type 2 Transmitter and Nondirectional Antenna

Direction of Transmission		Range in Miles Open Country	Range in Miles †City Streets
To Car.................	183	8.5 (8–12)	6 (3–7)
From Car.............	171	5.0	3 (1.5 to 4)

† Calculated with $a = 0$, $b = 15$ db.

FIG. 7—Frequency multiplication of 48 is accomplished in four-tube transmitter

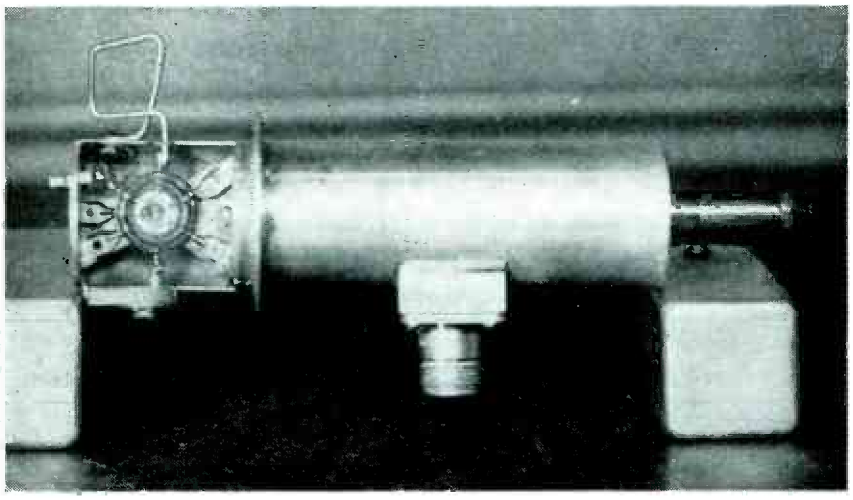

FIG. 8—Final doubler stage of the crystal-controlled transmitter shown in Fig. 7

quiring portable equipment. It includes a Raytheon developmental 556-A triode in a superregenerative detector circuit, and is probably one of the first receivers to successfully use a filamentary type triode at this frequency. A separate quench oscillator provides a square pulse to the grid, it having been found that self quenching was unsatisfactory because of transit time effects in the tube. This receiver has performance identical to that of the receiver in Fig. 4. An earlier model of the battery receiver is shown in Fig. 6.

A battery operated transmitter of similar size has been built and used in tests. The 556-A tube is used as a plate-modulated oscillator, and produces about 30 milliwatts of power.

Figure 7 shows an exterior view of a crystal-controlled transmitter (radio-frequency section only) having an output of one-half watt at 465 mc. A multiplication factor of 48 times from the crystal frequency is accomplished in four tubes. The fourth tube, a 6F4 triode, is mounted in the quarter-wave coaxial cavity shown in Fig. 8, and acts as a doubler.

The antennas used for both dry-battery models are half-wave dipoles protruding directly from the insulating case, and capacitively coupled to the plate of the oscillator. Either dry-battery model can easily be carried in one hand.

Two antenna types have been used in most tests. One consists of a quarter-wave vertical antenna operated above an equivalent ground plane of six radial elements. The other is a 90-degree corner reflector antenna with a gain in the forward direction of 12 db over an isotropic radiator.

Receiver sensitivity and other measurements requiring a signal generator were made with a Measurements Corp., model 84 signal generator. Frequency measurements were made with a General Radio model 720-A uhf frequency meter. Measurements of power below 1 watt were made with Sylvania type PM-8 and PM-9 power measuring lamps, and above 1 watt with a Radio Research Laboratory type 532-B wattmeter which has for a terminating load impedance a length of 50-ohm lossy coaxial cable.

Conclusions

A considerable amount of work must yet be done before finished sets in commercial form are ready to be offered to the public. It has been demonstrated, however, that simple and compact equipment can be built using existing techniques and available components. Citizens radio transmitter-receivers for fixed, mobile or portable use, drawing their power from storage batteries or a-c sources, can be built into convenient packages and will render a useful service. Dry battery operated sets of the hand carried or pocket types are also commercially practical for uses allowed by their limited range, and as Cledo Brunetti of the National Bureau of Standards has demonstrated, the limit of small size has not been reached.

The writer wishes to thank Nelson P. Case, chief engineer, and Harold Rensch, both of The Hallicrafters Company, for their active assistance and participation in the development and experimental work which is being carried on. Acknowledgment is also due to R. E. Beam of Northwestern University, for suggestions and help in completing a thesis project which formed a part of this work.

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(1) Kenneth Bullington, Radio Frequency Propagation at Frequencies Above 30 Megacycles, *Proc. IRE*, p 1122, Oct. 1947.

(2) Electronics Sponsors Citizens Radio Project, ELECTRONICS, p 80, Nov. 1947.

Limited COMMON CARRIER RADIO SERVICE

Hitherto unused frequency allocations provide extension of telephone answering service. Pioneer f-m 160-mc message-dispatching stations with solid coverage in Greater New York develop a new market for mobile radio systems

FREQUENCY ASSIGNMENTS in the region of 160 megacycles are being used by several relatively new services. Notable among these are taxi radio, already crowded and clamoring for more room, and common carrier systems that make possible an extension of telephone service to moving vehicles.

Although plans are now going forward for increased activity in the field of *limited* common carrier this category has so far received too little attention. A well-defined example of such a facility is furnished by the Brooklyn Telephone Answering Service, which uses radio to supplement its regular functions in Greater New York. Since June 1947, the organization has pioneered a new type of service in this country, though it is closely paced by other similar organizations with comparable aims, chief among them being the Telephone Exchange, Inc. located in Manhattan and using identical equipment.

Secretarial Service

A typical telephone answering service performs two general functions. It acts as a secretary for doctors or others whose offices are closed during certain periods of the day or night but whose duties are carried on over an essentially 24-hour day. By prearrangement, the service either comes in on a telephone line after three unanswered ringing signals or when the subscriber calls in to request that each call be answered immediately. Some business establishments list a telephone number that is answered only by the service and the service office in effect manages all the subscribing company's telephone business. Telephone interconnections are arranged through the Telephone Company, which has for years shown no inclination to dabble in this specialized field that constitutes a secretarial rather than a strictly communications service.

Subscribers to the Brooklyn service are so far principally doctors. Included, however, are an oxygen service, private ambulance operators, collision and towing-truck companies, commercial refrigeration emergency crews, marine riggers, limousine services, and fire adjusters. Most of these subscribers are also served by the supplementary radio dispatching service.

Present tariffs depend upon whether the subscriber rents or purchases the mobile equipment installed in his vehicle. For customers supplying their own equipment the cost is $17.50 a month for the first hundred messages. The second hundred messages cost 15 cents apiece. From 300 calls and up the charge is reduced to 10 cents. A message is defined as any complete transmission or reception at the central service office. Calls from cars to test reception conditions are not subject to charge.

Particularly in the initial stages, subscribers to the radio service are reluctant to spend the $300 to $600

Telephone Exchange, Inc. dispatcher with remote control unit and loudspeaker. Incoming and outgoing calls are channeled through her land wires necessary for the purchase of mobile equipment and yet are definitely desirous of obtaining the more favorable rates available to those owning their own equipment. The Brooklyn Service has taken a realistic attitude towards the matter and is now prepared to accept a cash down-payment and eleven notes, each payable on succeeding months at a yearly rate of 6 percent. Besides paying interest only on the time that the principal is actually outstanding, the subscriber saves more than the cost of the financing with a normal use of the service because of the reduced tariff.

Although the subscriber is ultimately responsible to the Federal Communications Commission for the operation of his equipment, the details of obtaining a simple license for type-approved transmitter-receiver are handled by the service company that makes installation.

Free-lance radio actor Carl Frank using a typical subscriber's installation served by the Manhattan service

Installation engineer Kendall adjusts a dispatcher's receiver at the St. George Hotel tower in Brooklyn. Transmitter and power amplifier are above two receivers

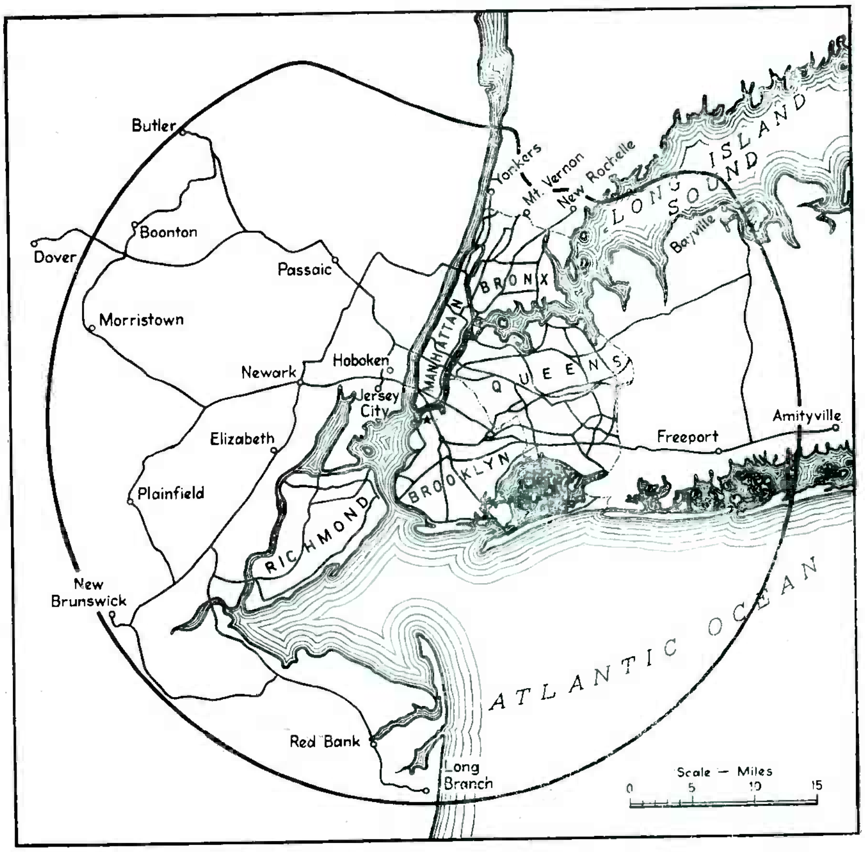
It should be understood that the subscriber in his car, or anyone calling the subscriber, talks only to the Brooklyn Answering operator-secretary. While at first blush this lack of direct contact between subscriber and correspondent might seem a disadvantage it has many good points. In the first place, anyone desiring the extension of normal telephone facilities can obtain them through the radio network set up by common carriers licensed for such service. The type of subscriber using the *limited* common carrier system may frequently find it inconvenient or undesirable (as is the case with doctors) to communicate directly with the person initiating the call.

A doctor can call briefly through the service to inform his office of his whereabouts or availability and then continue driving through traffic while his secretary attends to the details of his regular routine, informing him of his best schedule after she has considered all the factors in the case. This aspect of the service also enhances the economical use of the radio spectrum. A trained dispatcher can quickly present the essential information and receive a comprehensive reply, whereas two individuals talking over the telephone are likely to use manyfold the required time necessary for the transmission of the bare intelligence. Actual tests show that on a limited common carrier system the time elapsed between the reception of a message and its transmittal to a subscriber varies between six and eight seconds.

Installation

Besides providing a fixed transmitter of greater power than the mobile equipments, great care was exercised in the location and installation of the transmitting-receiving antenna and its associated equipment. Because of the premium placed upon tall buildings for f-m and television broadcast use, no attempt was made, after preliminary investigation, to compete with the rental costs imposed upon these services. Owners of lower buildings were canvassed and finally the roof of the Hotel St. George in Brooklyn was chosen as the most favorable compromise among the factors of location, elevation, and rental. The monthly rate (excluding additional power charge) is less than that for a comparable space in the guest rooms of the hotel, making the installation economically feasible. The transmitting-receiving installations are controlled over a pair of leased telephone wires from the main office of the answering service.

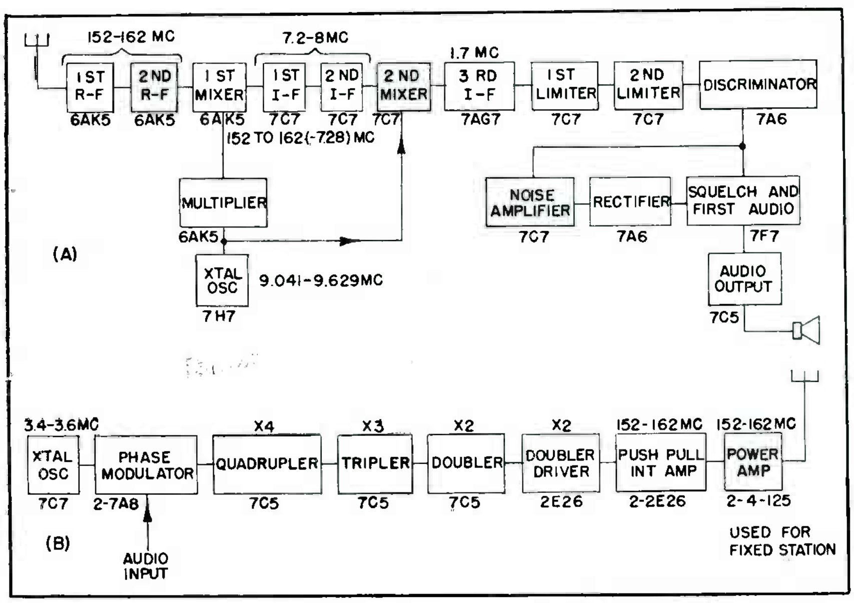
The engineer was careful to place the center of his antenna 40 feet above the roof of the 430-foot hotel penthouse. By this means, all overhangs and decorative cornices were at too low an angle to shade any but the nearest reception points that received adequate signal anyway owing to their proximity. As a result, the coverage indicated on the map is complete, without holes. Calls between the author in a car and the fixed station were made in the 42nd St. tunnel under Tudor City, on the Williamsburg and Brooklyn Bridges, and under the West Side Highway just after coming down the 54th Street ramp. All these locations interpose obstructions of steel or stone to the most direct signal path. With the vehicle in motion little distortion was apparent in the signals, with no loss of intelligibility.



Coverage provided from the Brooklyn 250-watt transmitter operating with an antenna gain of about 3 db. This map shows only the region for reliable talkback from mobile units. Fixed station coverage exceeds these limits

The circuitry of the equipment used both for mobile and fixed stations is by now conventional and is shown only in block-diagram form. The basic 30-watt mobile transmitter shown is also used as the driver for the 250-watt fixed station. Power source for mobile equipment is the car battery. In general, no special battery or unusual charging device is necessary because in this service the equipment is turned off when the vehicle is vacated and the receiver-transmitter standby current is only 8 amperes.

The mobile equipment installed by the Brooklyn company operates on 157.29 mc and is licensed under the blanket call W2XTK. The dispatcher's transmitter operating on 152.03 mc has the call W2XTJ. Since these frequencies are used in common with the Manhattan company, W2XJJ each dispatcher is provided with an additional receiver tuned to the latter frequency so that any interference between dispatchers is avoided. Mobile units identify themselves and are called by coded numbers, so that in the broad region in which the coverages overlap there is a minimum of confusion.



Block diagram of f-m receiver (A) for mobile or fixed operation at 160 mc. and transmitter (B). Choice of crystal frequency within the band depends upon channel authorization. The transmitter power amplifier is added to the low-power section for fixed-station operation

Thanks are extended to Jim Cody of Motorola, Inc., and particularly to P. R. Kendall, field engineer and regional manager of the same company, for system information and demonstrations. We are indebted to A. H. Simon for business statistics on the Brooklyn service.—A.A.McK.

DESIGN of a servomechanism by classical mathematics is difficult. The necessary characteristics of components of the mechanism seem mutually irreconcilable. The two principal components are (1) the error sensing, or perception, element and (2) the correcting, or restoring, force. Both these elements have been developed to a high degree and in wide variety; however they have not been adapted as extensively to cooperation.

In a servomechanism, corrective action is initiated by the sensing element perceiving an error between the required and the existing conditions as shown in Fig. 1. The error signal causes the power source to operate to reduce the error. Small error produces only a small restoring force, thus the system is insensitive to small error. To increase the accuracy, an amplifier can be introduced between sensing and restoring elements. Small error then produces large restoring force, thus the system over-corrects small errors. The over-correction may result in prolonged oscillation if the amplification is high. Thus it is seen that a sensitive servomechanism may be unstable.

Based on a mathematical analysis of the system, one solves the above dilemma by introducing a velocity-sensing element in the error signal mechanism so that the error signal is increased proportionally to the speed with which an error is developing. In this manner the correcting torque is removed if the error is rapidly being corrected (positive error plus negative speed of developing error results in zero error signal). The restoring force is thus removed before the actual error has been reduced to zero; the system slows down as it approaches balance, and is thus stabilized.

However, when the proper amount of velocity compensation is included in the servomechanism to compensate for a load of given inertia and friction, the system will not operate satisfactorily if the load changes. Thus one realizes that a purely mathematical approach to servomechanism design is limited.

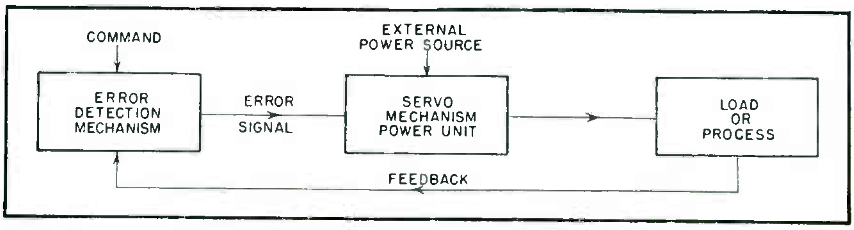


FIG. 1—Basic elements of a servomechanism include a feedback loop

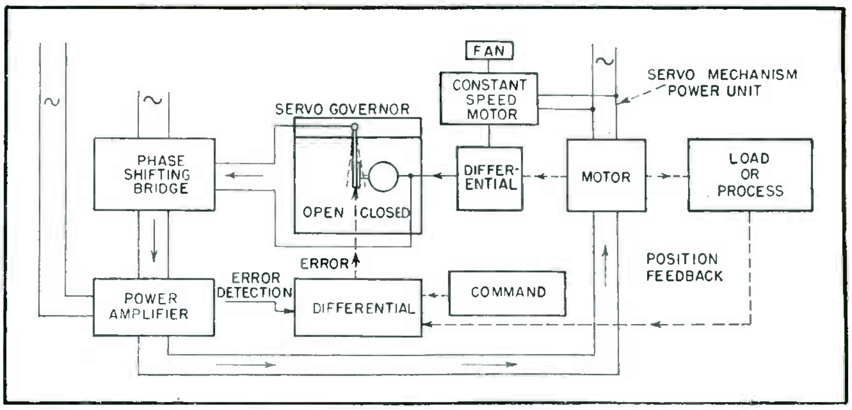


FIG. 2—The Motron servomechanism has governor—controlled feedback

A Packaged Servomechanism

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Basic Requirements

The basic requirements of a package servomechanism, if it is to be commercially successful, is that it be able to control any type load with only minor adjustments, and that normal changes of load do not affect stability and sensitivity of the servomechanism. Nor should the preselected operating point drift with changes in load, supply voltage, or temperature. In addition, if the servomechanism is to be useful in process control, it must automatically compensate for changes in lag time or process delays occurring in the process under control.

Other required characteristics include an error-detecting mechanism operating at very low torque so that the controlled function need not be disturbed. The servomechanism, acting as a torque amplifier, should follow the rate input smoothly. Extremely low dynamic errors are necessary only in a few specialized types of application such as milling machines or fire controllers. These applications require low-inertia motors and other refinements not necessary in a packaged servomechanism intended for general industrial use. Therefore most industrial applications can be filled by a system using standard induction motors and low-power electronic amplifiers. System performance should be sufficiently simple to be readily understood by installation

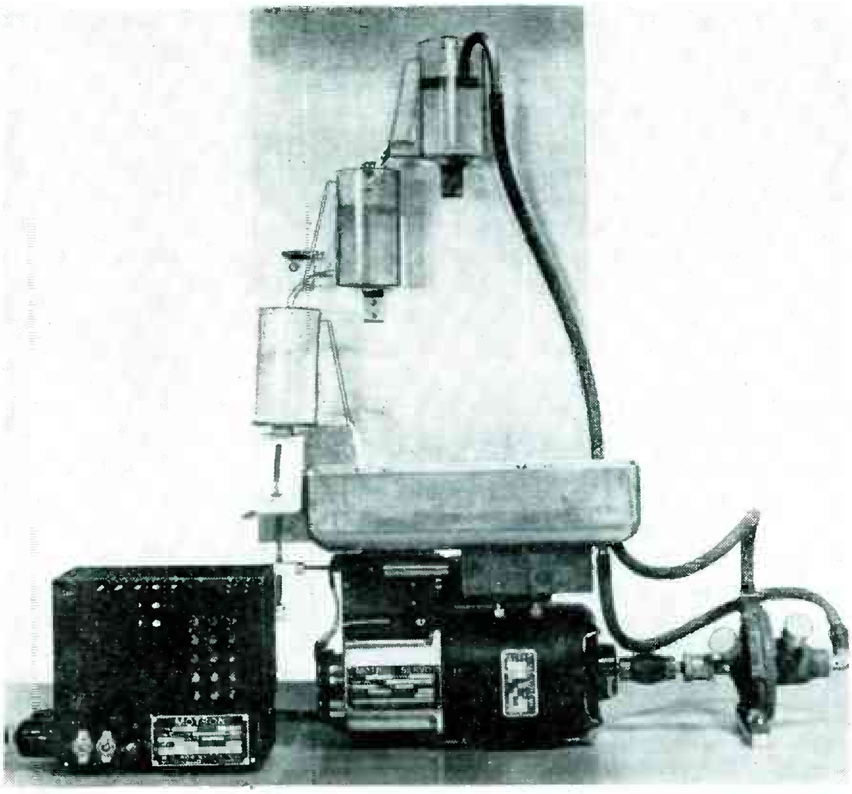


FIG. 3—Hydraulic pump control illustrates stability of the servomechanism

Industrial processing can be accurately and automatically controlled by servomechanisms. Although such devices are usually designed for a particular application, the one described here will control various loads such as a paper winder, milling machine, oil blenders, and blowers

and plant maintenance personnel.

From the foregoing comments one sees that, rather than attempt to design a packaged servomechanism to meet anticipated requirements by mathematical analysis, it will be better to consider basic physical principles. Such an approach simplifies examination of the effects of nonlinearities in the system. Based on Newton's first law of motion (objects continue in their states of rest or uniform linear motion unless acted upon by outside forces), it is deduced that the proper independent variable of the servomechanism is velocity (that is, rate of motion, or speed in a given direction), rather than position. Thus the velocity of the load is made proportional to the error in the region of balance; when the error is zero, the velocity is zero, and the load is at its balance point. Because the balance point is determined by the load reaching zero velocity, the difficulty of instability from overshoot previously described is avoided.

The second consideration is the conservation of energy. Excess kinetic energy stored in the system at high error-correcting velocities must be completely absorbed by reverse motor torque during a retardation period as the balance point is approached. The motor provides positive energy input to force the system to balance but absorbs all the stored kinetic energy (input energy minus frictional losses) as balance is re-established. In this way the condition of zero velocity, previously found desirable, can be obtained.

Two types of loads can be expected in industrial applications, one having small friction and high inertia, the other having low inertia and high friction. A single load may present different characteristics under variable operating conditions. Therefore two methods of preventing over-shoot are used assuring stability independently of system amplification. The first method is to vary the time during which the motor can develop full reverse torque. The second is to limit the top speed. The first method makes it possible to absorb all the stored energy; the second method limits the maximum stored energy (thus making it possible to absorb it in a reasonably short time).

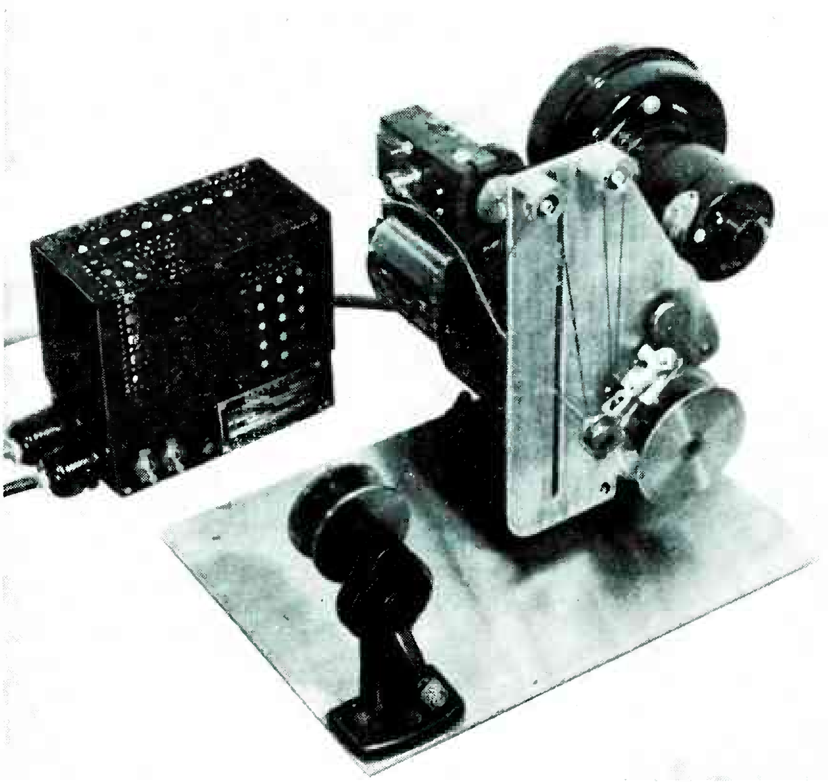
Servomechanism Design

By the type of operation described above, system stability is assured. Therefore it is possible to utilize extremely high amplification producing a very sensitive servomechanism. Furthermore, with virtually unlimited amplification possible, the error sensing mechanism can be made very sensitive, thus making it possible to detect minute errors.

These characteristics are realized in the Motron (trade mark registered, U. S. Patent Office) packaged servomechanism shown diagrammatically in Fig. 2 as follows: The motor constitutes a variable-speed power source whose speed is controlled by a governor. A control shaft on the governor controls the motor speed from full speed forward through zero to full speed in reverse. The speed selected by this governor control is obtained, within close limits, providing that maximum motor torque is capable of supplying the required energy to the system. Maximum motor speed in either direction can be limited by adjustable stops on the governor control. Time lag in the servomotor is the period necessary for full motor torque to accelerate the system inertia to the desired speed.

To combine these elements into a process control servomechanism, the output of the motor is made to move the governor control by way of the process so that the governor control approaches its center, or zero speed, position when the output shaft approaches the desired position. In actual industrial applications, the output motor drives whatever can be readily controlled that causes process changes (such as blower, winding motor, or guide roller as shown in the illustrations elsewhere in this article); the governor control is operated by the factor being controlled (such as air velocity, wire tension, or paper alignment) through a sensing element or indicating gage. Displacement of the controlled variable causes the motor to develop full torque until it obtains a velocity proportional to the displacement (or its maximum velocity). As the controlled variable returns to normal, the motor decelerates its load by absorbing energy from it, stopping it when the system has been corrected. Speed limiting stops on the governor control can be adjusted, if necessary, to limit the maximum speed (and hence maximum stored kinetic energy).

That the servomechanism will respond in this manner when applied to a practical process control problem is demonstrated by its performance in controlling an illustrative fluid flow system such as that of Fig. 3. To indicate the ability of the system to handle changing process time lags without losing stability, a series of three consecutive fluid storage reservoirs, each with narrow weirs so that the rate of flow is not proportional to the height of water in each reservoir, is set up to constitute the process. The servomotor drives (unidirectionally) a standard centrifugal pump with exponential discharge. The last reservoir rests on a small scale the deflection of which is transferred to the lever of the governor control, thus causing the servomotor to run at a rate to maintain the weight of water in the third reservoir constant. Rate of flow can be adjusted by changing the length of the linkage between scale and governor control, giving rates from maximum down to several drops per second.



Tension in a bobbin is controlled by running thread over pulley fastened to arm of eccentric shaft; servomotor pays out at constant tension

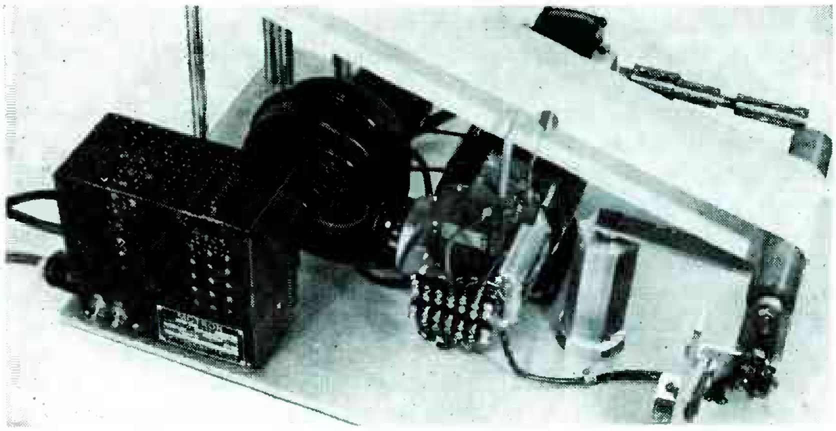
At high rates of flow, the system balances from a standing start with only several half-cycles of overshoot when the pump discharges in the last reservoir. As the rate of flow is decreased, the pump discharging into either the second or upper reservoir, there is a fairly abrupt point at which the system becomes unstable and hunts. Hunting can be stopped by restricting the maximum speed range of the motor by adjusting the limit screws of the governor control. Changing the discharge from one reservoir to another does not cause instability. In other processes in which there is added to the time lag of this type of system a backlash as well, the servomechanism is also dynamically stable because of the same action of coming to rest when the error is reduced to zero.

Governor Control

Thus far the discussion has been concerned with mechanical principles of the system and its over-all operating characteristics. These characteristics are dependent on the principle of operation outlined above, but their practical attainment depends on the motion of the governor control.

The governor control consists of a pair of pure metallic (silver or another equally good conductor) contacts. The contact resistance between them is one arm of a bridge that actuates the electronic motor controller (described later). One of these contacts (called the Governor Wand) is on the governor control shaft shown in Fig. 4 and hence is positioned by the controlled variable. This contact is a flat disc of silver about $\frac{3}{4}$ inch in diameter. The other contact is an $\frac{1}{8}$-inch diameter axial silver contact on the governor spring, thus its axial position is dependent on the instantaneous motor speed. As the servomotor causes the governor to accelerate, centrifugal force on the governor weights deflects the governor spring, pulling the governor contact away from the control shaft contact.

Critical governor speed is defined as that at which the centrifugal force pulls the governor contact away from the control, or wand, contact so that approximately one



Web of paper can be guided into continuous lateral position within plus or minus 0.004 inch. Paddle against paper is fastened to error eccentric

megohm of impedance appears between the two. This critical impedance between the silver contacts is obtained with infinitesimal pressure between them, thus providing the low power-absorption of the error-sensing device. (It has been suggested that the limit of sensitivity of the method of motion detection is a motion of molecular dimensions occurring in the boundary layers of the two contacting elements. Others have suggested that, rather than a restivity function being involved, it is a capacitive effect between molecular boundaries separated by molecular dimensions. Whatever the phenomena involved, the term Molecule Squeezer aptly describes this sensing element. It possesses the limiting ability to detect molecular positional errors with only infinitesimal force. Its motion could not be duplicated by a potentiometer.)

To make the governor sensitive to the direction of the servomotor rotation a rotational bias is introduced. The servomotor drives a differential through a belt. The cooling fan motor also drives one of the inputs of the differential through a belt; this drive constitutes the bias. The output of the differential then drives the governor. Thus at zero servomotor speed, the governor is driven at the speed determined by the fan motor. When the servomotor rotates oppositely to the bias rotation, the governor runs slow; when the servomotor rotates with the bias rotation, the governor runs fast. As displacement of the contact on the governor is linear only over the midrange of governor speed, this bias also places the governor contact on the linear portion of its displacement characteristic. The phases in which all the elements of the system and any interlocks are connected must be such that governor deflection will tend to follow the deflected position of the wand.

In comparison to other types of servomechanisms, the governor with its rotational bias performs the function of phase detector. Because the deflection of the governor is proportional to velocity, it performs the function of a differentiating circuit. Also, as a minute deflection of the Molecule Sqeezer is sufficient to unbalance the bridge, the governor acts as an amplifier. The governor responds with such rapidity to changes in load position (as indicated by the governor control wand position) and servomotor velocity that, especially about the balance point, the servomechanism has extremely fast response. This system can have a loop cutoff frequency when using low inertia servomotors as high as 150 to 300 cps compared to approximately 20 cps for other systems. The governor controls the servomotor output from zero to full torque in the limiting period of 0.25 to 0.10 cycle. Under such conditions, low inertia servomotors have shown stable acceleration and retardation rates of 200,000 to 400,000 deg/sec/sec.

Bridge Circuit and Amplifier

The governor contact, located on the axis of rotation of the clockspring governor loop, maintains brightly polished contacting surfaces by its wiping action. The bridge balancing current is less than a milliampere, so that pitting or arcing cannot occur. This contact is one leg of a bridge in the grid circuit of an electronic amplifier using a pair of 50B5 tetrodes and a pair of 35W4 rectifiers. The amplifier feeds one phase of a conventional, two-phase squirrel-cage induction motor rated at 1/15 hp, 115-v- a-c, 60 cps (manufactured by Bodine.) The main winding of the induction motor is excited from the power line.

The bridge circuit is balanced when about one megohm of resistance appears between the governor contacts. Balance causes in-phase current to the second winding of the motor, which then cannot develop torque. On either side of the balance point, the motor torque is in the respective direction of the bridge unbalance. As the amplifier does not use differentiating or stabilizing circuits, it has a very short time constant.

Before explaining further the op-

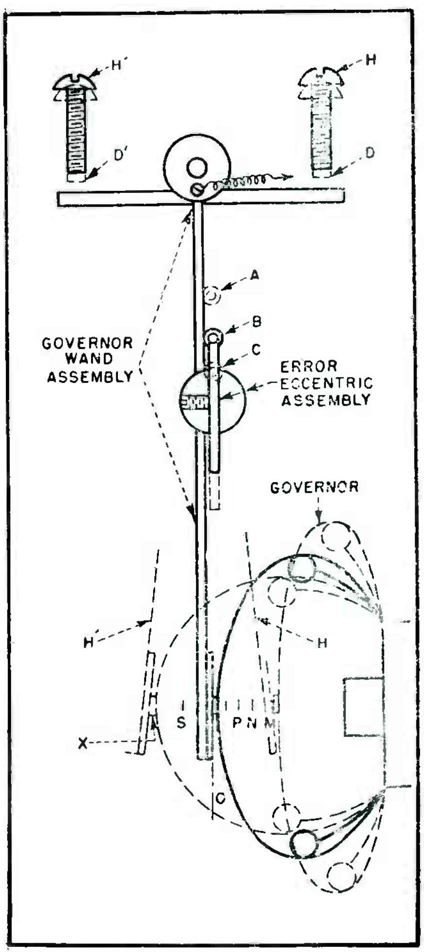


FIG. 4—Contact resistance between wand and governor indicates error

eration of the bridge and electronic amplifier, the characteristics of the motor should be briefly reviewed. A two-phase induction motor will run in one direction when two electrical currents are in quadrature in its field windings, and will run in the opposite direction when one of the phase inputs is reversed. When the phase of one of the inputs relative to the other is gradually shifted from one quadrature to the other, the stalled torque will gradually shift from maximum in one direction through zero to maximum in the opposite direction. When the motor is rotating, the phase shift necessary to produce a given torque is different than when the motor is stationary. It is the function of the servomechanism feedback loop to provide the correction in phase to produce the proper torque to develop the required speed.

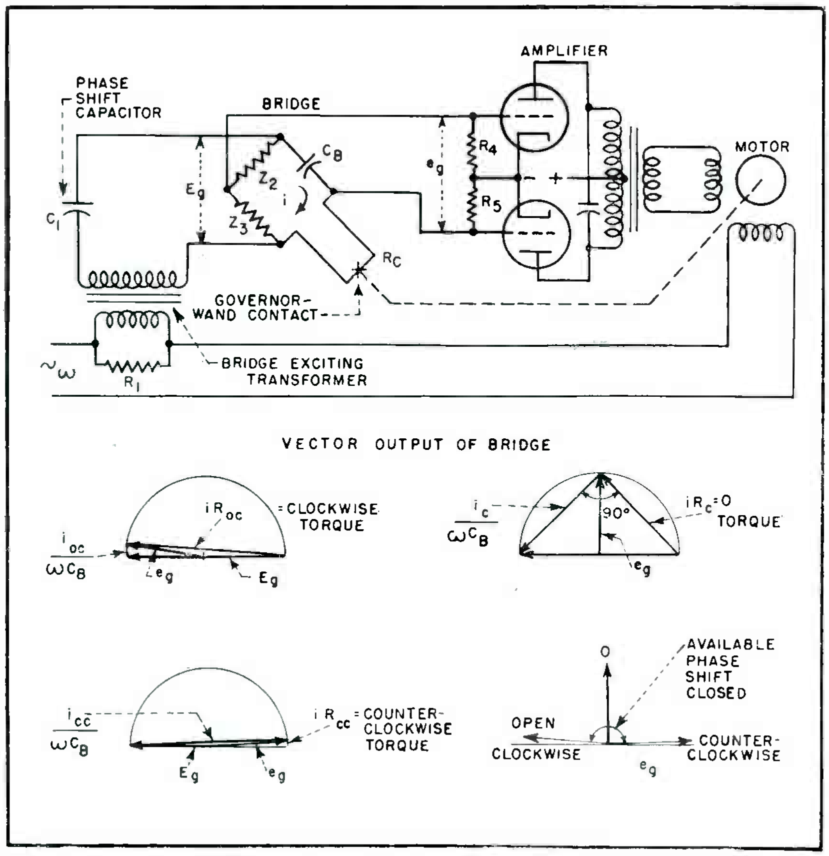


FIG. 5—Phase of bridge unbalance determines direction of motor rotation

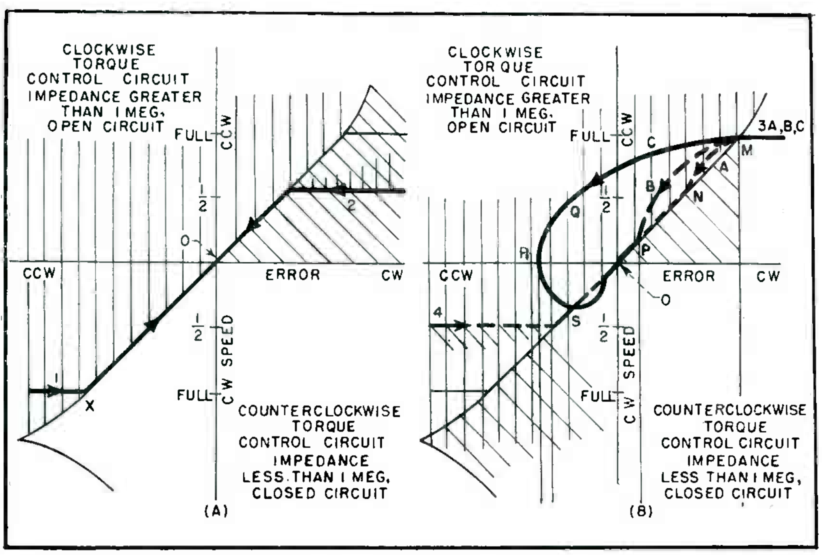


FIG. 6—Predominantly frictional (A) or inertia (B) loads are brought to balance along governor characteristic

The circuit used to accomplish the required phase shift derives its bridge phase excitation voltage from a transformer whose primary is in series with the main motor field winding as shown in Fig. 5. The primary of this transformer is shunted with a resistance that is chosen to give the proper voltage to the bridge for the current drawn by the particular motor used.

Series feed of the bridge excitation transformer has several important actions. It causes the amplitude of the amplifier grid drive to increase as the motor current increases. It also maintains a fixed phase relation between the bridge excitation voltage and the magnetic flux of the main field, thus the amplifier phase is always adjusted so that the magnetic flux in the control winding has the maximum controlling effect at any motor speed. The amplifier is thus made quite efficient in controlling the motor; a small amplifier (capable of supplying only two to ten percent of the power input to the motor) can be used. This factor, coupled with the fact that the amplifier need not incorporate compensating networks, as previously mentioned, means that rugged, miniature vacuum tubes can be used instead of large ones.

The bridge is fed from the excitation transformer through a phase shifting capacitor whose size is chosen to suit the particular motor being used. Two of the legs of the phase-sensitive bridge are equal, the third leg is a capacitor, the fourth, the Molecule Squeezer. When the governor control contact resistance equals the capacitative reactance of the adjacent arm, the motor develops no torque. When the governor contact resistance is lower, counterclockwise torque is developed by the motor; when the governor contact resistance is higher, clockwise torque is developed. A vector diagram shows how these relations are brought about. The rest of the circuit consists of a conventional pushpull amplifier. The phase relations at the output are substantially those at the input of this amplifier. The same controller is adaptable to a wide range of motor sizes and servomechanism applications. All components that are likely to require replacement are in a plug-in can on the amplifier chassis, and are also interchangeable with the same elements in other amplifiers.

Torque Requirements

In operation, the electronic motor controller supplies an electric phase input to the motor that develops a torque to drive the motor at a speed just to cause the governor to maintain the balancing resistance between the contacts of the Molecule Squeezer.

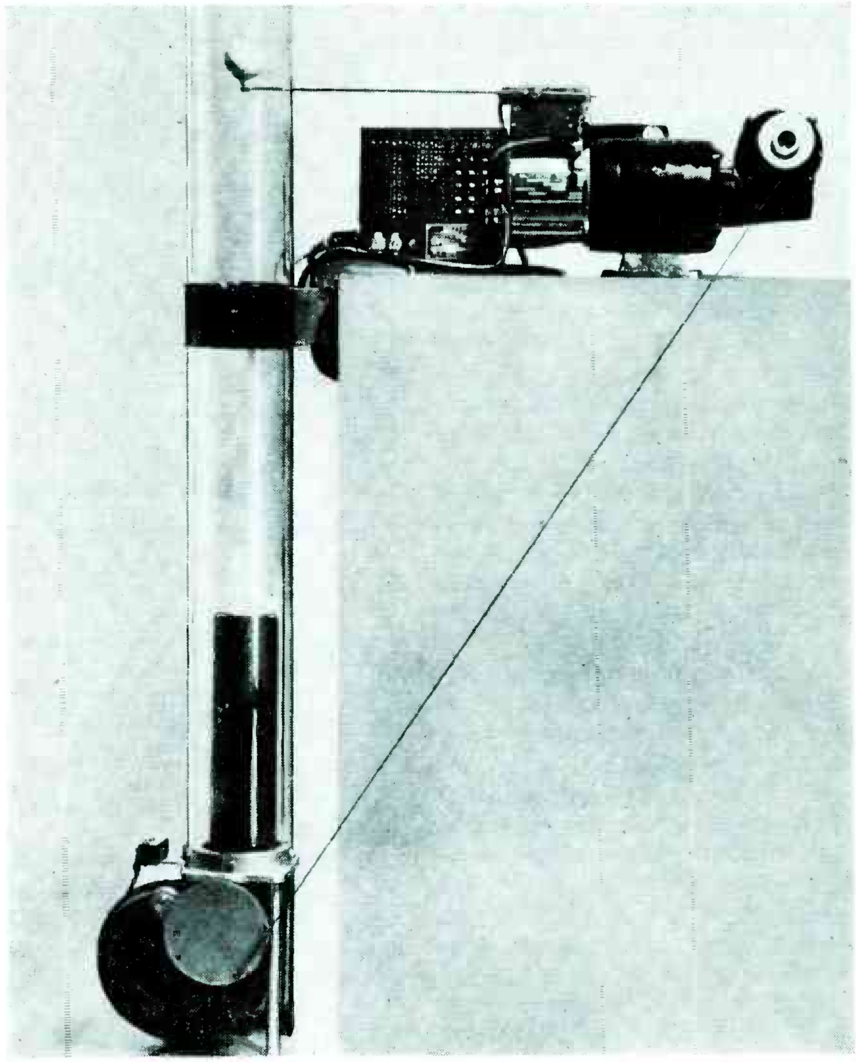
Torque-error-speed relationships of the motor necessary to produce the characteristic of gradually decreasing speed as balance is reached can be shown by the characteristic of the centrifugal governor, which is the determining element of the servomechanism. Four types of loads need to be considered: (1) a load that is predominantly friction and that is moved at the maximum speed of the servomotor, (2) a load that is predominantly friction but that is moved slowly, (3) a load of high inertia that is moved at high speed, and (4) a load of high inertia that is moved slowly.

With the first type of load, the servomotor must supply energy to the load even during retardation to supply friction losses. These friction losses, being caused by bearing surfaces and lubrication, are subject to large variations, thus proper motor torque to maintain a velocity that is proportional to error can vary greatly. If the friction is largely hydraulic, the required torque can fall rapidly as the velocity decreases; with dry surfaces and constant coefficient of friction, the torque will tend to remain constant (until at very low speed the friction changes from sliding to static, the latter being, in general, much the higher). The torque is therefore required to vary widely.

The governor and amplifier operation that brings the load to rest at the balance position under these conditions is a consequence of the slanting governor characteristic shown in Fig. 6A that divides the first and third quadrants of the velocity-error graph into areas where the control resistance is higher or where it is lower than the one-megohm balance value. (Second and fourth quadrants can only be reached if the load torque exceeds the motor torque, driving the motor.) With the limiting stops (H and H' Fig. 4) fully retracted, the servomotor will attain its maximum velocity for the particular load. This velocity will be only slightly less than the maximum no-load speed. If the load is unbalanced so as to open the control contact, the motor will reduce the error until the governor contact touches at point X on the governor characteristic. The motor speed then decreases and the governor speed increases so that the load is driven to balance at a decreasing speed. If the motor slows down too much, getting too far from the governor characteristic on the slow speed side, the governor contact will tend to open due to high governor speed, which will cause increasing bridge impedance and increasing motor torque to correct the speed. A similar action takes place if the load is initially unbalanced so as to press the governor contacts together, all factors being the reverse of the open condition. Thus the friction type of load tends to slide into balance with the bridge slightly unbalanced on the same side as that before the retardation period was reached.

The low-speed friction load is balanced similarly, except that the retardation action starts at a smaller error.

With a high-speed large-inertia load, when the load crosses the governor characteristic M as in Fig. 6B, maximum reverse torque is developed by the motor. This torque



Drag sphere used to monitor air flow operates wand against governor contact. Servomotor positions blower damper to maintain constant preset flow

may not be sufficient to absorb the decrement of kinetic energy (because kinetic energy varies as the square of velocity), so the load passes beyond the governor characteristic. As the reverse motor torque absorbs the kinetic energy of the load, lowering its speed, it returns to the governor characteristic, which it then follows to the balance point. The larger the inertia of the load the longer it will take for the motor to return the system to the governor characteristic (curves *A* and *B*, Fig. 6B). For very high-inertia loads (curve *C*), the load may drive the system beyond the balance point, in which case the motor immediately reverses and starts the same decelerating action from the other side of the balance point (at *S*).

The motor thus approaches balance with the governor contact in the opposite condition for high-inertia loads than that for friction loads, but in either case balance is approached along the governor characteristic with the load under the control of the motor, friction loads receiving positive torque, inertia loads receiving negative torque.

High inertia loads can be brought to balance without overshooting by decreasing the steepness of the governor characteristic, which is accomplished by decreasing the eccentricity of the error-eccentric (*C*, Fig. 4). An alternate adjustment is to restrict the maximum velocity with the speed limiting stops (*D* and *D'*, Fig. 4). Either adjustment will restore the system to dead-beat stability. Increasing eccentricity increases the speed of response. (Decreasing the eccentricity makes the system sluggish, increasing it too much makes the system sensitive to errors below the limiting sensitivity resulting in instability such as hunting, but which can be stopped by limiting the maximum velocity with the speed limiting stops; the system then becoming extremely responsive to small errors, yet remaining stable for large ones). Too much speed limitation can be nullified by placing contacts on the governor electronic control circuit that will be actuated by the error eccentric to disconnect the governor thus allowing the

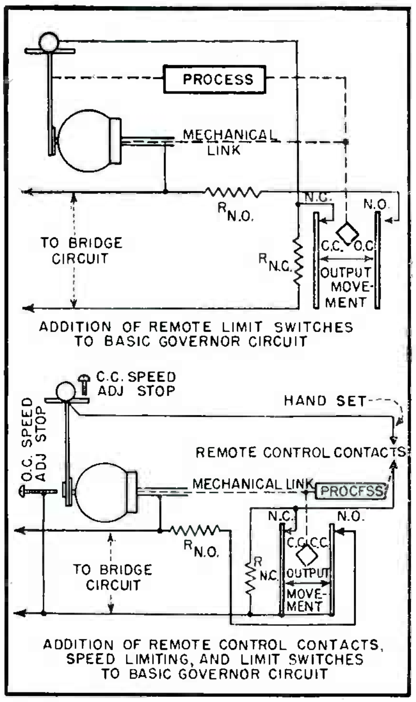


FIG. 7—Governor circuit can be modified for special requirements

motor to come up to full speed at large errors.

Dynamic error for fastest dead beat stability can be evaluated by setting the maximum work input to the motor rotor equal to the consequent change of kinetic energy of the rotor. This condition gives the fastest speed of response, as the load is neglected. The minimum dynamic lag angle (error) for an uncompensated Motron servomechanism is then $D=0.2Na(r^4)/PT$ where D is the dynamic lag angle in degrees of load, N is load rpm at maximum servomotor speed, a is length of rotor iron stack (1.87 in.), r^4 is fourth power of radius of rotor iron stack (1.068^4 in.), P is number of a-c poles (4), and T is average torque or 0.9 times the stalled torque of the motor rotor in ft-lb (approx 1/6 ft-lb). The numbers refer to a typical motor in use.

In the above equation, motor speed is in terms of the number of a-c poles for which the motor is wound, thus gear ratio and motor-speed are included in the one speed term of the 4 a-c poles. Because torque of a given motor increases as it is wound for a larger number of poles, a 4 or 6 pole motor (assuming all factors except gear ratio constant) is desirable for high dynamic accuracy as the kinetic energy stored in the rotor is less at the low rotor speeds resulting from the larger number of poles. The analysis indicates that a servomotor should have both high torque to inertia ratio and slow speed in order to obtain low dynamic errors with critical damping.

Applications

The servomechanism can be adapted to a variety of applications. A machine tool can be made to duplicate automatically the shape of a templet. The templet is fixed to the work bench. A tracer finger is linked to the governor control. The servomotor controls the position of the cutter head to which the servomechanism is connected. In this way, with only about an ounce load on the tracer point, the servomechanism will duplicate a pattern within plus or minus 0.00025 in. by making the velocity-error characteristic very steep and limiting the feed speed. A simplified servomechanism is obtained for some applications by omitting the governor and using the contact between an actuated and a fixed contact.

Continuous blending of heavy and light oils to give a fixed intermediate viscosity can be controlled by a servomechanism. The servomotor operates the mixing valve in the oil lines. The governor control is actuated by a kinematic viscosity sensing element. Temperature compensation can be provided by differentials coupled through drag cylinders rotated in oil; the drag will be proportional to viscosity, thus the more viscous side will determine the output to the governor control. Limit switches connected to the governor control circuit as illustrated in Fig. 7 and actuated by the process or servomotor output shaft can be used to reduce the motor torque after it has positioned the valve, leaving just enough torque to hold the valve position until viscosity changes unbalance the governor control. In a series of test runs, oils of 900 sec Saybolt Universal and 100 sec Saybolt Universal both at 130 F were blended to any intermediate viscosity. Blends of 150 sec S. U. were within plus or minus four seconds S. U., with considerable temperature variation of the oils being blended. Other types of process control can be devised.

Designing Thoriated Tungsten Filaments

Design data for carburized thoriated tungsten filaments are calculated using formulas applicable to filaments of pure tungsten. Procedure requires controlled carburization to give carburized and uncarburized filaments similar electrical characteristics

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Until recently, the design of thoriated tungsten filaments was largely empirical. However, in 1937 it was observed that thoriated tungsten filaments made according to empirical design data gave filament temperatures agreeing within ± 1 percent with the calculated temperature values for pure tungsten filaments. This discovery prompted further research which resulted in the formulas and data presented here.

Pure tungsten filaments require no carburization; thoriated tungsten filaments do require carburization and after being carburized have a higher resistance. Carburized filaments have greater thermal power emissivity than filaments of either pure tungsten or uncarburized thoriated tungsten. When the percentage of increased resistance resulting from carburization is equal to the percentage of increased power emissivity, a carburized filament will have some of the electrical properties of a pure tungsten filament; that is, the same current will heat both to the same temperature. For thoriated tungsten, this increased resistance is 1.2 times that which existed before carburization.

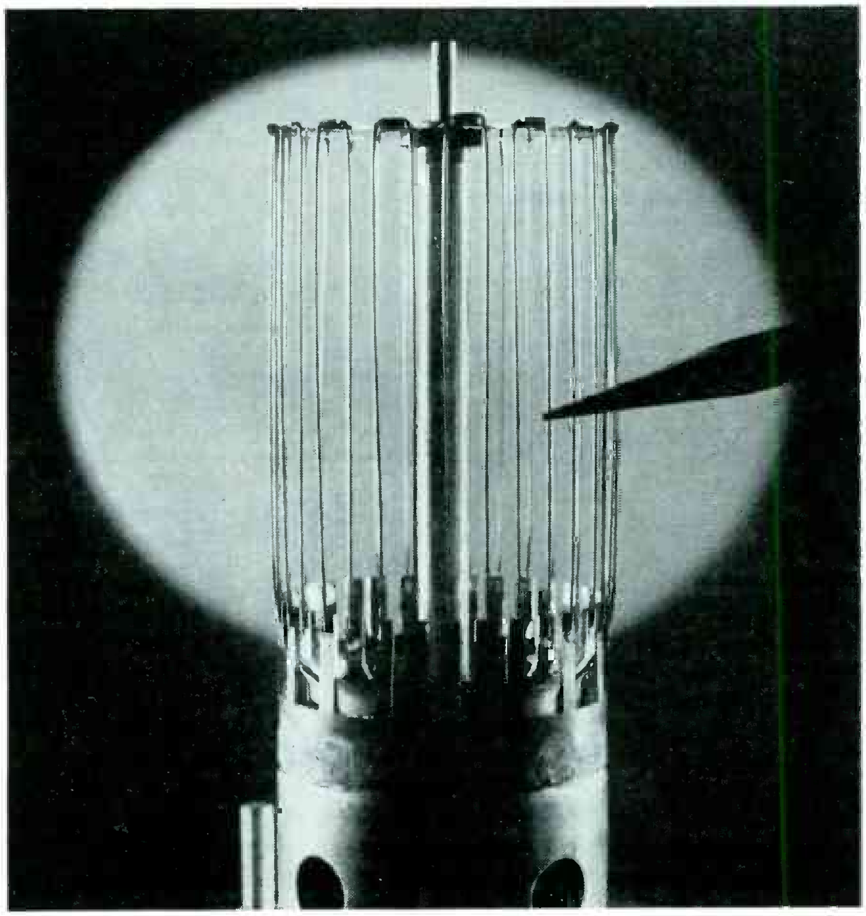
The power radiated into space from a straight wire may be expressed by

$$\eta = e_t \delta T^4 \qquad (1)$$

where η is equal to the power radiated in watts per sq cm per sec, e_t is the power emissivity of the surface at temperature T, δ is the Stephan-Boltzmann constant equal to 5.722×10^{-12}, and T is the temperature of the wire in degrees Kelvin. At 2,000 K, e_t is equal to 0.263 for pure tungsten[1] and $0.263 \times 1.2 = 0.315$ for the case of carburized tungsten[3].

Inspection of Eq. 1 reveals that when η is increased 20 percent by increasing the filament resistance by that percentage, and e_t is also increased by 20 percent due to filament carburization, for a given heating current T must remain constant. Therefore, Eq. 1 is applicable to either pure or carburized tungsten filaments for this set of conditions.

When it is desired to calculate the current required to heat a given tungsten wire to a particular tem-



This multiple hairpin filament of thoriated tungsten is typical of those used in high-power tubes for high-frequency industrial and broadcasting applications

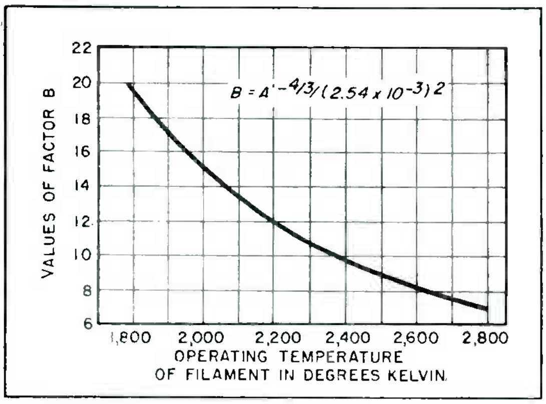


FIG. 1—The factor *B*, to be used in Eq. 5, is shown as a function of filament operating temperature

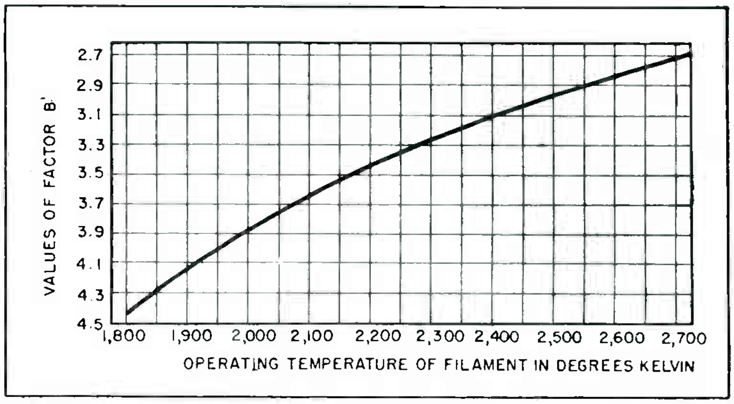


FIG. 2—The factor *B'*, used in Eq. 6 to give filament wire sizes directly in mils, varies with operating temperature as shown

perature, the following expression[2] may be used:

$$Ad^{-3/2} = A' \qquad (2)$$

In this equation, A is the required current in amperes, d is the diameter of the wire in cm, and A' is the current required to heat a wire 1 cm in diameter to the given temperature. The appropriate value of A' is taken from values published by Jones and Langmuir[1].

As small filaments are usually specified in terms of the weight of a 200-mm length, the value of d used in Eq. 2 must be obtained from the relation

$$d = 2.54 \times 10^{-3} (W/K)^{1/2} \qquad (3)$$

in which d is the diameter in cm, K is a conversion factor varying with the wire density, and W is the wire weight in mg per 200 mm. Values of K for pure tungsten and for thoriated tungsten are given in Table I.

When Eq. 2 and 3 are combined, the following results:

$$2.54 \times 10^{-3} (W/K)^{1/2} = A^{2/3} A'^{-2/3}.$$

Solving for W, one obtains

$$W = A^{4/3} K A'^{-4/3} (2.54 \times 10^{-3})^{-2} \qquad (4)$$

or

$$W = A^{4/3} K B \qquad (5)$$

when $A'^{-4/3} (2.54 \times 10^{-3})^{-2}$ is replaced by the factor B.

This relation holds for either pure or carburized thoriated tungsten when the correct conversion factor K is used for each. The carburized filament must be carburized to a 20-percent resistance increase at the rated current for Eq. 5 to hold rigorously. Values of B for various temperatures are given in Table II. They also appear in curve form in Fig. 1.

For the larger sizes of thoriated tungsten filaments, it is usually more convenient to measure the wire size directly in mils and to use the modified equation

$$d = A^{2/3} B' \qquad (6)$$

where d is the diameter in mils and A is the required heating current in amperes. Values for B' for various temperatures are given in Table II. They also appear in curve form in Fig. 2.

When a thoriated tungsten filament is carburized, the resistance is usually allowed to increase from 1.15 to 1.25 times the original resistance at the rated filament current. The power emissivity of the carburized surface normally does not change with the degree of carburization. Consequently, the temperature may be calculated over any range selected.

Let η_1 equal the power in watts required to heat a given filament that has been carburized to a 20-percent resistance increase; T_1 equal the calculated temperature of the above filament; η_2 equal the power in watts required to heat an identical filament that has been carburized to another resistance; and let T_2 equal the temperature of the second filament. The following equations may then be written:

$$\eta_1 = e_t \delta T_1^4 \qquad (7)$$

$$\eta_2 = e_t \delta T_2^4. \qquad (8)$$

Since e_t and δ are constant, upon dividing Eq. 8 by Eq. 7, one obtains

$$\eta_2/\eta_1 = T_2^4/T_1^4. \qquad (9)$$

Because T_1, η_1, and η_2 are known, Eq. 9 is solved for T_2, yielding

$$T_2 = T_1 (\eta_2/\eta_1)^{1/4}. \qquad (10)$$

As an example, the wire size necessary for a filament that is carburized to give a voltage increment of 20 percent, operate at 2,000 K with a filament current of 10 amperes, and be made of thoriated tungsten wire containing 2 percent of thoria by weight is calculated from Eq. 5 and Tables I and II. Substituting values of K and B, $W = 10^{4/3} \times 1.875 \times 15.06 = 610$ mg per 200 mm.

TABLE I—Values of Factor K for Various Filament Materials

Filament Material	Density in grams per cu cm	K
Pure Tungsten	19.06	1.931
1.0% Thoriated Tungsten	18.83	1.908
1.5% Thoriated Tungsten	18.73	1.898
2.0% Thoriated Tungsten	18.47	1.875

TABLE II—Values of B and B' for Various Filament Temperatures

Temperature in Degrees K	B	B'
1,800	19.68	4.44
1,900	17.14	4.14
2,000	15.06	3.88
2,100	13.37	3.65
2,200	11.93	3.45
2,300	10.76	3.27
2,400	9.69	3.11
2,500	8.82	2.97
2,600	8.07	2.84
2,700	7.41	2.72
2,800	6.83	....

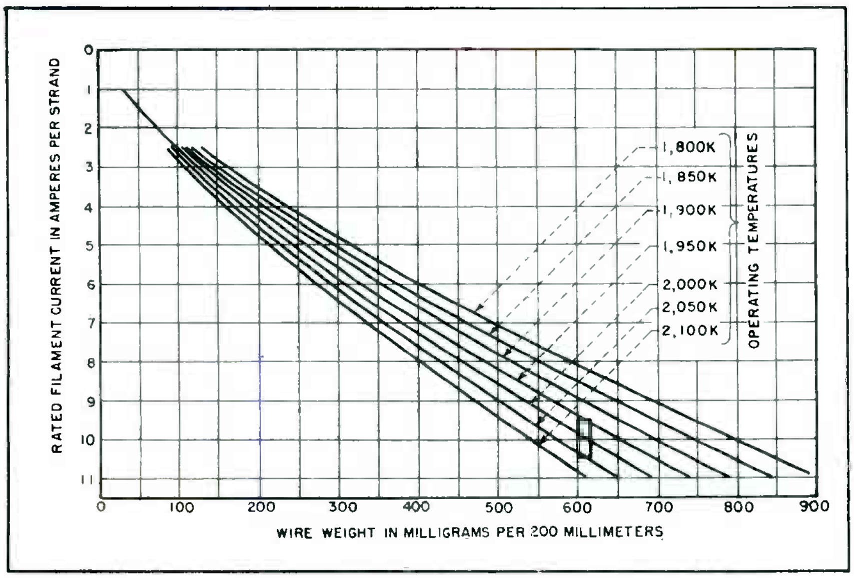


FIG. 3—Filament wire weight as a function of rated current for given operating temperatures. These curves are accurate for either pure tungsten or carburized thoriated tungsten filaments. Small rectangle outlines temperature deviations for example calculated

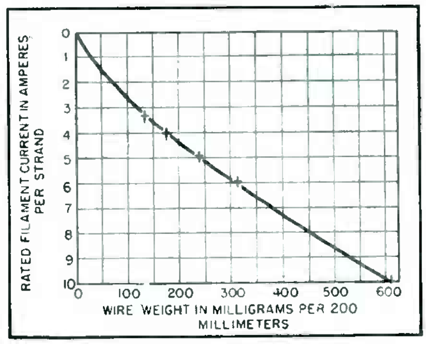


FIG. 4—Calculated curve of wire size as a function of rated filament current for a temperature of 2,000 K. Cross marks indicate filament sizes and current ratings determined empirically by the manufacturer. Length of horizontal line of each cross indicates tolerance on wire weight; length of vertical line indicates limits on filament current

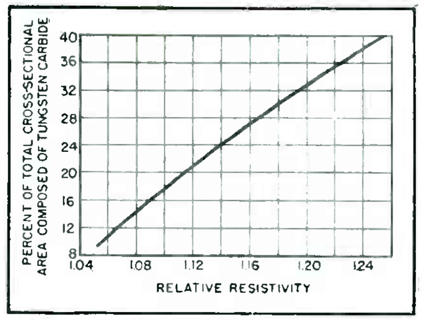


FIG. 5—Relative filament resistivity, or ratio of carburized to uncarburized resistivity, varies with percentage of tungsten carbide. Resistivity increase is determined by measuring increased voltage drop across filament carrying rated current

Assuming that the filament current limits are 9.5 to 10.5 amperes, the temperatures at those limits are calculated from Eq. 5 using Tables I and II and Fig. 1. Using the value of W calculated above, one obtains values of B equal to 16.12 for a filament current of 9.5 amperes, and 14.15 for a current of 10.5 amperes. From Fig. 1 the temperatures corresponding to these values of B are, for 9.5-ampere operation, $T=1,948$ K, and for 10.5-ampere operation, $T=2,052$ K.

The rectangle outlined in Fig. 3 shows the temperature variations resulting from both the variations in carburization and the necessary tolerance deviations in filament wire weight. Figure 3 covers the ranges of filament wire weight and filament current used for most thoriated tungsten filaments.

Figure 4 shows a curve calculated for 2,000 K with several filament wire weights and the corresponding current limits determined by Westinghouse after several years of experience.

The fragility of a given filament increases with the degree of carburization. Therefore, in considering this factor, use is made of Fig. 5 from which the percentage of filament cross-sectional area composed of tungsten carbide can be determined when the degree of carburization is known.

This analysis of filament design has been limited primarily to calculations of the heating current required for thoriated tungsten filaments. Data for end-loss calculations are given by Jones and Langmuir[1]. Although the calculations made here are rigorous only for those sections of filaments not affected by end cooling, experience indicates that the magnitude of error that arises from treating the entire filament by the data given here is usually less than the magnitude of normal manufacturing variations.

Table III presents a list of standard tubes with sizes of filament wire actually used, filament current limits, and calculated wire sizes at normal operating temperatures.

TABLE III—Calculated and Actual Filament Data for Several Standard Tubes

Tube Type	Calculated Operating Temperature in degrees K	Calculated Wire Weight in mg per 200 mm	Actual Wire Weight in mg per 200 mm	Filament Current Limits in amperes
204A	2,000	175	173–178	3.65–4.05
803	2,000	240	232–247	4.7 –5.3
833A	2,000	240	238–248	9.4 –10.3
849	2,000	99	97–100	4.75–5.25
860	2,000	137	138–144	3.1 –3.4
861	2,000	612	606–618	9.5 –10.5
891	2,540	45 mils	45 mils	57–62
895	2,560	51.3 mils	51.5 mils	66–72

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(2) W. E. Forsythe and A. G. Worthing, The Properties of Tungsten and the Characteristics of Tungsten Lamps, *Astrophysical Journal*, p 146, April, 1925.

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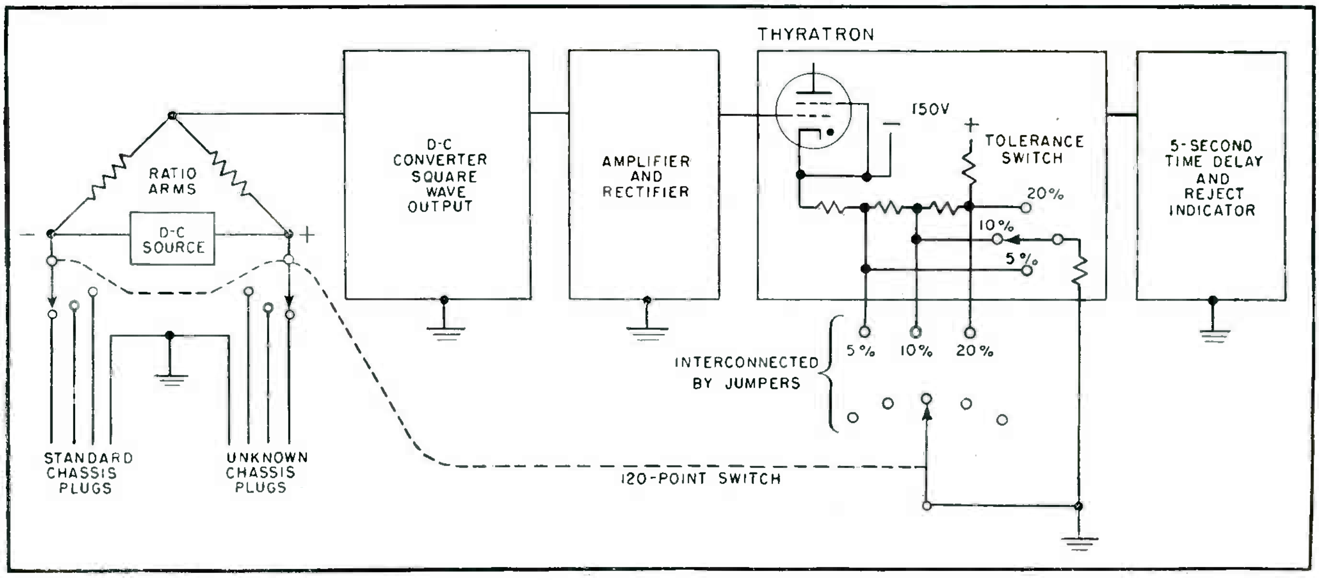


FIG. 1—Functions of the main stages of the automatic circuit tester

Automatic Limit Bridge for

Resistance of as many as 119 circuits are automatically compared with those of precision circuits in a standard chassis. Amplified output of a bridge is converted to square waves and applied to a thyratron whose bias is set for required acceptance tolerances

NEED has long existed for a simple automatic bridge to serve as the master test position on production assembly lines of electronic equipment. Bridges previously available for this purpose* have required an inordinately long setup time and have therefore been useful only on runs of thousands of identical chassis.

The equipment to be described requires about 15 minutes setup time and is therefore advantageous even on short production runs. The instrument consists of a 3-gang, 120-position ratchet-driven switch, arranged to step once per second, plus the circuit shown in the block diagram of Fig. 1. The instrument is capable of making 119 independent measurements of resistance to ground. Connection to the chassis under test is made through tube sockets and by clips at test points.

* ELECTRONICS, p 58, Feb. 1943.

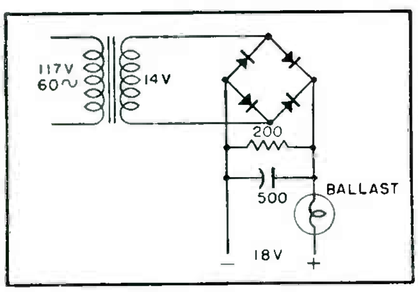


FIG. 2—Circuit of bridge voltage supply

Bridge Circuit Arrangement

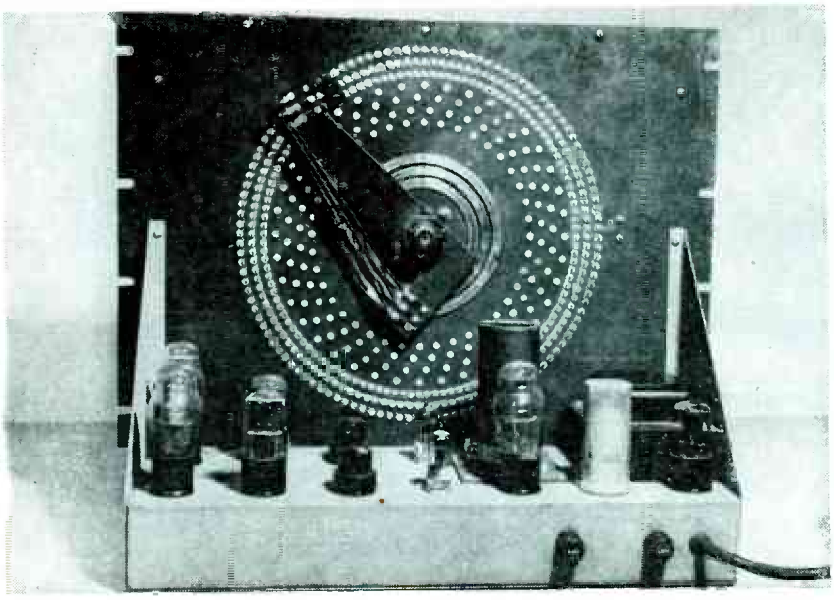
The arrangement of the bridge circuit is dictated by the necessity for grounding both standard and chassis under test and so that a given percent unbalance produce a constant output voltage throughout the entire resistance measuring range. The latter requirement makes it impossible to insert the bridge voltage between the center point of the ratio arms and ground, since drastic loss of sensitivity in measurement of low resistance values would result. Accordingly, the bridge voltage supply must float above ground and be well insulated.

The d-c unbalance voltage from the bridge is next amplified by a stage having high input resistance, and then converted into a-c for further amplification and rectification. Conversion to a-c is necessary, since the firing of the limit thyratron must be independent of the polarity of the original unbalance voltage.

The thyratron is provided with a tapped bias supply, to permit selection of several firing points corresponding to different amounts of bridge unbalance. The bias is controlled by a three-position tolerance switch and, in addition may be modified by the installation of jumpers on the main selector switch.

The final block includes a five-second time delay, which eliminates spurious rejects due to transients, and an indicator lamp which operates when a true reject occurs.

The circuit of the bridge voltage supply is shown in Fig. 2. The rectifier is made by reassembling com-



Moving-contact side of circuit-selecting switch and electronic stages of instrument

Production Testing

By R. D. CAMPBELL and E. J. TOTAH

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mercial selenium 5-plate groups having a current rating of 200 ma and a peak inverse voltage of 70 volts per plate. The ballast lamp quickly limits short-circuit currents to approximately 0.7 ampere.

A curve of bridge voltage against load resistance is given in Fig. 3. No attempt is made to regulate the bridge voltage and it therefore varies in proportion to the line. The error due to this variation has been reduced to one of second order magnitude by methods to be discussed later in connection with thyratron performance.

The vital portion of the instrument is the detector. This device must have high input impedance, an efficient conversion of d-c to a-c, and excellent zero stability. The order of magnitude of unbalance voltages to be detected is as follows: 5 percent yields 0.25 volt d-c, 10 percent yields 0.5 volt and 20 percent yields 1 volt. Accordingly a d-c vacuum-tube voltmeter circuit is necessary having a zero drift small compared to 0.25 volt. In addition, the zero must be the same whether the input be grounded directly or connected to ground through several megohms. The detector circuit is shown in Fig. 4.

It has been found that many commercial 6C4 tubes have grid currents less than 2×10^{-10} ampere. In addition, careful measurement permits pairs of tubes to be selected whose unbalance due to changes in heater voltage is less than one-fifth the unbalance observed when a single tube is paired with a fixed resistance. A matched pair of tubes is used as the input circuit of the detector, one tube being used as the load of the other. A special plate supply is not required. An amplified d-c voltage is therefore available across points *A* and *B* of Fig. 4. The input tubes can henceforth be considered as a high resistance and battery in series as indicated in

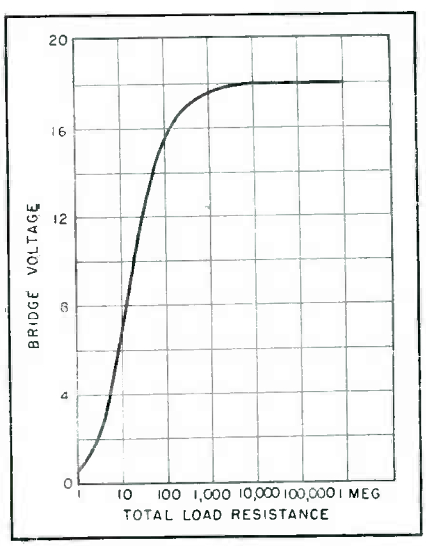


FIG. 3—Bridge voltage regulation curve

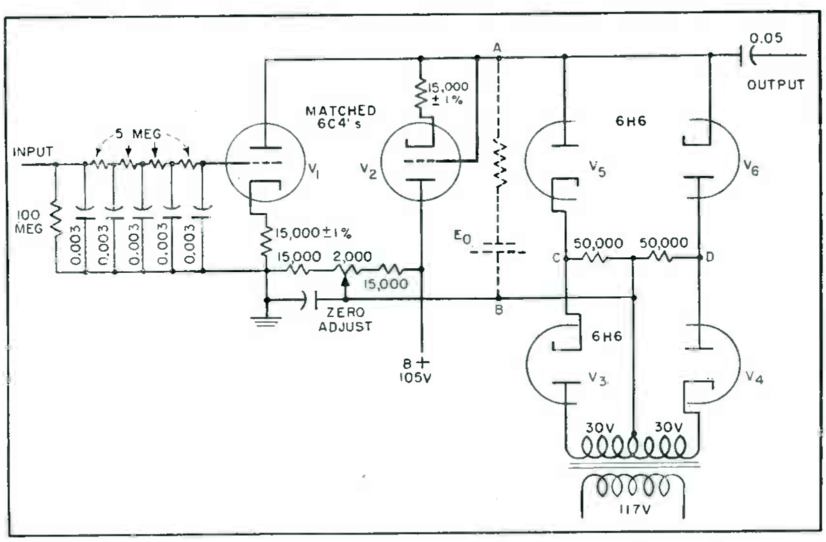
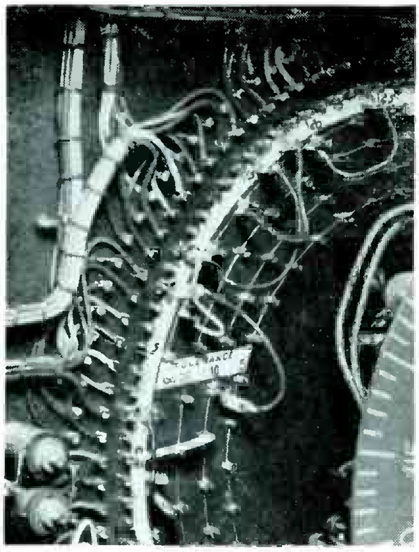
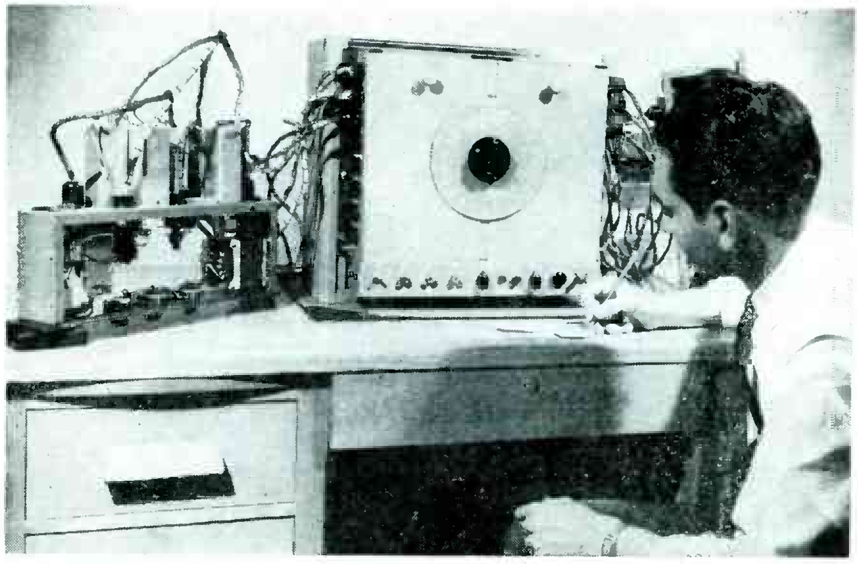


FIG. 4—This d-c amplifier circuit acts as the detector of bridge unbalance



Tolerance-selecting contacts



The circuit-indicating dial is mounted on shaft of the 120-position selector switch

dotted lines in the circuit of Fig. 4.

Figure 5 indicates the method of diode operation. Since V_3 and V_4 conduct together, the voltages V_{CB} and V_{DB} are half sinewaves and occur at the same time. If E_0 is zero. and V_6 removed, the contact potential of V_5 appears across AB except when it is cut off by the voltage V_{CB}. At those times the voltage V_{AB} is zero. Similarly, if V_6 is replaced and V_5 removed, square waves of opposite polarity are generated across AB due to the contact potential of V_6.

If both V_5 and V_6 are replaced, E_0 may be adjusted for balance, since it discourages one diode and encourages the other. At balance, the voltage AB is zero except for insignificant spikes of brief duration at the end of each half cycle.

If E_0 is increased by 1.0 volt, one of the upper diodes will remain conducting until the input voltage from the lower diodes has become one volt greater. The result is that diodes V_5 and V_6 act as switches which open and close across AB. Once E_0 has been set at balance, the output from the circuit will be square waves whose peak to trough amplitude equals any change in E_0. The battery and resistor across AB may now be forgotten and the circuit is seen to be a d-c amplifier plus an electronic shorting switch.

With suitable heater voltage control, the circuit of Fig. 4 will drift less than two millivolts after a warmup time of one-half hour. In this particular application no heater voltage regulation is necessary.

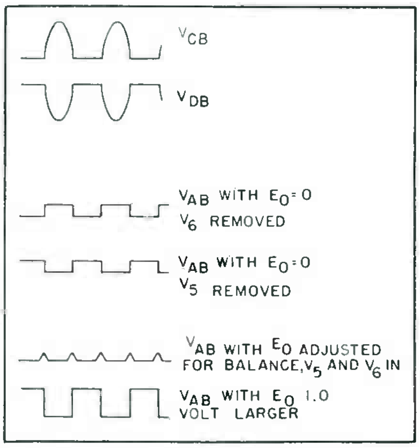


FIG. 5—Operation of the electronic shorting switch formed by the diodes of Fig. 4

The amplifier, rectifier, and filter are indicated in Fig. 6. Half of a 6SN7 is used as the gain stage, the other half being used as a shunt rectifier. This yields an output of square waves standing on the axis, rather than being symmetrically disposed about it. Thus the final value of filtered d-c is twice as great as would have been obtained with a series rectifier.

Thyratron Relay

The complete thyratron circuit is shown in Fig. 7. Essentially it is a normal a-c thyratron and relay circuit with a variable bias inserted between cathode and ground to permit selection of several firing points.

The tolerance switch on the instrument is grounded through 50,000 ohms, whereas the arm on the selector switch is grounded directly. Hence, when the selector hits a circuit where a jumper has been installed, the bias will be established by the jumper and not by the main tolerance switch.

The shunting effect of one circuit on the other creates negligible error. With the switch and jumpers as shown in Fig. 7, circuits 44, 47, 48, 49, and 50 will be measured to 10 percent tolerance. Circuit 46 will be measured at 5 percent, circuit 45 at 20 percent, and circuit 43 will not be measured at all since the bias available on the ∞ jumper point is greater than the maximum signal the amplifier can handle.

The VR75 and its associated resistors are inserted as a refinement to make the instrument nearly independent of line voltage. As pointed out, the bridge supply voltage is proportional to the line and one would therefore expect the signal at the thyratron grid to be proportional to the line. If this were true, and if the thyratron firing point did not vary with line voltage, the requirement would be satisfied by leaving the thyratron bias proportional to the line also.

The selector switch is stepped once per second by a tube-operated relay as long as circuits are encountered whose errors do not exceed the tolerances set up. However, when the thyratron fires, its relay prevents further stepping and the switch stops and waits upon that circuit. A reject is not immediately indicated. Instead voltage is applied to a 5-second delay circuit consisting of a resistor, capacitor, and another tube-operated relay. Upon operation of this relay a reject is indicated and the operator must manually step the switch to the next position by means of a key. If the unbalance had dwindled during the 5-second interval so that the thyratron went out, the switch would have continued on automatically. The delay is necessary to avoid spurious rejects of long time constant circuits where the resistors might be correct but the capacitors considerably different.

Choice of Tolerances

The bridge is arranged to be completely set up without accessory apparatus. Accordingly, step 0 of the selector switch is occupied by standard resistors, normally set to represent a 10-percent unbalance. If the gain, bias, and balance adjustments are made using these standards, the available tolerances will be 5, 10, and 20 percent. One standard may be varied slightly by means of a calibrated rheostat. This makes possible a choice of tolerance groups at 4–8–16 or 6–12–24 percent. Similar groups between these limits may be chosen. It is assumed that the usual choice of a tolerance group will be 6–12–24, for chassis containing chiefly 10-percent resistors. The 24-percent tap will then be available for measuring volume controls, and the 6-percent tap for more precise circuits.

Standard Chassis

A standard chassis must be built to represent accurately the group of production samples to be measured. In general the standard need contain only precision resistors. However, considerable time will be saved by duplicating long time constant circuits so that the bridge will not need to hesitate so often. Accordingly large capacitors should also be included. Note from Fig. 1 that any polarized circuit elements should be electrically inverted in the standard chassis. Small air-core coils may well be used to represent themselves, but

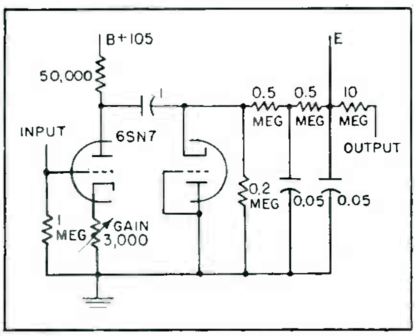


FIG. 6—Circuit of amplifier-rectifier stage

iron-core chokes and transformers may be replaced by resistors. Since the short-circuit current from the bridge supply is about 0.7 ampere, a check of low-resistance grounded circuits, such as r-f and i-f coils, will detect 0.4 ohm differences if the chosen tolerance is 5 percent. Thus, some shorted tuning and trimmer capacitors can be detected.

The resistor values used in a standard chassis are not the nominal values. A production run of chassis containing 1,000-ohm resistors cannot be properly checked if the standard chassis has precision 1,000-ohm resistors in the equivalent circuits.

A simple computation will indicate the reason for this. Consider the bridge of Fig. 1 with 20 volts as the bridge voltage and an unknown one percent different from the standard, such as 990 ohms and 1,000 ohms respectively. The computed unbalance voltage is 0.05 volt. Since the amplifier and detector are a linear system, the bridge will therefore recognize 5 percent as 0.25 volt, 10 percent as 0.5 volt, and 20 percent as 1.0 volt. Computing the unbalance for 1,200 ohms, or 20 percent high, the value becomes 0.91 volt. Computing the unbalance for an unknown of 800 ohms, or 20 percent low, the voltage calculated is 1.11 volt. Thus, a high value of resistance gives too little unbalance voltage and a low value gives too much.

The remedy is to choose the standard somewhat lower than 1,000 ohms. The proper size for the standard may be easily computed from the formula $P = 0.005\ Q^2$ where Q is the percent tolerance at which a resistor is to be checked and P is the percent low to select the standard. For example: if a 1,000-ohm resistor is checked to 10 percent tolerance, $P = 0.005\ (10)^2 = 0.5$. Therefore the standard should be 0.5 percent low or 995 ohms. For maximum accuracy the standards should be chosen in this manner. This consideration is particularly important when the tolerance setting is high. At 20 percent tolerance, if the nominal value were used as the standard, the bridge would accept resistors lying between 18.2 percent low and 22.2 percent high.

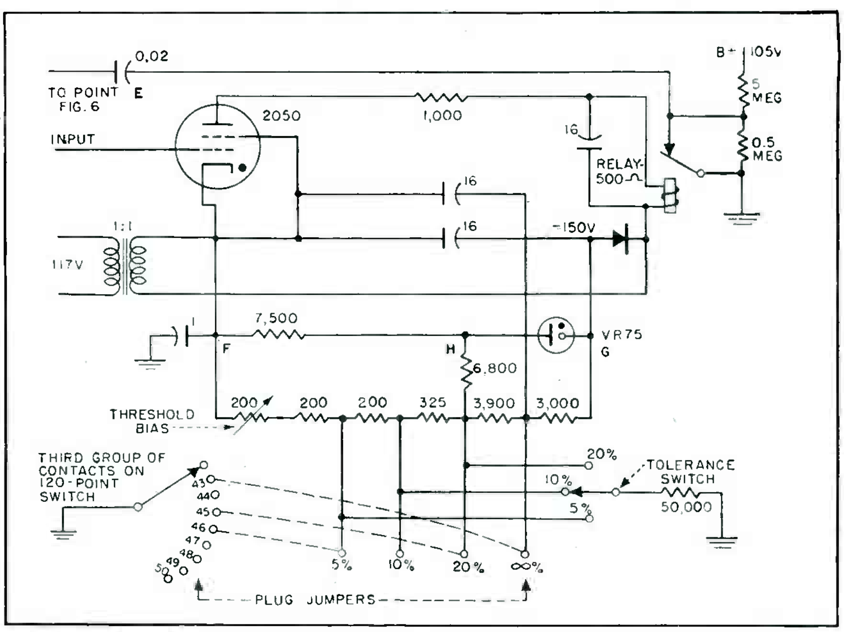
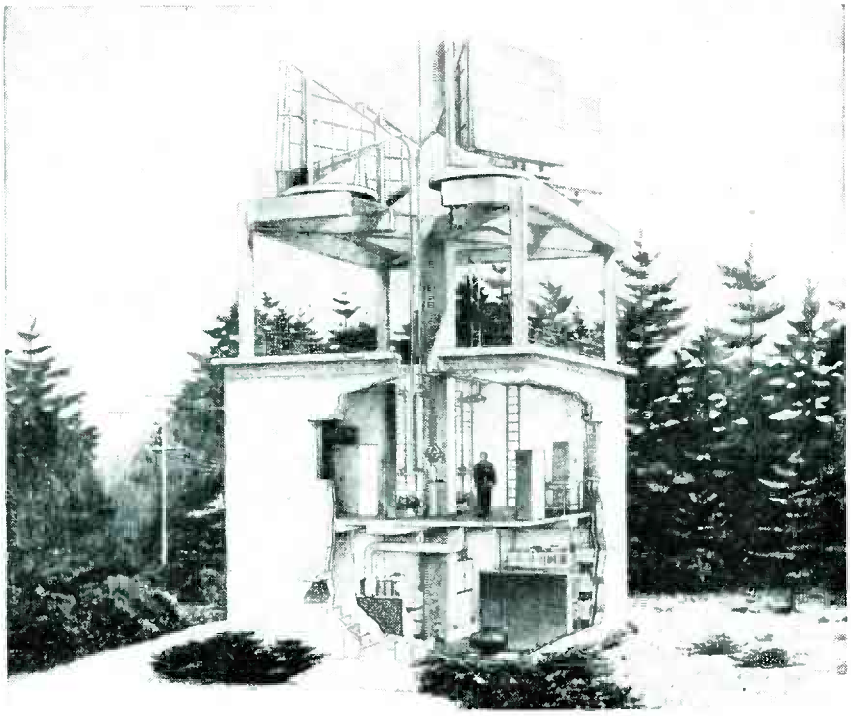


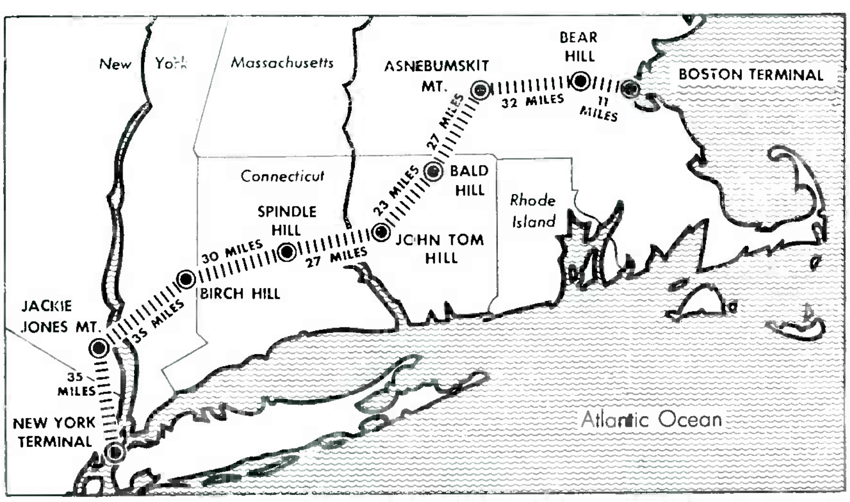
FIG. 7—Method of providing automatic tolerance selection

NY—Boston Microwave

New seven-station radio relay operating in 3,700 to 4,200-mc band provides two 5-mc channels in each direction over 220-mile route. Horn antennas with metal focussing lenses provide total gain of 100,000,000 per hop. Unique frequency control systems are used



Cut-away view of typical radio relay station. Emergency power equipment and storage batteries are on first floor. The four microwave repeaters, two for each direction, are on the second floor, with waveguide feed to the metal-lens horn antennas on a platform above the roof



Map of new Bell System 220-mile radio relay route between New York and Boston. Repeater stations are on carefully chosen hilltops to give line-of-sight paths

HERALDING network television operations serving the entire middle Atlantic region, the formal opening November 13 of the Bell System microwave radio relay between New York and Boston featured a telecast by ten stations in New York, Philadelphia, Baltimore, Washington, and Schenectady.

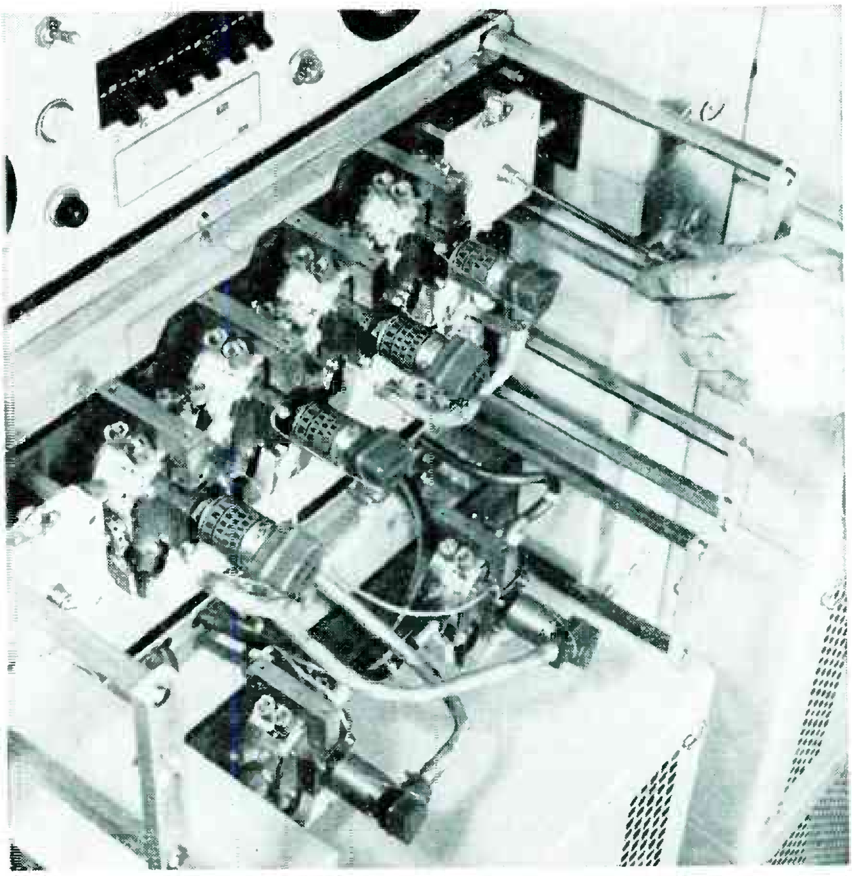
A feature of the demonstration was transmission of a television test pattern to Boston and back twice by radio, using both microwave channels in both directions as a double loop for this purpose so that the television signals actually traveled a total of 880 miles before reaching the receivers.

Technical Features

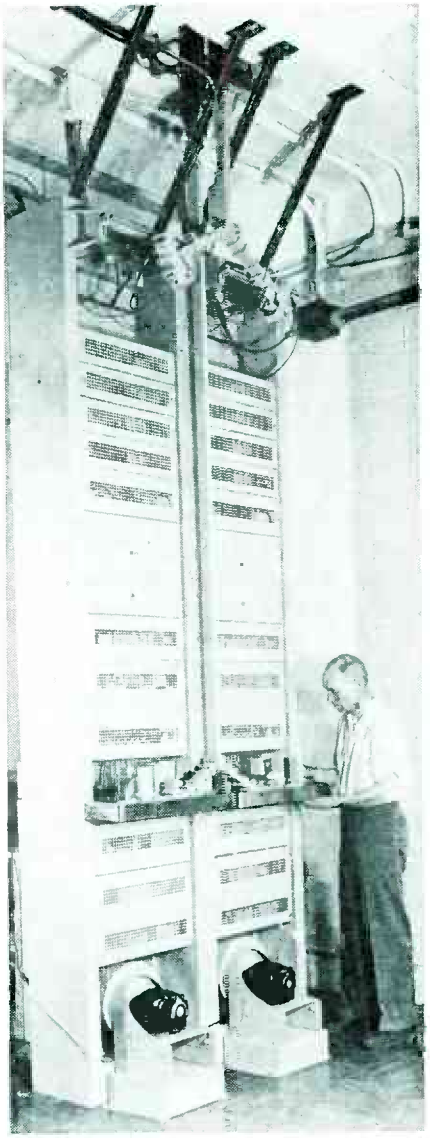
The New York-Boston relay system uses four frequencies in the 3,700 to 4,200-mc band. These frequencies are utilized in the manner shown in Fig. 1, with incoming and outgoing carrier frequencies differing by 40-mc at each repeater to avoid crosstalk.

Identical broadband horn antennas with metal focussing lenses are used at all stations. Each receiving antenna has two input frequencies, one for the regular channel and one for a standby channel, with signal separation being achieved by new types of filter sections inserted in the wave guides. On the roof of each repeater station are four antennas, two facing along the route toward New York and two toward Boston. The mouth of each antenna is 10 feet square and horn length is ten feet; each antenna has a gain of 10,000, or 40 db, making reliable relay operation possible under all weather conditions with a transmitter power of less than 1 watt. Beam width of the horn antennas is only 2 degrees.

Television Relay



Microwave amplifier with cover removed for adjustment of slug in tuning cavity. Tubes are two-gap velocity-modulation types mounted in slug-tuned cavities, with coax feed between cavities. Caps cover cathode ends of tubes; anode ends project into air-cooled chamber behind



Repeater rack for two channels. The two carrier frequencies from the receiving antenna come down one waveguide and are separated by waveguide filters in the upper wye while amplified signals on two new carrier frequencies for the next hop join in the lower waveguide wye to go up to the transmitting horn

There are four repeaters at each of the seven hilltop stations, one for use and one for standby in each direction. Each repeater is a broadband amplifier station capable of handling substantially any type of signal using any kind of signal modulation having a bandwidth up to 5-mc wide. Gain is constant within 0.1 db over the entire 10-mc bandwidth characteristic of the repeater.

At present, frequency modulation with a low index is being used, with a total swing of 4-mc. This makes it possible to run the high-level amplifier stages near their overload points, at maximum output.

Circuit Details

The basic circuit used for transmitting terminals is shown in block diagram at the top of Fig. 2. The 65-mc frequency-modulated picture-signal output of the f-m oscillator-limiter-amplifier unit is fed into a balanced modulator along with a 3,865-mc local oscillator signal to give the desired 3,930-mc carrier signal. This is boosted 23 db in level by a microwave amplifier containing four type WE 402-A two-gap velocity-modulation amplifier tubes of the "Samuel" type, with the last tube delivering a power output of somewhere between 0.5 and 1.1 watts on a frequency of 3,930 mc.

The 3,865-mc local oscillator frequency is generated by a reflex klystron of the Shepherd-Pierce type. The output frequency of this oscillator is compared with the resonant frequency of a silver-plated invar cavity, and the error signal output of the frequency-comparing circuit is used to drive a servo-motor-driven potentiometer that adjusts the frequency of the klystron by varying its repeller voltage.

Repeater Circuit Features

Frequency values for one of the repeaters are given in Fig. 2 (center diagram) to illustrate the basic repeater circuit arrangement used. The 3,930-mc signal from the receiving antenna comes down a waveguide to a branching filter,

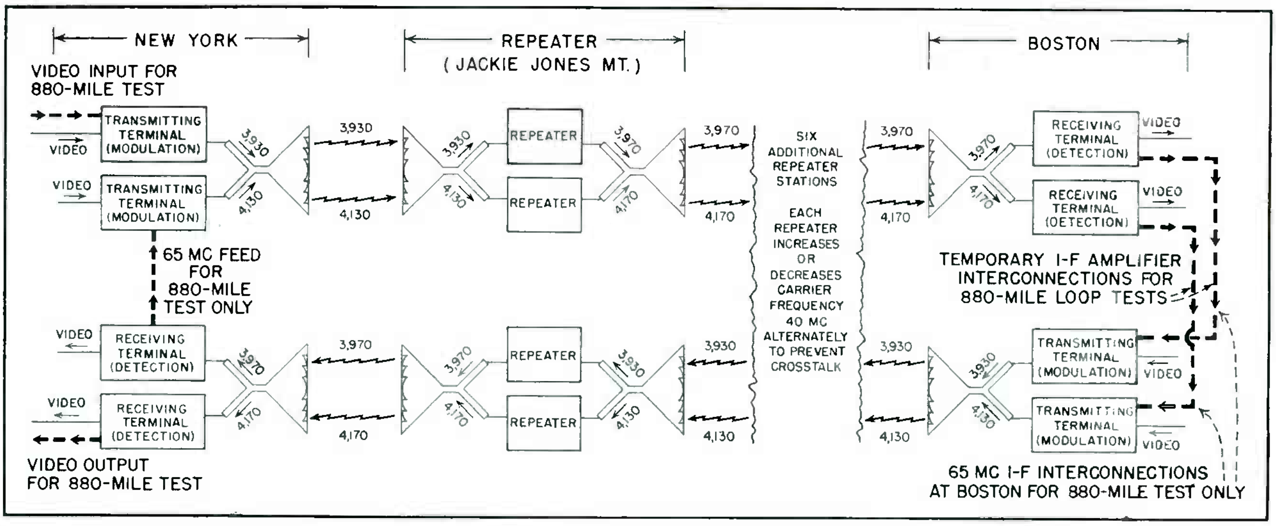


FIG. 1—Block diagram of complete New York-Boston microwave relay providing two video channels in each direction. Dotted lines show how channels were interconnected at i-f amplifier points during opening demonstration to give 880-mile relay equivalent to distance from New York to Chicago.

comprised of a wye section of waveguide with a filter section inserted in each arm of the wye. The filter accepts the correct signal and rejects the signal 200-mc away (4,130-mc in this case, as indicated in Fig. 1) that is also coming down the waveguide for the standby channel.

The correct 3,930-mc input signal reaches a balanced modulator employing sensitive silicon crystals as nonlinear elements, with the waveguide equivalent of a hybrid coil being used to feed this signal and the 3,865-mc oscillator signal to the crystals.

The oscillator signal in turn is obtained from another balanced modulator fed by a 40-mc crystal oscillator and by a 3,905-mc klystron oscillator and frequency-stabilizing circuit. The result is a 65-mc i-f output that undergoes two stages of amplification in a unit at the end of the waveguide. This preamplifier uses a grounded-grid tube having low noise, and a tube similar to the 6AK5 but having about twice the figure of merit.

From here the signal goes by coaxial cable to the main i-f amplifier, and thence to a balanced modulator that is fed by the 3,905-mc microwave oscillator to give the desired 3,970-mc output carrier frequency—just 40 mc higher than the input carrier frequency.

The local microwave oscillator frequency thus cancels out as an error source; since the 40-mc crystal oscillators offer frequency accuracy far better than is needed, there are no cumulative frequency errors in the entire relay system.

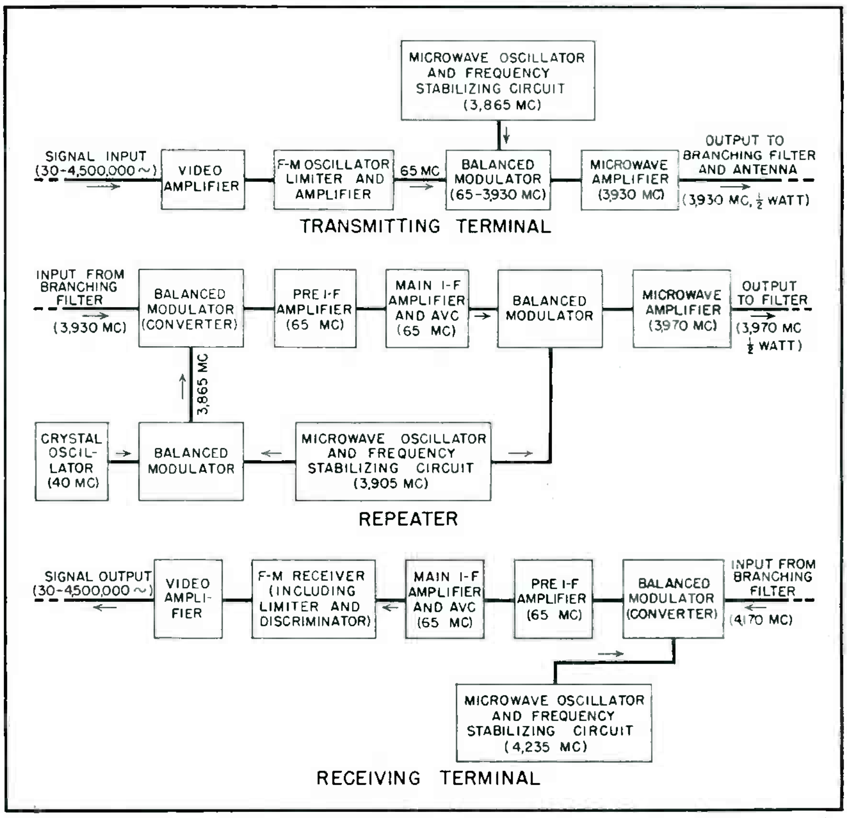


FIG. 2—Block diagrams showing details of terminal equipment and typical repeater. Use of only four different carrier frequencies on route permits standardization and interchangeability of equipment

At the receiving terminal in Boston for the channel under discussion, video frequency values would be as indicated at the bottom of Fig. 2. Sound portions of television programs are transmitted by land wire for this experimental relay system.

Since time delay differences for different frequencies in the band transmitted are cumulative for the seven relay stations, equalization of the delay was required. The final system has been equalized to within 50 millimicroseconds for all frequencies in the 5-mc bandwidth handled, which is appreciably less than the time of one picture element and is therefore not a cause of picture distortion.—J.M.

Temperature Coefficients in Electronic Circuits

Factors influencing frequency-temperature stability of tuned circuits are analyzed to determine design criteria for circuit elements. Application of these criteria permitted development of an airborne transmitter having negligible frequency drift

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Of the few studies of the effects of temperature coefficients on electronic circuits which have been published during recent years, some have presented views which conflict with respect to theoretical principles, or which are in disagreement with experimental results. These disagreements are due chiefly to the disregard of theoretical factors whose importance has been recognized only recently.

Of major interest in governing the resonant frequency of an R-L-C circuit are (1) inductive temperature coefficients of coils, leads and wiring; (2) capacitive temperature coefficients of fixed and variable capacitors, inter-electrode capacitances in tubes, and capacitances between terminals, switch contacts and wiring; and (3) resistive temperature coefficients of resistors. Resistive coefficients are of importance because changes in circuit resistances affect tube operating voltages and can thus produce frequency changes.

Parameter and Frequency Coefficients

If f represents the frequency, and L and C the inductance and capacitance, respectively, of an L-C circuit, then it can be shown that

$$\frac{df}{f} = \frac{-dL}{2L} \text{ or } \frac{-dC}{2C} \quad (1)$$

Equation 1 is valid for frequency, inductance and capacitance changes, all occurring over the same range of temperatures.

From Eq. 1, it follows that

$$a \text{ or } b = 2\left|\frac{df}{f}\right|, \quad (2)$$

where a is the capacitive temperature coefficient, equal to $|dC/C|$ and b is the inductive temperature coefficient, equal to $|dL/L|$.

Where inductance and capacitance in the tuned circuit both change as a result of thermal variations, the frequency temperature coefficient is

$$\left|\frac{df}{f}\right| = \left|\frac{dC}{2C}\right| + \left|\frac{dL}{2L}\right| \quad (3)$$

Frequency Drift Compensation

Design of coils and capacitors with low temperature coefficients

Table I—Temperature Coefficients of Dielectrics

Material	Temperature Coefficient (Parts per Million per Degree C)		Permittivity (Dielectric Constant)
	Permittivity	Expansion	
Polyvinyl Chloride (Geon No. 2046)	7,140[a]	30	3.5
Phenolic, molded[12] (BM-120 Bakelite)	3,940	30 to 40	4.2
Glass, white flint[5]	2,000		7.5
Phenolic, laminated	1,055 to 1,290[b]	17 to 30	5.5
Glass, Pyrex[5]	600	3.2	4.5
Ebonite[5] (hard rubber)	500	70 to 80	3.0
Cordierite[17], ceramic (Alsimag No. 202)	500	1.6	5.0
Porcelain[5]	500	3.5	5.4
Phenolic, mica-filled aniline formaldehyde (Resinox No. 7013)	400[c]		4.3
Steatite[5]	150	8.0	6.5
Mica[5]	20 to 100	3.0	7.0
Fused silica[16]	50	0.5	3.85
Mycalex[d]		10 to 11	7.5 to 9.2
Polystyrene[18] (Victron white)	−35	70	2.4 to 2.9
Titanium Dioxide[11,12]	−1,800 (max)	6 to 10	90 to 170
Paraffin wax[12]	−1,930[c]	130	2.5
Water[11,12]	−3,600[e]	195	80

Notes: [a]Data from mfgr. Varies widely with temperature and frequency. This figure valid for 15–70 C, 60 cps.
[b]Figure obtained from tests on bandswitches.
[c]Approximate only.
[d]Data from mfgr.
[e]Approximate data. Varies with temperature and becomes positive above 10^{10} cps. This figure valid at 25 C, up to 100 mc.
Numerical superscripts refer to references cited in text.

for use in fixed-frequency circuits, or the compensation of these elements is relatively simple. But for variable-frequency circuits the design problem is complicated by the fact that inductive temperature coefficients of coils vary with frequency and corresponding coefficients of variable tuning capacitors change with rotor position. Few discussions of drift compensation have pointed out the fact that in a variable-frequency circuit using a fixed inductor, the inductive temperature coefficient must be compensated by an inductive component over the frequency range of tuning.[1] If a capacitor should be used for compensation, its capacitance change Ca would have to vary according to the inverse square of the frequency, an impossible requirement for a single compensator. Thus, despite the fact that the use of a single compensating capacitor would permit simpler and more economical design, the most satisfactory solution to the problem of reducing frequency drift in variable-frequency L-C circuits is to design fixed inductors with an inductive temperature coefficient as near as possible to zero. On the other hand, with variable inductance tuning and variable permeability tuning,[2] the use of capacitors for compensation proves more satisfactory.

Inductive Coefficent Components

It is important to realize the error in the common conception that the inductive temperature coefficient depends solely or even principally upon the thermal coefficients of linear expansion of the conductor and coil form. In addition to the factor of linear expansion, Groszkowski showed in 1937[3], that the inductive temperature coefficient is influenced by eddy current or "internal inductance" effects, as well as by skin effect in the conductor and self capacitance as noted by previous investigators.

Bloch[4] investigated the relative magnitude of the different components. Measurements on a small coil of 68 turns of No. 28 copper wire indicated an inductive temperature coefficient of $(20 \pm 1) \times 10^{-6}$ per degree C. Conductor skin effects and Groszkowski's eddy-current effects were grouped together as the internal inductance component, since both effects depend upon penetration of the turns of the conductor by the magnetic field and upon the coefficient of resistivity of the conductor which affects such penetration. The calculated values of the components of inductive temperature coefficient were: component due to linear expansion of coil, 8×10^{-6} per degree C; internal-inductance component, 13×10^{-6} per degree C; and self-capacitance component, 1×10^{-6} or 2×10^{-6} per degree C.

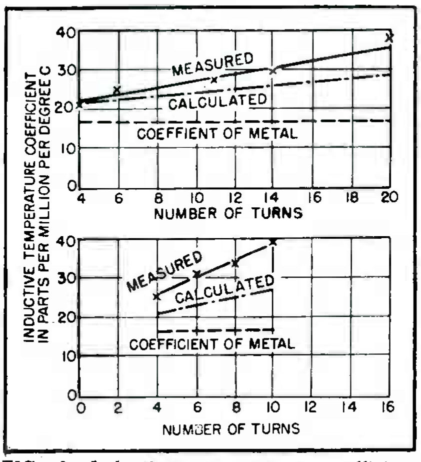

FIG. 1—Inductive temperature coefficient as a function of number of turns for two coils having small self inductance, wound on low-expansion forms. Difference between measured and calculated values is the internal inductance component

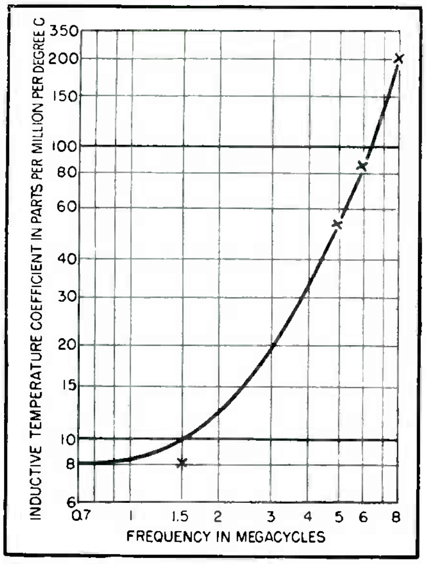

FIG. 2—Self-capacitance effects cause this variation with frequency of inductive temperature coefficient of a small coil

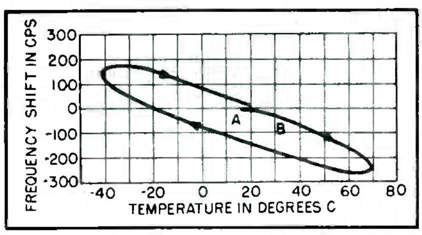

FIG. 3—Temperature cycling measurements yielded data for this frequency shift-temperature characteristic of a small low-expansion coil. Thermal lag of coil parts causes segment AB to deviate from main part of curve and results in displacement of retrace curve

Figure 1 shows the variation in inductive temperature coefficient with number of turns for two coils having small self capacitance, each wound on a skeleton glass-bonded mica form with small axial expansion coefficient (8.8×10^{-6} per degree C).[5] The discrepancy between calculated and measured values is accounted for by the internal inductance component. Note that the temperature coefficient varies almost linearly with the number of turns. This fact is significant for the case of variable-inductance tuning, and for tapped and variometer coils.

Self Capacitance of Coils

In some coils, the conductors are embedded in grooves or in slots in the supporting insulation, or the conductors may be fired or deposited electrolytically on ceramic or glass forms. Such coils will have greater distributed capacitance than those consisting of a single self-supporting layer or of round conductor wound on a smooth form. Multilayer coils and closely wound solenoids have higher values of distributed capacitance because of the decreased spacing and replacement of air between turns by solid insulation of higher permittivity.

Distributed capacitance of a coil increases its effective inductance to a value L', as indicated by the formula

$$L' = \frac{L}{1 - \omega^2 C_o L} \qquad (4)$$

in which C_o is the distributed capacitance, ω is the angular frequency, and L is the inductance when C_o is not taken into account. The distributed capacitance of a single-layer solenoid can be calculated readily, and rather surprisingly, does not depend upon the number of turns but upon the turn spacing and the coil and conductor diameters. Distributed capacitance does not include that of the mass of the coil to ground or the capacitance between leads or terminals.

The inductive temperature coefficient γ due to self capacitance[5] is

$$\gamma = \frac{k + \omega^2 L C_o \sigma}{1 - \omega^2 L C_o} \qquad (5)$$

where k is the composite temperature coefficient of expansion determined by the coil form and the conductor, and σ is the temperature coefficient of permittivity of the coil form or other dielectric between turns. Equation 5 indicates that the inductive temperature coefficient will increase with frequency, with the temperature coefficient of permittivity of the dielectric, including that of any impregnant or finish, and with the magnitude of the distributed capacitance.

The magnitude of self-capacitance effects at frequencies above one-tenth of the natural resonance frequency may be noted from Fig. 2. This curve shows the variation in inductive temperature coefficient with frequency, calculated and measured by Thomas[5] for a small coil having the conductor deposited electrolytically in grooves in a ceramic form. As the natural frequency of this coil, 10.9 mc, is approached, the temperature coefficient rises from a low value of 8×10^{-6} per degree C, approximately equal to the expansion coefficient of the ceramic, to nearly $1{,}000 \times 10^{-6}$ per degree C. Components other than expansion and self capacitance were small in this particular coil.

Not only is it important that a coil have small distributed capacitance, but also that the insulation have a small temperature coefficient of permittivity. The scarcity of data on this coefficient prompted the writer to collect the information presented in Table I.

Table II—Temperature Coefficients of Commercial Capacitors

Type of Capacitor	Temperature Coefficient (Parts per Million) per Degree C)	Notes
Fixed ceramic compensating	−1,600 to +150	Linear and stable; coefficient varies at low frequencies[2,12]
Molded mica	+50 to −500	Writer's measurements. Aging has somewhat variable effect on capacitance shifts[9,12].
Molded silvered mica	−250 to +250	Writer's measurements. Aging effect about 1/5 that of mica type.
Mica compression trimmer	+400 to +800	Writer's measurements.
Molded paper (JAN spec)	−20,000 to +20,000	Variable. Large aging effect.
Paper (impregnated and sealed)		Vary widely with temperature, frequency, and type impregnant[14,15,19].
Variable air dielectric:		
Ganged receiver type (ceramic insulation, no trimmer)	+98 to +28	Writer's measurements. See Fig.4.
Trimmer (ceramic insulation; at midposition)	+136	Writer's measurements.
Vacuum type (GE Type GL-1L38, 50 μμf, 7,500 v)	+27	Manufacturer's rating. Probably linear and stable.

Note: Numerical superscripts refer to references cited in text.

Practical Coil Construction

The writer's test on receiver and small transmitter coils, using finishes having a neutral effect, covered a range of temperature coefficients from 4.1×10^{-6} per degree C, for a special coil with silvered-invar conductor and low-expansion ceramic, up to 60×10^{-6} per degree C for a low-frequency antenna coil. Temperature coefficients as low as 1×10^{-6} per degree C have been obtained by others by the use of more complicated designs.[5,6,7]

One of the basic problems in coil design is that of obtaining inductance that is stable cyclically with temperature variations and also has secular, or long term, stability. For example, self-supported single-layer coils are found to have poor cyclical stability. Figure 3 shows results of a complete temperature cycling test at 1.5 mc on an oscillator coil wound with silvered nickel-alloy conductor on a ceramic form having a small expansion coefficient.

Temperature Coefficients in Capacitors

Fixed and variable air-dielectric capacitors have been constructed, after careful design, to have temperature coefficients as low as 1×10^{-6} per degree C, and to have excellent retrace characteristics as well as secular stability.[7,8,9,10] However, such special and expensive constructions, some of which require low-expansion plates and spacing elements and bimetallic compensators, are seldom used commercially.

Considerable use has been made of ceramic compensating capacitors in tuned circuits of receivers and transmitters,[1,2] despite the difficulties and compromises in compensation usually involved. Although they are stable, ceramic types have higher r-f losses than air-dielectric types,[10] and their temperature coefficients cannot be predicted as accurately as desired before firing. Ceramic compounds of higher permittivity are now being made of various mixtures of titanium dioxide and barium titanate, which has a permittivity of 1,200, or other combinations with strontium and calcium titanates.[11] Many of these compounds have linear characteristics with temperature and frequency at above 10 to 50 cps.[2,10]

The capacitance - temperature shift of a low-priced, ganged receiver tuning capacitor, employing phenolic insulation for the stator and attached trimmers, was found to be much greater than that of a similar unit using ceramic insulation. Capacitance shift and temperature coefficient as functions of rotor position for the ceramic-insulated capacitor are shown in Fig. 4.

Humidity Effects

Changes in capacitance of air-dielectric capacitors due to the temperature coefficient of permittivity of air are negligible in most cases, being only 1.87×10^{-6} per degree C for dry air at 20 C. The effect of humidity becomes appreciable at higher temperatures, amounting to 217 parts per million for a change in relative humidity from 0 to 100 percent at 50 C.

Moisture Films

Of more importance, is the effect of films of moisture on capacitor plates or over the outer surfaces of coils, that is, lying within the electric field between turns. Such films are of particular importance when they are formed over thin films of oil or grease on metals, thereby increasing the effective film thickness. Table I shows that water has a very high temperature coefficient of permittivity as well as a high dielectric constant. Consequently, frequency shifts due to such invisible moisture films may exceed 100 cycles per mc even before absorption of moisture occurs in insulating materials. Obviously, the much thicker films formed by visible condensation will have even more substantial effects.

It is generally known that the absorption of moisture by solid insulating materials increases their permittivities, but the fact that water has a large negative temperature coefficient is not so well known, nor has its wide variation with temperature and with certain temperature-frequency combinations been widely recognized.[11, 12]

Table II presents data on the temperature coefficients of capacitors of various types. Tests made by the writer showed the variation of temperature coefficient for commercial mica and silvered-mica types over the extreme working range, differences between units of the same type and make, and their erratic changes with time.[13] Unfortunately, the bulk of commercial grades of mica and silvered-mica capacitors, such as are used commonly in radio receivers, differ greatly from the high grade components referred to by some writers,[7, 10, 14] and enjoy a better reputation for low temperature coefficient, cyclical reliability, and permanence than their performance under adequate temperature tests warrants.

Tube Capacitance Changes

The input capacitance of a 7A4 tube changes about 0.17 $\mu\mu$f during the first fifteen minutes of operation. For a 6J5, the change is about twice as great. In receiver r-f tubes, the change in interelectrode capacitance is about one-fifth to one-eighth of these values.[15]

For an assumed circuit capacitance of 25 $\mu\mu$f, such tube-capacitance shifts cause frequency shifts of 3.4 kc to 6.8 kc at a nominal frequency of 10 mc for 7A4 and 6J5 oscillators, respectively. When circuit capacitance is large, the effect of tube-warmup shift is minimized, and a similar order of capacitance change in bakelite wafer-type switches, sockets, and the like, is also minimized.

Wiring and Switching Devices

From the data in Table I, it can be seen that stray circuit capacitances, particularly those involving dielectric materials such as phenols and other plastics, can cause very large circuit temperature coefficients when stray capacitance is a large fraction of total circuit capacitance. Ceramic tube sockets and ceramic and glass-bonded mica insulation for contacts and terminals are probably the best materials where frequency stability is critical.

Tuned-Circuit Resistance

Wiring and leads to coils and capacitors also undergo changes in inductance with temperature due to expansion and skin effect. The latter varies with frequency and size of conductor, and as a result, inductive temperature coefficients in the order of 20×10^{-6} to 60×10^{-6} per degree C can occur.[16]

The resonant frequency of an R-L-C circuit, when the resistance is taken into account is given by

$$f = \frac{\sqrt{4LC - R^2C^2}}{4\pi LC} \qquad (6)$$

The more familiar formula, $f = 1/2\pi\sqrt{LC}$, takes no account of the small effect of circuit resistance upon the frequency.

An example will illustrate the contribution of resistance in a practical case of an R-L-C circuit in which $L = 100$ μh, $C = 100$ $\mu\mu$f and $R = 10$ ohms. The resonant frequency is approximately 1,592 kc. The resistance factor in the numerator of Eq. 6 reduces this frequency 12.5 parts per million, or 19.9 cycles in this example. For a resistive temperature coefficient for annealed copper wire of $3{,}930 \times 10^{-6}$ per degree C at 20 C, the resulting frequency temperature coefficient would amount to less than one part per million.

This low calculated value checks with the maximum value found by Thomas[5] in checking the effect of coil resistance in a test oscillator. Under the poorest operating condition, he found the maximum frequency temperature coefficient to be 1.2 parts per million.

Therefore, it is apparent that the only serious effect due to changes in coil resistance with temperature are the resulting changes in eddy currents in the conductor which affect the internal inductance coefficient, as described above.

Resistor Variations

Resistors that control tube operating voltages often have appreciable resistive temperature coefficients. In a reasonably well designed commercial radio receiver, the oscillator frequency drift is not likely to exceed 300 parts per million for a change of 10 percent in line voltage, and shifts as low as 25 parts per million are reported for permeability-tuned oscillators.[2] Therefore, it is unlikely that shifts greater than a few parts per million per degree C can be ascribed either to carbon resistors having temperature coefficients, usually negative, between 600×10^{-6} and $8{,}900 \times 10^{-6}$ per degree C, or to wire-wound resistors having coefficients of 200×10^{-6} to 500×10^{-6} per degree C.

The mechanical design of sets

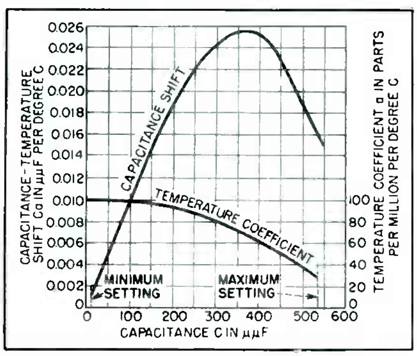

FIG. 4—Capacitance-temperature shift and temperature coefficient for a ceramic-insulated ganged tuning capacitor as functions of capacitance setting

and components must be such that stressing of materials beyond elastic limits at extreme temperatures does not occur. For example, wire on a coil form may be stressed when the coil form has a much higher coefficient of expansion than the wire. Buckling of chassis or structural members must also be avoided. The nonlinearity of curve 1 in Fig. 5 is probably due to such unequal expansion effects. In drift tests on a military radio receiver, the writer found that a radical change or reversal of the temperature coefficient occurred at a temperature below freezing. This effect was traced to leads on an air-dielectric trimmer capacitor which were too taut, distorting the stator assembly.

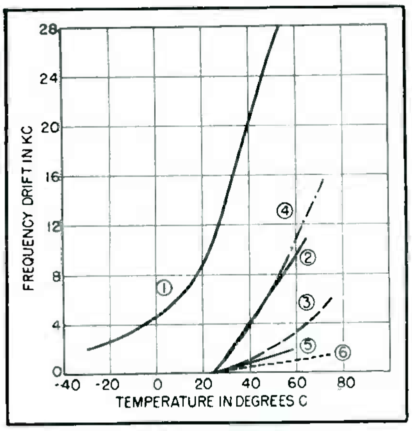

FIG. 5—Frequency drift-temperature curves illustrate analysis of drift in development of an airborne transmitter. Curve 1: total circuit drift due to original coil with bakelite endpieces; curve 2: component produced by coil frame; curve 3: drift from relay contact plate; curve 4: drift from toggle switch; curve 5: component from rotor coil; curve 6: drift obtained with revised coil construction

Test on Developmental Transmitter

A number of the factors involved in causing frequency drift are illustrated in Fig. 5 which depicts the history of the laboratory development of a radio transmitter for military aircraft use. This experience and the analysis of drift factors resulted in replacement of standard commercial parts with components having lower temperature coefficients. Many laboratories probably reached similar conclusions in solving such design problems during the war.

Each component under investigation was mounted in the temperature-controlled test chamber and was used to control the frequency of an oscillator beating with a crystal-controlled oscillator. Curve 1 of Fig. 5 shows the frequency drift with temperature at a frequency of 3 mc for the original oscillator coil assembly. Despite the fact that this variable inductor was wound on a grooved ceramic form, a frequency drift of 630 cycles per degree C, or 210 parts per million, was observed above room temperature. This measurement confirmed the original suspicion that the coil contributed largely to the bad drift characteristics observed in the initial model of the complete transmitter. The reduced rate of drift at low temperatures was probably due to nonlinear expansion effects in the coil assembly.

The coil frame endpieces, on which the terminals were also mounted and which were constructed of high-grade laminated phenolic, were tested separately. Curve 2 indicates that these endpieces contributed to the circuit a component of frequency temperature coefficient equal to 90×10^{-6} per degree C. This component is nearly half that due to the whole coil assembly, and results from the high temperature coefficient of permittivity of the phenolic, shown in other tests to be of the order of $1{,}000 \times 10^{-6}$ to $1{,}300 \times 10^{-6}$ per degree C. Other components employing phenolic insulation were a toggle switch, used to select quartz crystals for fixed-frequency operation, and the contact mounting plate of a band-change relay. Curves 3 and 4 show that these parts added drift components of 110×10^{-6} and 41×10^{-6} per degree C to the overall result. Although each of these circuit elements contributed only a few $\mu\mu$f of capacitance to the circuit, their capacitance changes with temperature were large enough to affect seriously even the stability of circuits employing large tank capacitors.

Redesign of Coil

The large frequency drift was remedied by a new coil design. The new coil, of slightly reduced size and inductance, employed a silver-jacketed nickel-alloy conductor with a temperature coefficient of linear expansion of 1×10^{-6} per degree C. This coil was wound on an Alsimag No. 202 grooved ceramic form having a very small expansion coefficient of 1.88×10^{-6} per degree C as compared to a coefficient of 6.34×10^{-6} per degree C of the coil form previously used. The bakelite endpieces were replaced by aluminum plates into which ceramic bushings were inserted for insulated parts. The new coil had a frequency temperature coefficient of only 19.5×10^{-6} per degree C, including 4.1×10^{-6} per degree C due to a rotor coil as shown in curve 5, indicating an improvement of more than ten to one. The drift curve obtained with this new coil is shown in curve 6.

The toggle switch was replaced with a rotary type employing ceramic insulation and the relay contacts were mounted on a piece of glass-bonded mica. A large ceramic capacitor with a very small negative temperature coefficient was used to compensate the remaining positive drift components due to the coil, wiring and oscillator tubes.

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Permanent Magnet Alloys

Alloy	Chemical Composition	MAGNETIC DATA: Residual Flux Density B_R (gauss)	Coercive Force H_C (oersteds)	Maximum Energy Product $(BH)_{max}$ (8π ergs/cu cm) x 10^{-6}	B_d† (gauss)	PHYSICAL DATA: Density (lb/cu in)	Mean Coefficient of Temperature Expansion (20 C-300 C) (inches/inch/° C x 10^6)	Electrical Resistivity at 25 C (ohm-cm/sq cm) x 10^6
0.65% Carbon Steel	0.65 C, 0.85 Mn, bal. Fe	10,000	42	0.18	6,500	0.283	13.3	18
1% Carbon Steel	1 C, 0.50 Mn, bal. Fe	9,000	51	0.20	5,900	0.282	12.4	20
5% Tungsten Steel	5W, 0.70C, bal. Fe	10,500	70	0.33	7,000	0.292	13.5	28
6% Tungsten Steel	6W, 0.70C, 0.50 Mn, 0.50 Cr, bal. Fe	9,500	74	0.33	6,500	0.294	14.5	30
1% Chrome Steel	0.90 Cr, 0.60C, 0.45Mn, bal. Fe	9,500	52	0.23	6,500	0.282	13.4	23
2% Chrome Steel	2.15 Cr, 0.90C, bal. Fe	9,300	60	0.26	6,300	0.282	13.1	28
3½% Chrome Steel	3.5 Cr, 1 C, 0.50 Mn, bal. Fe	9,500	66	0.29	6,500	0.281	12.6	29
6% Chrome Steel	6 Cr, 1.1C, 0.40 Mn, bal. Fe	9,500	74	0.30	6,200	0.281	12.2	34
9% Cobalt Steel	9 Co, 0.90C, 1.25 W, 5 Cr, bal. Fe	7,800	122	0.41	5,100	0.286	14.0	30
17% Cobalt Steel	17 Co, 0.70C, 8.25 W, 2.5 Cr, bal. Fe	9,000	170	0.65	5,900	0.302	15.9	28
36% Cobalt Steel	36 Co, 0.80 C, 3.75 W, 5.75 Cr, bal. Fe	9,600	228	0.93	6,300	0.296	17.2	27
40% Cobalt Steel	40 Co, 0.70C, 5W, 4.25 Cr, bal. Fe	10,000	242	1.03	6,500	0.296	17.4	25
Alnico IA	12 Al, 22.5 Ni, 5 Co, bal. Fe	6,600	540	1.40	4,100	0.249	12.6	75
Alnico IB	12 Al, 21 Ni, 5 Co, bal. Fe	7,100	450	1.40	4,700	0.249	12.6	75
Alnico IC	12 Al, 19.5 Ni, 5 Co, bal. Fe	7,600	400	1.40	5,200	0.249	12.6	75
Alnico IIA	10 Al, 18 Ni, 12.5 Co, 6 Cu, bal. Fe	7,000	630	1.60	4,200	0.256	12.4	65
Alnico IIB	10 Al, 17 Ni, 12.5 Co, 6 Cu, bal. Fe	7,500	560	1.60	4,600	0.256	12.4	65
Alnico IIC	10 Al, 16 Ni, 12.5 Co, 6 Cu, bal. Fe	8,000	425	1.60	5,500	0.256	12.4	65
Alnico IIIA	12 Al, 26 Ni, bal. Fe	6,500	560	1.35	4,000	0.249	13.0	63
Alnico IIIB	12 Al, 25 Ni, Bal. Fe	7,000	470	1.35	4,500	0.249	13.0	63
Alnico IIIC	12 Al, 24 Ni, bal. Fe	7,500	400	1.35	5,000	0.249	13.0	63
Alnico IVA	12 Al, 28 Ni, 5 Co, bal. Fe	5,500	730	1.25	3,100	0.253	13.1	75
Alnico IVB	12 Al, 27 Ni, 5 Co, bal. Fe	6,000	660	1.30	3,400	0.253	13.1	75
*Alnico V	8 Al, 14 Ni, 24 Co, 3 Cu, bal. Fe	12,700	650	5.50	10,100	0.264	11.3	47
*Alnico VIB	8 Al, 15 Ni, 24 Co, 3 Cu, 1 Ti, bal. Fe	10,500	760	3.65	7,100	0.268	11.4	50
*Alnico VIC	8 Al, 15 Ni, 24 Co, 3 Cu, 0.5 Ti, bal. Fe	11,000	700	4.00	7,900	0.268	11.4	50
Alnico XII	6 Al, 18 Ni, 35 Co, 8 Ti, bal. Fe	6,100	1,000	1.65	3,200	0.264	11.0	62
Nipermag	12 Al, 30 Ni, 0.4 Ti, bal. Fe	5,600	660	1.34	3,100	0.249	13.0	66
Sintered Alnico II	10 Al, 17 Ni, 12.5 Co, 6 Cu, bal. Fe	7,200	550	1.50	4,400	0.249	12.4	68
Sintered Alnico IV	12 Al, 28 Ni, 5 Co, bal. Fe	5,500	730	1.25	3,100	0.232	13.1	68
Cunico I	50 Cu, 21 Ni, 29 Co	3,400	710	0.85	2,000	0.300	—	—
Cunico II	35 Cu, 24 Ni, 41 Co	5,300	450	0.99	3,400	0.300	—	—
*Cunife I	60 Cu, 20 Ni, 20 Fe	5,700	590	1.85	4,200	0.311	—	18
*Cunife II	50 Cu, 20 Ni, 2.5 Co, 27.5 Fe	7,300	260	0.78	4,700	0.311	—	18
Remalloy; Comol	12 Co, 17 Mo, bal. Fe	10,000	230	1.10	6,900	0.295	—	45
*Vectolite	30 Fe_2O_3, 44 Fe_3O_4, 26 Co_2O_3	1,600	900	0.50	940	0.113	—	225x10⁶
Silmanal	86.75 Ag, 8.8 Mn, 4.45 Al	590	6,300‡	0.083	292	0.325	Δ20.5	26
Vicalloy I	9.5 Va, 38.5 Fe, 52 Co	9,000	300	1.00	5,500	0.296	11.2	60
*Vicalloy II	13 Va, 35 Fe, 52 Co	10,000	450	3.00	8,200	0.293	11.2	60
Platinum Alloys	77.8 Pt, 22.2 Fe	5,830	1,570	3.07	3,400	—	Δ10.2	—
	76.7 Pt, 23.3 Co	4,500	2,700	4.00	2,600	—	Δ11.4	42
New KS	3.7 Al, 17.7 Ni, 27.2 Co, 6.7 Ti, bal. Fe	7,150	785	2.03	4,300	Δ0.268	Δ11.7	Δ55

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Nominal magnetic, physical, and mechanical characteristics of 42 types of magnet steels, cast magnets, magnetic alloys, and sintered magnets

MECHANICAL DATA

Tensile Strength (as used) (lb/sq in.)	Transverse Modulus of Rupture (lb/sq in.)	Hardness (as used) BR-Brinell (RC-Rockwell)	
φΔ300,000	—	φ60-65 RC	
φΔ300,000	—	φ60-65 RC	
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	1
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	
Δ300,000	—	60-65 RC	
4,000	13,900	45 RC	
4,000	13,900	45 RC	
4,000	13,900	45 RC	
3,000	7,200	45 RC	
3,000	7,200	45 RC	
3,000	7,200	45 RC	
12,000	22,500	45 RC	
12,000	22,500	45 RC	
12,000	22,500	45 RC	2
9,000	24,000	45 RC	
9,000	24,000	45 RC	
5,450	10,500	50 RC	
23,000	45,000	56 RC	
23,000	45,000	56 RC	
39,500	50,000	58 RC	
10,500	23,000	45 RC	
65,000	70,000	43 RC	
60,000	85,000	42 RC	3
100,000	—	200 BR	
100,000	—	200 BR	4
100,000	—	200 BR	
100,000	—	200 BR	5
—	—	60 RC	6
nil	—	—	7
Δ110,000	—	230 BR	8
—	—	60 RC	
200,000 (65% Red.) 360,000 (90% Red.)	—	60 RC	9
103,000	—	210 BR	
—	—	—	
—	—	—	

METHOD OF MANUFACTURE

1. So-called magnet steels, usually cast in ingots and hot-rolled into bars and strips. As-rolled hardness (depending upon section, steel, and treatment) varies from approximately 25 RC to approximately 55 RC and material is ordinarily suitable for hot forming and punching operations but not for cold forming or machining operations unless carbide tools are used. Material may be annealed to 25-35 Rockwell C in the case of cobalt steels, and to approximately 15 RC in all other cases. This will permit of ordinary cold machining operations but the anneal is detrimental to magnetic properties and should be kept as light as possible. After forming, material is hardened (depending on steel) by either water or oil quench from hardening temperature. Intricate shapes may be cast.

2. So-called cast magnets. Unlike the magnet steels which are frequently formed and hardened by the consumer, the Alnicos are always provided in final form and heat-treated by the manufacturer. Grinding, which is the only finishing or machining operation practical, may be performed by either consumer or manufacturer. Cast of final shape in sand molds from induction furnaces, Alnico is a hard, weak, and brittle material but possesses sufficient strength for successful use in almost all permanent magnet applications. May be precision cast. Precipitation hardening alloys. Alnicos V and VI heat-treated in magnetic field possess properties indicated only in direction established by this field.

3. Same characteristics as cast Alnico except slightly stronger physically. Material manufactured by mixing component powders, pressing to final shape, and sintering. Most applicable to magnets one ounce or less in weight.

4. Ordinarily chill cast in the form of small bars, which may then be cold-rolled to strip and punched, or the bars may be machined and cut to size. (Material not hot workable as of date.) Material is reasonably malleable and ductile and readily machineable both before and after its final heat treatment (which will ordinarily be performed by the manufacturer). Intricate shapes may be precision cast or sand cast. Precipitation hardened alloy. As cast, hardness is 180 BR. Magnets may also be sintered.

5. Sand cast in form of small bars and cold-drawn or rolled to wire or strip sizes. Magnetic properties depend upon severe cold reduction, and those specified are in direction of drawing or rolling only. Material is malleable, ductile, and machinable both before and after final heat treatment. Heat treatment performed by manufacturer. As cast, hardness is 135 BR. Material not hot workable.

6. Cast in ingot form and hot-rolled to bars and strips, which may then be hot-bent, hammered, sheared, punched, or cold-machined, but not cold-formed or rolled. As cast, hardness is 20-40 RC. A precipitation hardening alloy, it is heat-treated after forming or machining operations, after which it may be only ground. Quite fragile and brittle. Intricate shapes may be sand cast and machined before heat treatment.

7. Component oxides are mixed, pressed to final shape, and sintered in oxidizing atmosphere, after which material is heat-treated in a magnetic field. The magnetic properties indicated are in direction of this field only. Material very weak physically but may be ground with proper technique.

8. Cast is very small ingots, homogenized, and cold swaged or rolled (preferably swaged) to small bars. Material not hot-workable. Cold-working necessary to development of magnetic properties, although material not directional. A precipitation hardening alloy, it is heat-treated after swaging. Ductile, malleable, and machineable both before and after final heat treatment. Hardness as cast is 100 BR; after homogenizing or solution treatment—60 BR; after cold swaging—150 BR.

9. Ordinarily cast in form of small bars and hot-rolled to bars or strips. As cast or hot-rolled, hardness is 25-30 RC. Material may be readily hot or cold rolled, formed, or machined. Hardness after cold rolling is 40 RC. Precipitation hardening alloys. Heat-treated after rolling or machining, after which material may only be ground. Vicalloy II is severely cold-reduced (usually to 0.002 inch tape) before heat treatment, and the magnetic properties indicated (which depend upon this treatment) are those in direction of rolling only.

* Directional magnetic properties.
‡ B_o = flux density at point of maximum energy product.
\# Intrinsic coercive force, H_{ci}.
Δ Approximate value only, for comparison purposes.
φ Value for hard outside shell. Softer core will have a lower value.

PROPAGATION of

A definitive statement, based in part on the experience of the MIT Radiation Laboratory, of some of the factors governing propagation at frequencies from 100 to 30,000 megacycles. This installment, the first of two, treats one-way transmission

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Part I

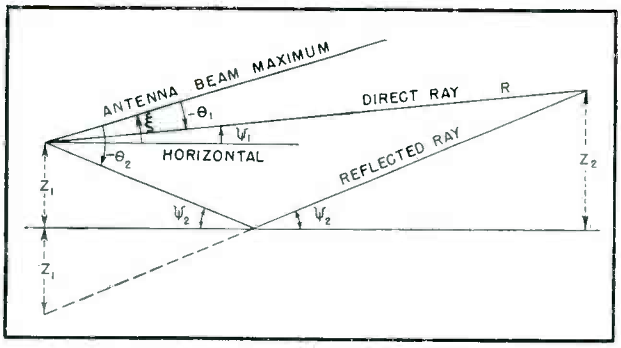

FIG. 1—Geometry of reflection from a plane earth. The simple properties of this figure can be applied to the real earth as shown in Fig. 3

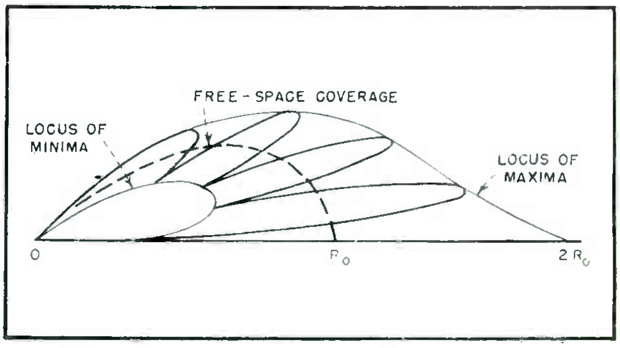

FIG. 2—Coverage diagram, over a plane earth, for vertical polarization. In the case shown, the reflection coefficient decreases with increasing angle of incidence

THE accelerated wartime development of radar and associated equipment has brought to light new and interesting information concerning the mechanism of propagation of radio waves at frequencies above 100 mc. In many respects these very short waves behave like visible light, but in other respects they behave quite differently. Accurate description of the mechanisms involved necessitates borrowing techniques from such widely separated fields as physical optics, quantum theory, and meteorology. This article is intended to outline briefly some of the problems involved, and to present a few of the principles employed in their solution. The experimental data quoted here were obtained by the Propagation Group of the MIT Radiation Laboratory operating under Contract No. OEMsr-262, but the general information summarizes the activities of many investigators in various parts of the world.

One-Way Propagation in Free Space

The most useful way of expressing the radiation of energy from an antenna is in terms of the antenna pattern function or radiation pattern, $f(\theta,\phi)$. It expresses the ratio of field strength radiated in the direction θ, ϕ to the field radiated in the direction of maximum transmission (where $\theta = \phi = 0$). In general f is a complex quantity, but in the interest of simplicity this fact will be ignored in the following treatment. The generalization to complex f is obvious. For the special case of a uniform or isotropic radiator, f is unity for all angles, but for the usual directive antennas f is unity along the axis of symmetry ($\theta = \phi = 0$), and decreases with increasing values of either angle. The power gain G of a particular antenna relative to a reference antenna is easily shown to be*

$$G = \frac{\int f_r^2(\theta,\phi)\, d\Omega_r}{\int f^2(\theta,\phi)\, d\Omega} \qquad (1)$$

where Ω is the solid angle occupied by each antenna pattern and f_r is the pattern of the reference anten-

* For further discussion of antenna directivity and gain see Schelkunoff, "Electromagnetic Waves," Chapter 9, D. Van Nostrand and Co., New York.

VERY SHORT WAVES

NEW INFORMATION

Of all the knowledge massed during the war, none is more important to the future of the radio art than the new information on the propagation of waves shorter than three meters. Because the subject is inherently complicated and the new data voluminous, very little has appeared in the technical press on this subject since VJ day.

The editors are happy to present, therefore, this two-part paper by Mr. Kerr, who headed the propagation section of the MIT Radiation Laboratory. This material is a masterful condensation of an immense mass of new theory and data, made possible only by the liberal use of symbolic notation and close-knit style.

Lest readers be scared away by the slightly forbidding aspect of these articles, accept our assurance that the treatment is as simple as the subject permits, and that the subject is well worth the effort. Suffice it to say that effective use of uhf and shf radio systems cannot be made without sound knowledge of how the waves get there.

And did you know, as the text points out, that the free-space range of a 10-watt 10-cm transmitter with a reflector one meter in diameter, when picked up by a similar antenna and a receiver of normal sensitivity is 31,000 miles?—The Editors

na. If the reference antenna is isotropic the numerator of Eq. 1 is 4π. All antenna gains used here are referred to the isotropic radiator.

The power gain in Eq. 1 is evidently related to the power flow from the antennas, given by the Poynting vector S. The magnitude of this vector giving the power flow across a unit area normal to the direction of transmission from a directive antenna in free space is given in terms of the radiated power P_t, distance R, gain G_t and pattern function f_t by

$$S = \frac{P_t G_t}{4\pi R^2} f_t^2\,(\theta,\phi) \qquad (2)$$

where the subscript t serves to distinguish the transmitting antenna from a receiving antenna of different characteristics.

It is frequently desired to find the three-dimensional coverage diagram of a given antenna. This is the locus in space of all points at which either the electric field or Poynting vector assume some particular assigned value. These values may be stated in absolute measure (in volts per meter or watts per square meter), or they may be specified relative to the value of either of these quantities at some reference distance from the antenna. In mks units, the rms electric field E and time average of the Poynting vector are related by $S = E^2/120\pi$. Then Eq. 2 yields

$$|E| = \frac{\sqrt{30 P_t G_t}}{R} \left| f_t\,(\theta,\phi) \right| \text{ volts per meter} \qquad (3)$$

A familiar special form of Eq. 3 is that for the field strength in the equatorial plane of a half-wave doublet, for which $G = 1.64$;

$$E = 7\sqrt{P_t}/R \text{ volts per meter} \qquad (3a)$$

In particular, if we denote by E_s and S_s the field strength and Poynting vector at a reference distance R_s in the direction of maximum transmission Eq. 2 and 3 lead to

$$\sqrt{\frac{S}{S_s}} = \left|\frac{E}{E_s}\right| = \frac{R_s}{R}\left| f_t\,(\theta,\phi) \right| \qquad (4)$$

These three relations may be summarized by one simple equation

$$R = R_f\,|\,f_t\,(\theta,\phi)\,| \qquad (5)$$

where

$$R_f = R_s \left| \frac{E_s}{E} \right| \qquad (6)$$

Equation 5 specifies the distances defining the locus of points at which the field strength has a specified value E. This locus is a surface with the shape of the antenna pattern, enclosing a volume depending upon the particular value of E.

In order to abstract energy from the radiated field, a receiving antenna is oriented in the general direction of the transmitter. It may be characterized by its effective area A_r or by its gain G_r, which depends upon A_r and upon the wavelength λ by $G_r = 4\pi A_r/\lambda^2$. The effective area is commonly $\frac{1}{2}$ to $\frac{3}{5}$ of the geometrical area, and refers to orientation for maximum reception; see Schelkunoff, first footnote. The power intercepted by the antenna, P_r, is the product of the incident Poynting vector, the effective area, and the square of the receiving antenna pattern function:

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi R)^2} f_t^2\,(\theta,\phi)\, f_r^2\,(\theta',\phi') \qquad (7)$$

where the angles describe the orientations of the two antennas relative to the line joining them.

Assuming that both antennas are aligned for maximum reception ($f_t = f_r = 1$), we may determine the maximum range to which satisfactory reception can be obtained. This maximum range will be called the free-space detection range R_0. At this range the received power P_r will be reduced to the minimum useful (barely perceptible) value, denoted by P_{min}. The determination of P_{min} is often a difficult process, and is outside the scope of this paper. For the present purpose we assume P_{min} to be known. Then Eq. 7 becomes

$$R_0 = \frac{\sqrt{G_t G_r}\,\lambda}{4\pi}\sqrt{\frac{P_t}{P_{min}}} \qquad (8)$$

This important equation states the relations between the system parameters and the best possible free-space performance. The free-space range R_0 has become a generally accepted yardstick of performance. It is instructive to consider a numerical example to obtain orders of magnitude likely to be encountered. Assume that a microwave communications system has the following characteristics: $P_t = 10$ watts; $P_{min} = 10^{-13}$ watts; $\lambda = 10$ cm; antenna diameters = 1 meter and effective areas $2/\pi = 0.637$ times the geometrical value, giving a gain of 200π. These values, inserted into Eq. 8, give a free-space range of 50,000 km, or 31,000 miles! Such fantastic ranges are never observed in practice, of course, because of the effects of the presence of the earth, which will be described presently.

It should be noted that if $R_0 = R_f$ in Eq. 5 and 6, these equations define the volume in free space inside which satisfactory reception can be obtained, and the maximum permissible space attenuation of electric field. In particular, if we confine ourselves to the vertical plane ($\phi = 0$), a polar plot of $R = R_0 f(\theta)$ is called the free-space coverage diagram. As will be seen later, the earth and atmosphere usually distort it to a marked degree.

In this section we shall assume that the earth is plane, and that its effects can be expressed by a plane-wave reflection coefficient, $\Gamma = \rho e^{-j\phi}$, the ratio of field strength in a plane wave reflected from the surface to the field incident upon it. The reflected wave is attenuated by the factor ρ and is retarded in phase by an angle ϕ. Both ρ and ϕ depend upon the earth constants, wavelength, polarization, and angle of incidence as discussed in the second installment of this paper.

The modification of the free-space distribution of field strength may be expressed conveniently in terms of a quantity termed the pattern-propagation factor, represented by F. It is chosen to express as nearly as possible all of the factors external to the system, i.e., those involving the antenna pattern and propagation effects alone. Its definition is: F is the absolute value of the ratio of electric field at a point under stated physical conditions to the maximum possible free-space field at that point. In symbols,

$$F = \left|\frac{E}{E_0}\right| \qquad (9)$$

where E_0, the maximum free-space field, is given by Eq. 3 with $f_t(\theta, \phi) = 1$. Because of its usefulness we shall focus our attention primarily on F, or on $20 \log_{10} F$, the actual field strength relative to free-space field strength expressed in decibels. The significance of F will become clear from the following illustrations. (Note that under free-space conditions F is just $|f|$).

As shown in Fig. 1, energy travels from one terminal to the other by two routes, one the direct-ray path and the other the reflected-ray path. Along the latter path, the energy appears to come from the image of the source below the surface, and it traverses a path length R_2 that is greater than R_1. The resultant field strength is the vector sum of the fields traversing the two paths, and an interference pattern is formed in space because of the spatial phase relationships.

The field from the energy traveling along R_1 is

$$E_1 = E_s \frac{R_s}{R_1} e^{-jkr_1}$$

where $k = 2\pi/\lambda$. If the antenna is isotropic the field incident on the surface is as strong as that radiated along the direct-ray path, and after reflection it appears at the field point as

$$E_2 = E_s \frac{R_s}{R_2} \rho e^{-j(kR_2 + \phi)}$$

The derivation is limited to small angles and ratios of heights to range (the usual approximations). Then in the denominator we may set $R_1 = R_2 = R$, but of course cannot do so in the numerator, as the difference $R_2 - R_1 = \Delta R$ is the quantity required. Then the total field is

$$E = E_1 + E_2 \cong E_s \frac{R_s}{R} e^{-jkR_1} \left[1 + \rho e^{-j(k\Delta R + \phi)}\right]$$

But the coefficient of the quantity in brackets is just the free-space field; consequently the magnitude of the quantity in brackets is F for this case. Elementary geometry shows that $\Delta R \approx 2z_1z_2/R$, so F becomes

$$F = |1 + \rho e^{-j\alpha}| = \sqrt{1 + \rho^2 + 2\rho\cos\alpha} \qquad (10)$$

where

$$\alpha = \frac{4\pi z_1 z_2}{\lambda R} + \phi \qquad (11)$$

This shows that the field strength is periodic with height, oscillating between $1 + \rho$ and $1 - \rho$ times the free-space field.

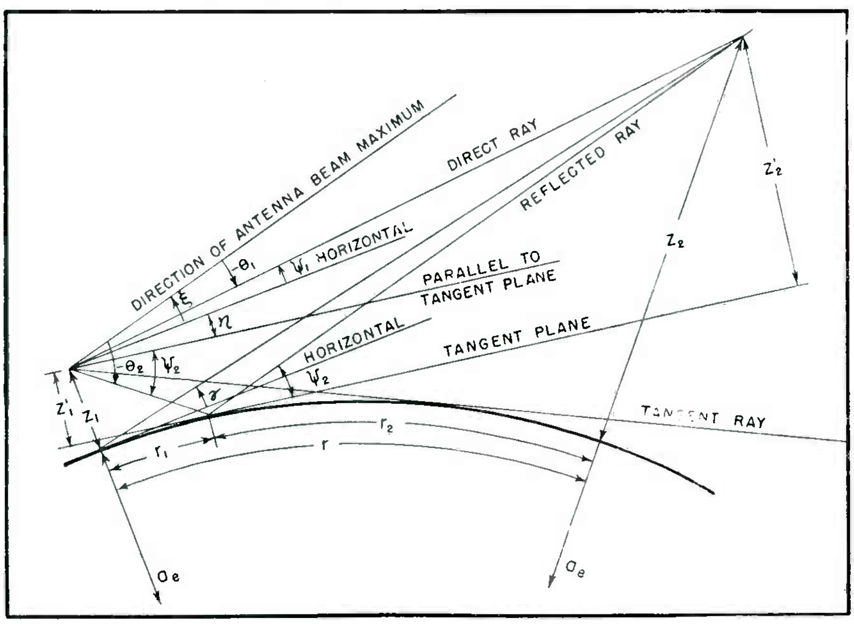

FIG. 3—Geometry of standard propagation over a sperical earth, in the interference region

In this installment ρ will be assured constant in order to simplify the discussion.

An important special case occurs when $\rho = 1$ and $\phi = \pi$, which occurs at grazing incidence. Then Eq. 10 becomes

$$F = 2\left|\sin\left(\frac{2\pi z_1 z_2}{\lambda R}\right)\right| \quad (12)$$

which shows that the field strength is twice the free-space value when $2z_1z_2/\lambda R = n/2$, where n is an odd integer, and is zero when $2z_1z_2/\lambda R = n$, where n is an integer. The complete variation of field strength with range for this case is given by

$$\left|E\right| = \left|E_0\right|F = 2\frac{R_s}{R}\left|E_s \sin\left(\frac{2\pi z_1 z_2}{\lambda R}\right)\right| \quad (13)$$

which shows that as R increases the field oscillates out to where $z_1z_2/\lambda R = 1/4$, after which it decreases without oscillation. In this latter region, as $2\pi z_1 z_2/\lambda R$ becomes very small, the sine may be approximated by its argument, and Eq. 13 becomes

$$E = E_s R_s \frac{4\pi z_1 z_2}{\lambda R_z} \quad (14)$$

the familiar result for the so-called "inverse square law" region. This is a useful approximation for wavelengths that are not too short and for ranges small enough that the earth's curvature is not important. (The temptation to use this simple formula may easily lead one astray, however.)

Equations 10 to 13 may be easily modified to give the complete expression for F including the antenna pattern. As may be seen from Fig. 1, the fractions of field strength radiated along the direct and reflected ray paths are $f(\theta_1)$ and $f(\theta_2)$, respectively. Then a derivation similar to that for Eq. 10 shows that

$$F = |f(\theta_1) + \rho f(\theta_2)e^{-j\alpha}| = \sqrt{f^2(\theta_1) + \rho^2 f^2(\theta_2) + 2\rho f(\theta_1) f(\theta_2)\cos\alpha'} \quad (15)$$

Both antenna pattern and reflection coefficient now limit the range of variation of F, the limits of which are $f(\theta_1) \pm \rho f(\theta_2)$. To calculate F in a specific case the behavior of ρ and ϕ must be known (see second installment) and θ_1 and θ_2 must be

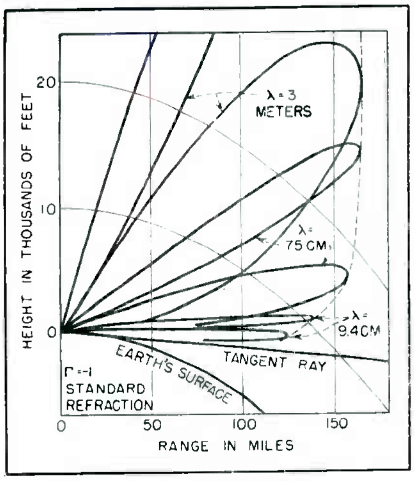

FIG. 4—Contours of field strength 103 db below that at a distance of one meter, from an isotropic antenna 110 feet above the surface (two lowest lobes are shown for each wave length; R = 88 miles)

determined. From Fig. 1 we see that

$$\left.\begin{aligned} \theta_1 &= \psi_1 - \xi \\ \theta_2 &= -\psi_2 - \xi \\ \tan\psi_2 &= (z_1 + z_2)/R \end{aligned}\right\} \quad (16)$$

The arrows indicate the positive directions for the angles, except for ψ_2, which is always positive. The calculation of field strength above a plane earth is simple and straightforward, and is expressed (except for reflection coefficient) in Eqs. 3, 9, 15 and 16.

The relation of a coverage diagram to F may be derived by recalling the definition from Eq. 9, $|E/E_o| = F$. But $|E_o| = |E_s|R_s/R$; therefore $R = R_s|E_s/E|F$. From Eq. 6 $R_s|E_s/E| = R_f$. If we set $R_f = R_o$ the free-space detection range, then the coverage diagram is a polar plot of the equation

$$R = R_0 F \quad (17)$$

This is an implicit relation, as F is a function of R. For many practical purposes this is unimportant, because for small elevation angles and ranges greater than a few miles F can be expressed approximately as a function of γ, the angle of elevation, by noting that $\psi_1 \approx \psi_2 \approx \gamma$. Consequently, a polar plot of F may be converted into a coverage diagram by introducing R_o as a scale factor. As $0 \leqq F \leqq 2$, the operating range of a system over a plane earth may at most be twice the free-space range, or may be reduced to zero, although the range of variation is in practice always less than this, as shown by Eq. 15. Figure 2 shows a sketch indicating qualitatively how a coverage diagram may appear when the antenna pattern and decrease of ρ with the angle ψ_2 are important in influencing F.

Equation 7 for received power in free space may now be modified to include F. The Poynting vector incident on the antenna is $S = E^2/120\pi = E_0^2F^2/120\pi$, from which it may be shown that the new expression is

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi R)^2} F^2 f^2_r(\theta', \phi') \quad (18)$$

One-Way Propagation Over Spherical Earth

The spherical shape of the earth introduces complications into the problem of field strength computation which will only be outlined briefly here.** The region in Fig. 3 above the tangent ray is called the interference region because, as in the case of the plane earth, interference between direct and reflected waves produces interference patterns. The region below the tangent ray is called the diffraction region, because energy penetrates it by diffraction around the bulge of the earth. The radius a_e is the effective radius of the earth, different from the true radius as a result of atmospheric refraction, and is discussed in the second installment of this paper.

In the interference region the formula for F is similar in form to that for the plane earth, but differs in some details. Because the reflected wave strikes a convex rather than a plane surface, upon reflection it is spread out, resulting in a weaker field than that reflected from a plane surface. This weakening of the reflected field is expressed by the divergence factor D, which now appears in combination with ρ where ρ appeared in the plane-earth formulas. At high elevation angles D is essentially unity, but it falls to zero rather abruptly in the vicinity of the tangent ray. A second difference appears in the formula for ΔR, which as can be seen from Fig. 3, is $\Delta R \approx 2z'_1 z'_2/R$, where

** Details of new methods for rapid computation of field strength are given in Vol. 13 of the forthcoming Radiation Laboratory Series, "Propagation of Short Radio Waves," to be published by McGraw-Hill Book Co., Inc., New York.

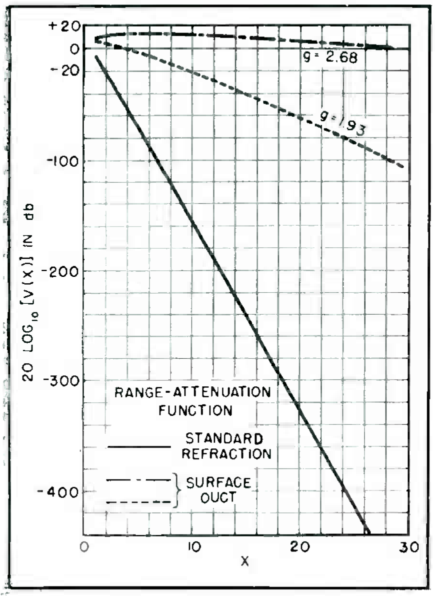

FIG. 5 — Range-attenuation function for standard refraction, and for two surface ducts (see text for significance of duct parameter g)

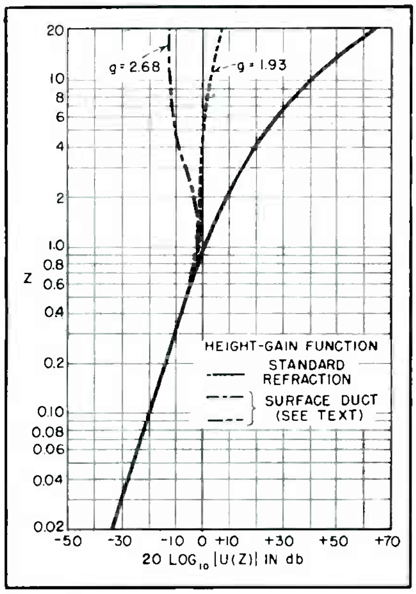

FIG. 6—Height-gain function for standard refraction and for two surface ducts, corresponding to range-attenuation function of Fig. 5

z'_1 and z'_2 are the heights of the terminals above the plane tangent to the earth at the point of reflection, and are less than the true heights above the earth's surface. It is easily shown that for $z/a_e \ll 1$ and $r/a_e \ll 1$,

$$z'_{1,2} \simeq z_{1,2} - \frac{r^2_{1,2}}{2a_e} \qquad (19)$$

Before ΔR, D, or the other required quantities can be calculated r_1 must be obtained; unfortunately this requires solution of the cubic equation

$$r_1^3 - \frac{3}{2} r r_1^2 + \left[\frac{1}{2} r^2 - a_e(z_1 + z_2)\right] r_1 + a_e z_1 r = 0 \qquad (20)$$

Although simple in theory, the procedure is laborious and is awkward numerically. (Graphical methods have been devised to give r_1 and all quantities depending on r_1, and are described in detail in the book mentioned in the second footnote.)

The relations necessary to obtain θ_1, θ_2, and D are given by

$$\left.\begin{aligned} \theta_1 &= \psi_1 - \xi \\ \theta_2 &= -\psi_2 - \xi - \eta \\ \eta &= r_1/a_e \\ \tan\psi_2 &= (z'_1 + z'_2)/r \\ D &= \frac{1}{\sqrt{1 + \dfrac{2z'_1 z'_2}{a_e r \tan^3\psi_2}}} \end{aligned}\right\} \qquad (21)$$

Once r_1 is known, Eq. 21 can be used to calculate field strength for the spherical earth from the appropriate expression for F, which is,

$$F = |f(\theta_1) + D\rho f(\theta_2)e^{-j\alpha}| = \sqrt{f^2(\theta_1) + D^2\rho^2 f^2(\theta_2) + 2D\rho f(\theta_1)f(\theta_2)\cos\alpha} \qquad (22)$$

where

$$\alpha = \frac{4\pi z_1' z_2'}{\lambda R} + \phi \qquad (23)$$

Thus the field strength distribution in the interference region above a spherical earth is qualitatively similar to that above a plane earth. The lobes occupy somewhat different positions from those over a plane earth because of the modified form for α given by Eq. 23 and 19, and the range of variation of F is further limited by D, which predominates near the tangent ray.

A coverage diagram illustrating the general features described above is given in Fig. 4, which has been drawn for an isotropic radiator and $\rho = 1$, $\phi = \pi$. Only the two lowest lobes are shown for each of the three wavelengths. The effect of D is shown by the dotted line, which approaches zero near the tangent ray. Since we have assumed $\rho = 1$, F approaches 2 in the lobe maxima, i.e., the maximum range is twice the free-space range at high angles, while it approaches zero at the minima. (As pointed out above, the combination of D, ρ, and f always reduces the range of variation in a practical case, although for wavelengths of roughly 1 meter or more the conditions shown in the diagram are often closely approached over water.)

Perhaps the most striking and important feature of Fig. 4 is the comparison of wavelengths that it affords. Note that transmitter height is fixed and wavelength is varied. The angular elevation of a given lobe increases with (but not in direct proportion to) the wavelength and decreases with increasing height. The superiority of short wavelengths for operation at low elevation angles is clearly indicated. The accompanying penalty consists of having the high coverage for the shorter wavelengths broken up into many fine lobes. This important fact must be considered in choices of wavelength for applications in which the detailed structure of the coverage diagram is important.

Description of the field in the diffraction region requires an entirely different approach from the simple methods of geometrical optics employed up to this point; physical optics must be applied. It is now necessary to sum infinite series, which in the region of the tangent ray usually requires an inordinately large amount of labor. Fortunately, in the diffraction region sufficiently far below the tangent ray only the first term of the series is important, and we shall limit our discussion to this special case, for which

$$20 \log_{10} F = 20 \log_{10} [V(X)] + 20 \log_{10} |U(Z_1)| + 20 \log_{10} |U(Z_2)| \qquad (24)$$

where V and U are called the range-attenuation and height-gain functions respectively, and the dimension less variables X and Z are obtained by introducing scale factors as follows:

$$X = R \Big/ \left(\frac{a_e^2\lambda}{\pi}\right)^{1/3} \qquad (25)$$

$$Z = 2z \Big/ \left(\frac{a_e\lambda^2}{\pi^2}\right)^{1/3} \qquad (26)$$

The components of Eq. 24 are shown in Fig. 5 and 6, the solid lines referring to the situation considered here. Thus we see that in the region well below the tangent ray the field strength may be calculated rather more easily than in the interference region. It should be noted in passing that no distinction is made here between horizontal and vertical polarization, because in the microwave region the diffraction field depends only slightly on polarization, and negligible error results from treating both polarizations alike. This is far from true at low frequencies, of course.

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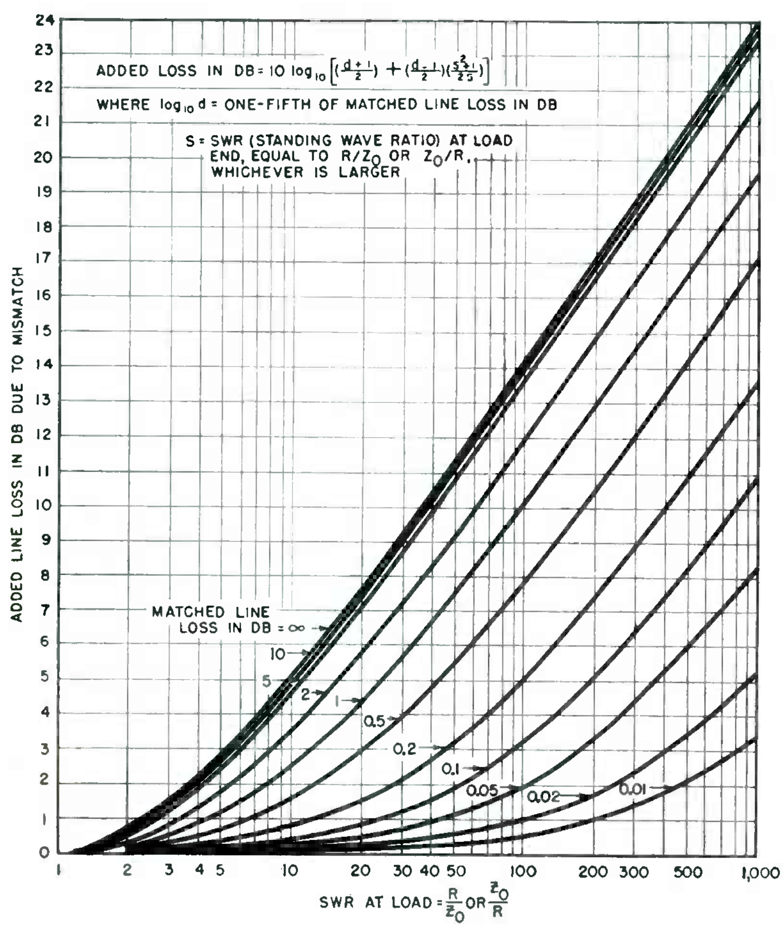
Mismatch Loss Chart for Transmission Lines

Loss due to mismatch between load and line impedance is given directly, in terms of total rated loss of line and standing wave ratio at load end

By J. M. HOLLYWOOD
*Airborne Instruments Laboratory, Inc.
Mineola, New York*

LEAST loss in a transmission line is obtained when its load impedance is equal to the characteristic impedance of the line, and standing waves are absent. Attenuation figures for lines are usually given on this basis. Since perfection is seldom obtained in practice, it is desirable to know the penalty incurred if a line is not perfectly matched. The accompanying chart shows this in a simple manner for ready use.

Each curve is for a line having a given loss in db when perfectly matched (loss equals attenuation in db per unit length multiplied by the length used). From published or known line data, the appropriate curve is selected or interpolated. If the standing wave ratio (SWR) at the load end of the line is known, the intersection of the corresponding vertical line and the selected curve gives the added line loss or attenuation in db, as shown on the scale at the left. This can be found in the same way for a known ratio of a resistive load R to the line impedance Z_0, using the alternative scale at the bottom.



As an example, consider a 500-ohm antenna used with 100 feet of RG-8/U cable at a frequency of 93 mc, having 2 db nominal attenuation, and a characteristic impedance of 52 ohms. R/Z_0 is 9.6; using the 2-db curve on the chart, the added loss due to mismatch is found to be 3.3 db.

As another example, if an antenna has to be used over a frequency range such that the standing wave ratio on a 52-ohm line becomes 5:1 and the line has 5 db attenuation when matched, the chart shows the added line loss to be 2.4 db at the extremes of the frequency range used.

The chart illustrates several points: (1) large SWR introduces little added loss if matched loss is very small; (2) little loss is added even to a large matched loss if the SWR is very small; (3) the added loss is almost the same for any matched loss over 10 db.

The chart and equation apply strictly only to lines of an integral number of quarter-wave lengths, or half-wave lengths for complex impedance loads. A very short line without leakage, for example, would have least loss if operated into an infinitely large load resistance.

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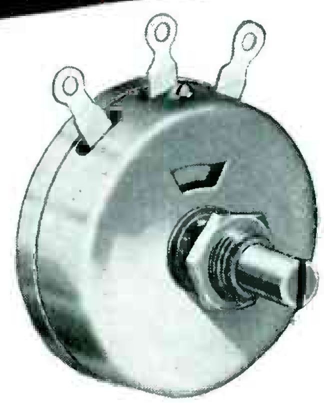

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Edited by VIN ZELUFF

Ferries Use F-M

OPERATED BY the Maryland State Highway Commission, two-way f-m equipment, said to be the first radio-equipped regularly scheduled ferry system in the nation, has been installed in the Chesapeake Bay area. Sets have been installed in the wheelhouse of each ferryboat while 60-watt units are located on the docks and in the State Highway Commission's office at Annapolis.

The system is expected to enable dockmen to talk the ferries in, in spite of fog and heavy storms which are prevalent in the area especially in the fall and winter, and to speed up docking and traffic throughout the main Bay channel. Marine traffic is heavy on this inland waterway because the upper end of the Bay connects with the Delaware River, through the Delaware Chesapeake Canal. Use of the equipment will also aid in the reporting of marine accidents and other public service applications.

Installed by the U. S. Marine Technical Service in cooperation with General Electric engineers, the ferry system operates on 43.02 megacycles. Remote control of the sets in the wheelhouse is provided in the rear of each ferryboat. Remote control units are also used in conjunction with central equipment.

The ferries operate from Sandy Point to Matepeake, Md., a distance of four miles, and are used by commuters, shoppers, and tourists who travel between Annapolis and Baltimore to Washington, or points to the north and south of these cities.

Ferry-to-ferry communication by f-m is utilized by Captain Yewell of the Chesapeake Bay Ferry System

Underwater Light Meter

A HYDROPHOTOMETER developed during the war for use in underwater photography, measures turbidity of fresh and salt water enabling a photographer to determine the maximum camera-to-object distance under any condition of water turbidity.

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One photoelectric unit contains a light source as well as a photocell and condensing or focusing lenses. Part of the light falls on the cell and generates an electric current. The remainder of the light passes through the lenses and across the intervening water to the lenses of the second photoelectric unit where it strikes another photocell, setting up a second current. Since turbid water scatters light, the currents produced by the two photocells will not be the same. The difference is a measure of the turbidity. (Dept. of Commerce report PB-47060)

Feed Control for Lathe

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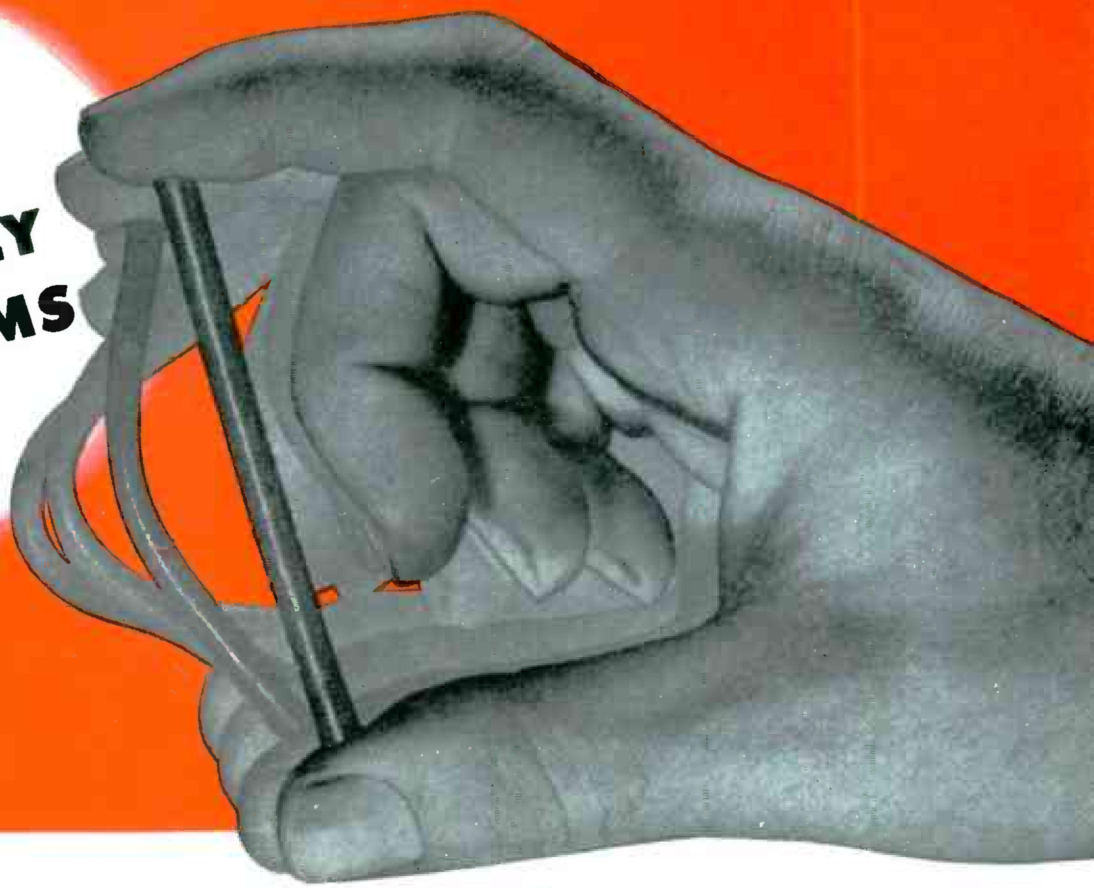

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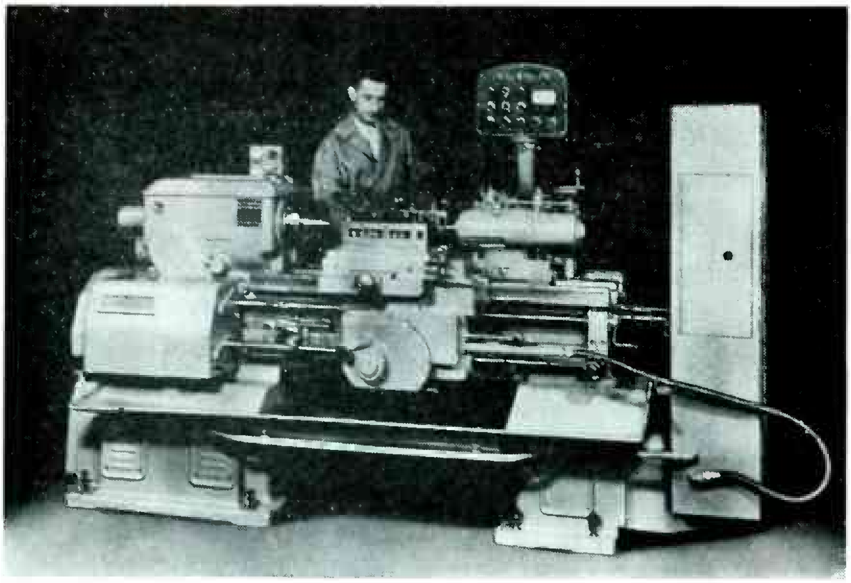


Electronically controlled feed motors provide infinitely variable feed ranges and practically constant feed on this lathe made by Monarch Machine Tool Company

and a longitudinal traverse of 80 inches per minute. Cross feed range is 1 to 40 inches per minute. Because of the fast cross feed, a separate traverse is not necessary. Regardless of the cross feed used, the top feed of 40 inches per minute may be made to become operative automatically as soon as the slide starts to move out. Micrometer stops are provided to limit both traverse movement and cross movement in both directions.

All motors may be started and stopped; all feeds may be started, stopped and regulated from a panel located within easy reach of the operator. Once the machine is set up, all the operator need do, in addition to loading and unloading the work, is press the cycle start button. He may stop or reverse the cycle at any time. A visual feed indicator enables him to set up the machine with the certainty that he is selecting the feeds he desires and tells him at a glance the feed being used at any point in the cycle.

Phototube-Operated Trigger Circuit

By John Degelman

Engineer
McElroy Mfg. Corp.
Littleton, Mass.

The circuit shown in Fig. 1 has been very useful in an application in which only a slight voltage change was available from a phototube. It contains a trigger circuit, operated by a slight change of level of the input signal, which functions as a sensitive d-c amplifier.

Provided with an inverted high-voltage supply, the circuit delivers an effective negative cut-off voltage to the control grid or suppressor of a directly connected following tube. Use of this negative keying voltage on the controlled tube makes no power demand upon the trigger circuit, which makes voltage regulation of the trigger circuit an easy matter.

Power supply filtering for the trigger circuit is also simplified because no power output is required from the trigger circuit, making the current requirements of the circuit low.

Due to the fact that both trigger tubes contribute to the bias voltage across R_k (or one trigger tube can be made to cut the other off by means of a proper relationship in values between R_k, R_f and R_{g2}) the trigger circuit has very high input resistance, thus making effective very high values of R_{g1}.

This application of the trigger circuit was devised because, in our problem, the phototube was not well screened when it was required to be dark, and it was not well illuminated when it was required to be excited. Thus, only a slight voltage change delivered by the phototube was available.

In applications where the keying frequency is high, or may vary over a high and wide frequency range, keying transients are effectively cancelled if two 6SJ7 tubes are substituted for V_3 and the cutoff voltage from the trigger circuit is applied to the suppressors of the 6SJ7 tubes. The signal to be keyed is then applied by way of a phase inverter to the control grids of the two controlled tubes. Thus, the keying voltage transients, being in phase, are cancelled, and the signal

(continued on p 150)

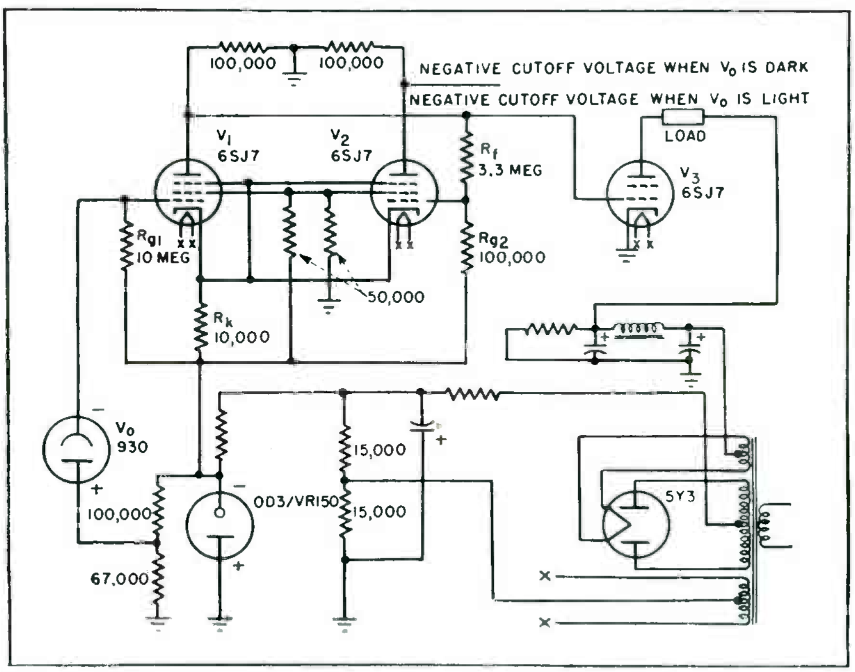
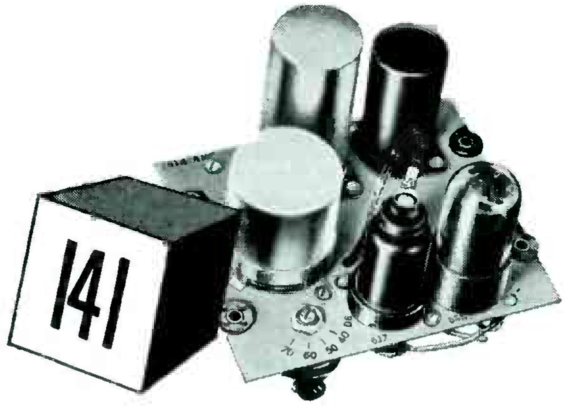


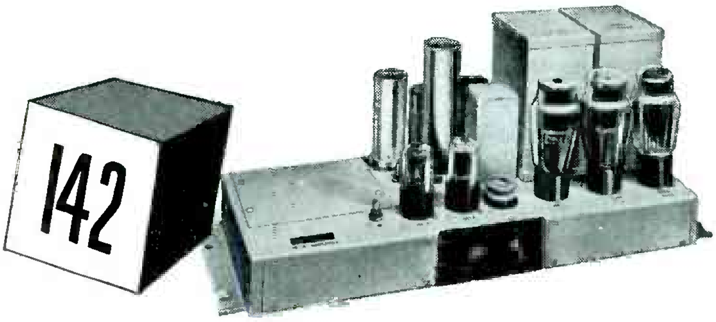
Fig. 1—Very small voltage change from the phototube actuates trigger circuit

BUILD YOUR QUALITY SOUND SYSTEM

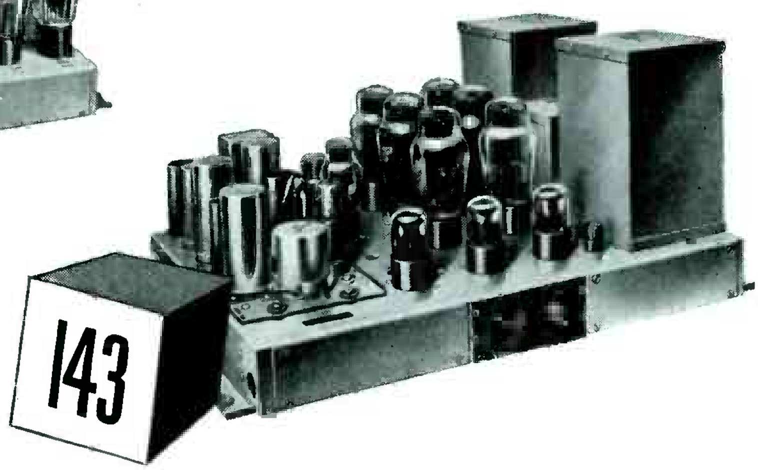
with these "BUILDING BLOCK" Amplifiers

A new three-stage amplifier designed to operate from microphone and other low level sources and to raise them to line levels. Provided with gain adjustment and sufficient power output capacity to make it ideal for booster and line amplifier applications.

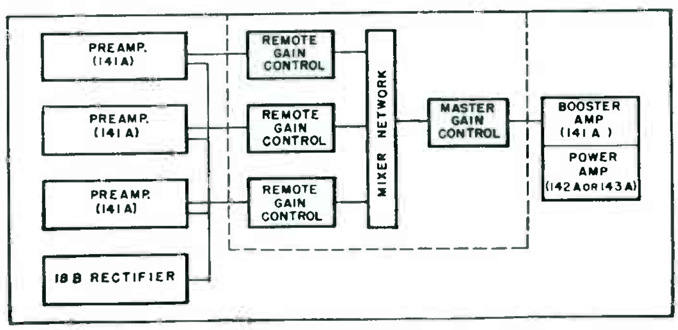




Self-contained power amplifiers, available for rack or cabinet mounting. Notable for flexibility in building sound system installations. Arranged for wide variety of input circuit combinations and capable of accommodating a wide range of load impedance without sacrificing power output. Employs negative feedback, thereby maintaining the internal impedance at an exceptionally low value. Audio power output of 142 is 25 watts, of 143 is 75 watts. Each has facilities for mounting a 141 amplifier directly on the chassis, and each can be used as bridging amplifier with a bridging coil for which mounting space is provided.



HERE'S an integrated series of Western Electric amplifiers that was designed by Bell Laboratories to fit like "building blocks" into systems of any size . . . from the simplest single channel set-up to the most complex multiple channel system. A simple system can thus be increased to any size or complexity by easy and economical addition of units. They provide program distribution systems with the utmost flexibility in use, quality in performance, and reliability through years of trouble-free service.



This schematic diagram illustrates the adaptation of these "building block" amplifiers to a representative sound system.

Bulletin T-2361 is available to help you with your sound system planning. Ask your local Graybar representative for it, or write Graybar Electric Co., 420 Lexington Ave., New York 17, N. Y.

Western Electric

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THE ELECTRON ART

Edited by FRANK ROCKETT

Effect of Modulation on Transmission Efficiency

MODULATION METHOD not only affects the transmitted bandwidth and signal-noise ratio (ELECTRONICS, p 124, June-15 1947), but also the efficiency with which the transmission bandwidth is utilized to convey information and to combat interference from thermal noise. Although it may not be immediately possible to make use of this principle in radio transmission, it can be used in electronic computers and highly directional or guided communication services to obtain the maximum performance from a given bandwidth in the face of irreducible noise.

Revised Hartley Law

At the meeting of the New York IRE Section on Nov. 12 (p 72, this issue) the Hartley Law was extended to include the effect of signal-noise ratio on the transmitted bandwidth. A. G. Clavier of Federal Telecommunication Laboratories applied the revised law to the determination of the relative transmission efficiencies of various forms of modulation operating well above the noise level. Mr. Clavier, as reported below, defined transmission efficiency in terms of the spectrum f_m and the time t_m occupied by the message (before modulation and after demodulation), and the bandwidth f_t and the time of use t_t of the transmission channel or line (after modulation and before demodulation as

$$\eta = \frac{2f_m\, t_m \log_{10}(1 + S_m/N_m)}{2f_t\, t_t \log_{10}(1 + S_t/N_t)} \qquad (1)$$

where S/N in each case is the signal-noise ratio in power units. The numerator and denominator are expressions of the revised Hartley law, as derived elsewhere in this issue. The transmission efficiency so defined indicates the extent to which a given system of modulation untilizes the bandwidth assigned to it, for a given signal-noise performance. For definiteness, the comparison between systems is made with a high quality signal, represented by a signal-noise ratio S_m/N_m of 60 db.

In the case of frequency modulation, with modulation index m (deviation divided by modulation frequency), Eq. 1 becomes

$$\eta = \frac{1.25}{(m+1)(2.76 - \log m)} \qquad (2)$$

In this case, the transmission efficiency decreases as the modulation index increases (as the bandwidth increases for a given grade of service).

In the case of pulse-time modulation, in which the position of a pulse in a sequence is varied with the modulation, the expression is

$$\eta = \frac{2}{(2m+1)(2.76 - \log m)} \qquad (3)$$

Here m is ratio of time displacement of the pulse to pulse duration, a quantity similar to the modulation index in f-m. In this case, as shown in the table, the efficiency is lower than in f-m and decreases with increasing values of m.

In pulse-code modulation, the efficiency is constant at the value $\eta = 0.33$, and is higher than the best case in f-m or ptm.

Mr. Clavier inquired into what system would produce an efficiency which increased with the bandwith. One such system is pulsed frequency modulation (pfm) in which an amplitude-modulated pulse train frequency modulates the carrier. In this case the expression is

$$\eta = \frac{1}{8.8 + (2m+2)/n_c} \times \frac{3}{2.76 - \log m} \qquad (4)$$

where n_c is the number of channels employed. For a modulation index of 10, in this case the efficiency increases with the number of channels (as the bandwidth is increased) from $\eta = 0.06$ for 1 channel to $\eta = 0.19$ for 100 channels. The accompanying table shows the relative transmission efficiencies at various bandwidths (as represented by their modulation indexes).

Modulation Index	Frequency Modulation	Pulse-Time Modulation
m	η	η
1	0.23	0.09
5	0.10	0.045
10	0.065	0.023

Magnetic Oxygen Analysers

OXYGEN is one of the few strongly paramagnetic gases; that is, it has a permeability greater than unity but does not exhibit saturation as do ferromagnetic substances. This property of oxygen can be used in gas analysers to indicate the precent of oxygen present in a mixture. However, the property is usually used indirectly to induce a gas flow, the cooling of the circulating gas producing the indication. Nitric oxide is also strongly paramagnetic.

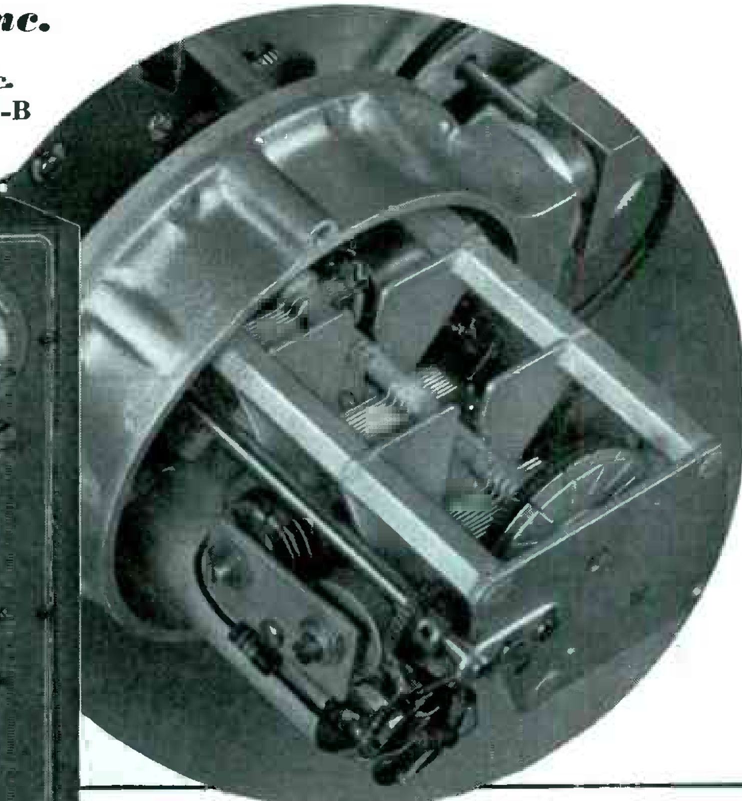
For analysing the oxygen content of gases inhaled by flight personnel during experiments by the Aero Medical Laboratory at Wright Field, The Brown Instrument Co. developed an analyser consisting of a brass measuring cell in a strong but inhomogeneous magnetic field produced by Alnico V magnets. Fine platinum wires forming arms of a hot-wire bridge were located in the cell.

In operation, the bridge arms heat the gas. Because the magnetic susceptibility of the heated oxygen is lower than that of the cool oxygen, it is forced to regions of low flux density and is replaced by cooler oxygen from regions of high flux density. The gas movement so produced cools the platinum wires, the amount of cooling being proportional to the concentration of paramagnetic gas (oxygen) present in

FM SIGNAL GENERATOR

Type 202-B 54-216 mc.

Additional coverage from 0.4—25 mc. with accessory UNIVERTER Type 203-B



Shown above is an interior view of the 202-B Signal Generator RF assembly with shield cover removed. Heavy aluminum castings form the mounting base of this RF unit resulting in a compact and highly rigid structure. Girder type condenser frame construction, multiple rotor shaft grounding contacts, and welded interstage shield plates are but a few of the many design features of this unit which give added circuit stability.

Designed to meet the exacting requirements set forth by leading FM and television engineers throughout the country, the 202-B FM Signal Generator has found widespread acceptance as the essential laboratory instrument for receiver development and research work.

Frequency coverage from 54 to 216 megacycles is provided in two ranges, 54 to 108 megacycles and 108 to 216 megacycles. A front panel modulation meter having two deviation scales, 0-80 kilocycles and 0-240 kilocycles, permits accurate modulation settings to be made.

Although fundamentally an FM instrument, amplitude modulation from zero to 50%, with meter calibrations at 30% and 50%, has been incorporated. This AM feature offers increased versatility and provides a means by which simultaneous frequency and amplitude modulation may be obtained through the use of an external audio oscillator.

The internal AF oscillator has eight modulation frequencies ranging from 50 cycles to 15 kilocycles, any one of which may be conveniently selected by a rotary type switch for either amplitude or frequency modulation.

The calibrated piston type attenuator has a voltage range of from 0.1 microvolt to 0.2 volt and is standardized by means of a front panel output monitor meter.

The output impedance of the instrument, at the terminals of the R.F. output cable, is 26.5 ohms.

AVAILABLE AS AN ACCESSORY

is the 203-B Univerter, a unity gain frequency converter which, in combination with the 202-B instrument, provides the additional coverage of commonly used intermediate and radio frequencies.

R.F. Range: 0.4 mc. to 25 mc.

R.F. Increment Dial: ±250 kc. in 10 kc. increments.

R.F. Output: 0.1 microvolt to 0.1 volt. Also approximately 2 volts maximum (uncalibrated).

For further information write for Catalog E

UNIVERTER

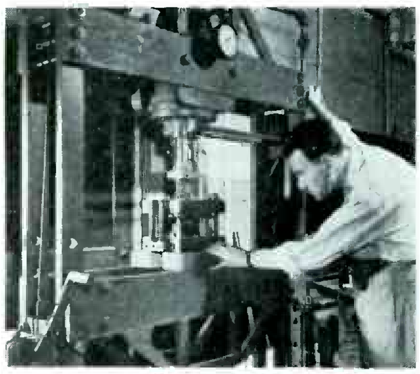
Type 203-B

BOONTON RADIO *Corporation*

BOONTON·N·J·U·S·A·

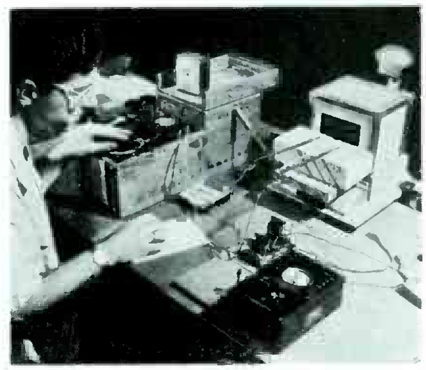
DESIGNERS AND MANUFACTURERS OF THE "Q" METER . . . QX-CHECKER . . . FREQUENCY MODULATED SIGNAL GENERATOR . . . BEAT FREQUENCY GENERATOR . . . AND OTHER DIRECT READING TEST INSTRUMENTS the cell. The unbalance of the bridge produced by differential cooling of the arms provides the oxygen indication. (Constructional details and performance of the analyser are described in A Paramagnetic Oxygen Analyser, by C. A. Dyer, in The Review of Scientific Instruments, p 696, Oct. 1947.)

A similar instrument was developed in Germany. It, too, depended on the change in paramagnetism of oxygen that takes place with temperature changes, and used the induced flow of oxygen to cool the two halves of a center-tapped platinum resistance coil in a Wheatstone bridge. The normal range of the instrument was 0-2 percent oxygen, but the range could be extended. This instrument also provided almost instantaneous recording, independence of chemical reactions, and ease of operation. It was found particularly satisfactory for measuring oxygen content of acetylene and butadene. (Multilithed paper-bound copies of the 188 page report, including discussions of this and other German instruments prepared for British Intelligence and made available in America through the Office of Technical Services, can be obtained from Mapleton House, Publ., 5415 17th Ave., Brooklyn 4, N. Y. at $6 a copy.)



In research into semiconductors, after the powders are thoroughly mixed, the author compresses them into test samples

The test bars are fired at high temperature for several hours in a hydrogen atmosphere to complete the processing



Research students measure and tabulate the temperature-resistance characteristics and resistivities of the samples

Sintered Semiconductors

By HENRY H. HAUSNER
Consulting Engineer
Research Division
College of Engineering
New York University
New York, N. Y.

RESISTIVITY and temperature coefficient of resistance can be controlled by composition and processing of resistors made of sintered ceramic-metal compounds. Research into the controlling factors and obtainable properties shows that resistors can be made with various characteristics, possibly with zero temperature coefficient. The accompanying photographs show how these resistors are made and tested in the Powder Metallurgy Laboratory at New York University.

Resistance Mechanism

Resistivities of sintered ceramic-metal materials are determined by many controllable variables, and do not follow the laws for other resistive materials. Being composite materials containing conductors, semiconductors, and nonconductors, their resistances result from both the contact between particles and the resistance within individual particles. Their resistivities fall in the range 10^{-2} to 10^{6} ohm-cm characteristic of semiconductors, and therefore they may be classed as semiconductors, but they can have positive, negative, or zero temperature coefficients, or temperature coefficients that change variously with temperature. Common semiconductors, on the other hand, have negative temperature coefficients (at room temperature).

Figure 1 shows a schematic diagram of a sintered ceramic material and the respective equivalent circuit. The sintered material is composed of three components A, B, and C, which can be considered of spherical shape, uniform particle size, and uniform distribution throughout the mixture. Resistances of the individual particles are R_A, R_B, and R_C, which will in general be different from each other. In series with each of these particle resistances are the contact resistances R_{ABX}, R_{ABY}, R_{BCX}, R_{BCY}, R_{ACX}, R_{ACY}. The contact resistances will depend on the electrochemical reaction between the two particles in contact, the contact areas, and the pressures. In general, because of the processing techniques, the contact resistances along different axes of the composite material (series and parallel contacts) will differ. Thus, the total resistance of the body will be composed of nine different types of resistance (for a resistor composed of three materials) each of which may have its own temperature coefficient.

In a sintered ceramic, the total resistance of the particles is dependent on their total volume, or weight, and is independent of their particle size. However, a change in particle size in the raw material will change the number of contacts between particles; a change in particle shape would also change the number of contacts. In addition, the contact surface area and contact pressure can be affected by compacting pressure, sintering temperature, and time.

To study effects of particle size,

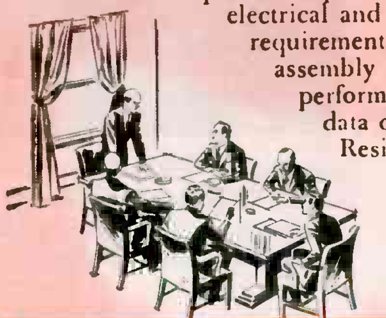
(continued on p 178)

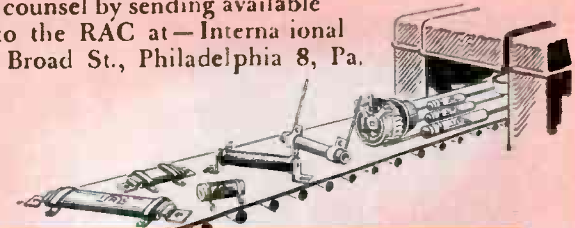
The Best Resistors Are Not Enough

SERVICE IS VITAL

The most complete line of high quality resistors is not enough. IRC considers sincere service—cooperative development work, unbiased recommendations, on time deliveries, genuine help in emergencies and friendly follow thru also vital in meeting advancing demands of industry.

The RESISTOR ANALYSIS COUNCIL is a natural development of this concept. Sponsored by IRC, and established to provide experienced technical aid on your resistor problems—electrical and mechanical. Working together on your specific requirements, confidential analysis may disclose ways to cut assembly costs, eliminate expensive "specials" or improve performance. You may obtain this counsel by sending available data on your resistor problem to the RAC at—International Resistance Company, 401 N. Broad St., Philadelphia 8, Pa.



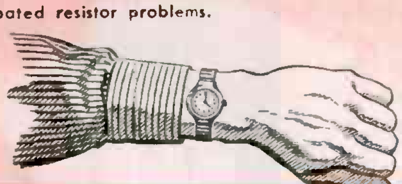


Resistor Analysis Council

A new IRC industry service. Composed of IRC electrical and mechanical engineers plus production specialists, the RAC—Resistor Analysis Council operates as consultant to engineers and designers. Provides confidential analysis of resistor requirements—helps solve electrical, mechanical and cost considerations. RAC's industry knowledge is sufficiently broad that recommendations need not be confined to IRC products. Consult the Resistor Analysis Council on your present or anticipated resistor problems.

Complete Line

Only IRC produces such a wide range of resistor types. All your requirements can be readily supplied from one source. Manufacturing all types, IRC's recommendation on the proper resistor for your product is unbiased. For over two decades IRC has concentrated its engineering and manufacturing talent exclusively on resistors. You benefit by this accumulated experience when you specify IRC. Technical Data Bulletins are available on each IRC resistor type.



On Time Deliveries

Purchasing Agents and material control executives rely upon IRC's "on time" deliveries. They know that regardless of a product's high quality, assembly line problems are a natural consequence when delivery schedules aren't met. IRC delivers "on time"—also maintains factory stock piles of most popular resistor types and ranges assuring you of real assistance in emergencies.

Industrial Service Plan

Providing speedy "round-the-corner" deliveries on your small order requirements, IRC's distributor network maintains well-stocked shelves of all standard items. No time lost when you need experimental or maintenance quantities in a hurry. When time means money you profit by competent service from the IRC distributor in your area—write for his name and address.

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NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications received.

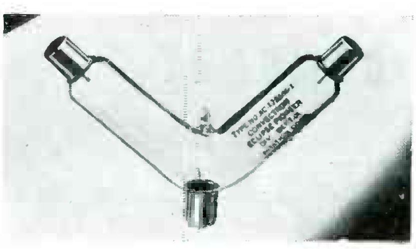
Automatic Oscillograph (1)

HATHAWAY INSTRUMENT CO., 1315 S. Clarkson St., Denver 10, Colorado. Type RS-9 automatic oscillograph is designed to meet every need of a control station engineer for recording faults or for staged system testing. As many as twelve quantities can be recorded at once

and many automatic features are built in to make the equipment suitable for remote, unattended operation. As many as 100 transients can be handled either seconds or months apart. Write for technical bulletin SP-196.

Electronic Plumb Bob (2)

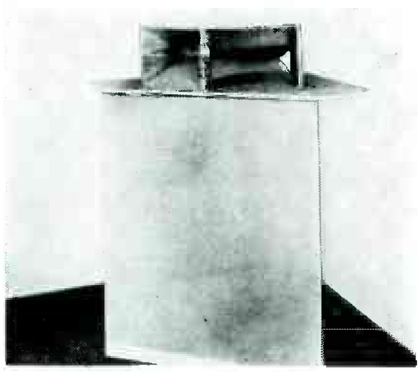
ECLIPSE-PIONEER DIV., BENDIX AVIATION CORP., Teterboro, N. J. The Y-type position Convectron when used in a bridge circuit is able, by changes in gas convection



currents to indicate displacements to right or left of null. The tube has no moving parts. Signal depends only upon the rate at which convection currents leave a heated filament to rise along the vertical.

Fidelity Speaker (3)

BROCINER ELECTRONICS LAB., 1546 Second Ave., New York 28, N. Y. Model 1A Klipsch speaker system



described in an available brochure gives an essentially flat response from 30 to 15,000 cycles at low harmonic and intermodulation distortion. Mounted in a corner, the speaker gives good dispersion of middle and high frequencies throughout a room. Output of the model described is rated 20 watts.

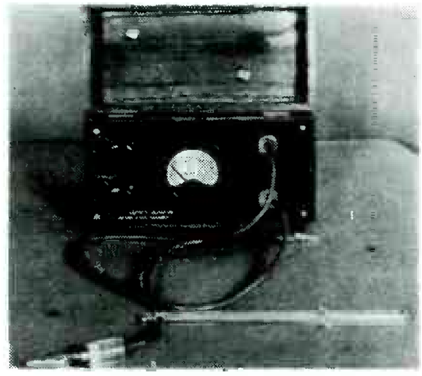
USING THE NUMBERS

Readers desiring further details concerning any item listed in the New Products department can obtain the information by using the cards furnished as a stiff, colored insert elsewhere in this department.

Place the number (appearing to the right of the heading) of one item in which you are interested in a circle and then fill out the balance of the card according to directions appearing on the colored sheet. Unnumbered items listed at the end should be procured direct from the manufacturer or publisher upon payment of the fee noted.

Kilovoltmeter (4)

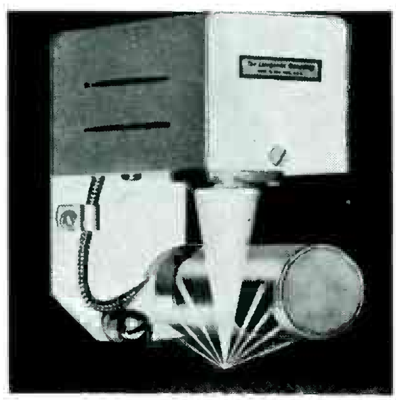
BETA ELECTRONICS CO., 1762 Third Ave., New York 29, N. Y. Series 101 kilovoltmeter has a full-scale drain of only 20 microamperes and is available in ranges up to 50 kilovolts. Guaranteed accuracy of



each instrument is 3 percent of full-scale. They have been designed for television, electrostatic precipitator, Geiger counter, and similar work.

Photo Control (5)

LANGEVIN CO., INC., 37 West 65th St., New York 23, N. Y. First of a new series of industrial electronic controls is the model SC-300 photoelectric scanner that can be adjusted



to operate with transmitted or reflected light. Bulletin 1021 gives some further details.

Frequency Meter (6)

BROWNING LABORATORIES, INC., 742 Main St., Winchester, Mass. The new model S-5 frequency meter operates between 30 and 500 mega-

cycles with an overall accuracy of 0.0025 percent. The crystal standard with oven has a long-time accuracy of 0.001 percent. A telescoping antenna is employed as a means of pickup.

Level and Impedance Matcher (7)

PIERCE PRODUCTS CO., Box 3840, Merchandise Mart Sta., Chicago 54, Ill. Type VA-11 variable attenuator and impedance matching unit is a portable apparatus used in all sound work where adjustments are required. Input impedances for 50, 250, and 600 ohms as well as bridging are provided as are similar output impedances. Output and input can be balanced or unbalanced.

When used between matching input and output impedances, the range of attenuation is 2 to 60 db in 2-db steps with infinite attenuation on the last step.

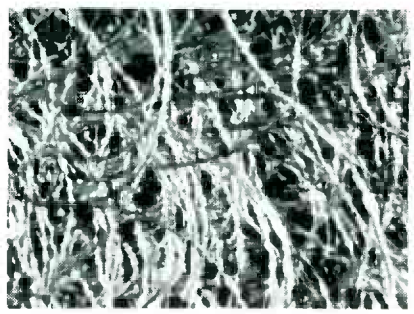
Small Capacitor (8)

DUMONT ELECTRIC CORP. 34 Hubert St., New York, N. Y. Small capaci-

tors with high leakage resistance and low power factor are available in the capacitance range from 5 to 100,000 micromicrofarads for use with voltages from 500 to 10,000.

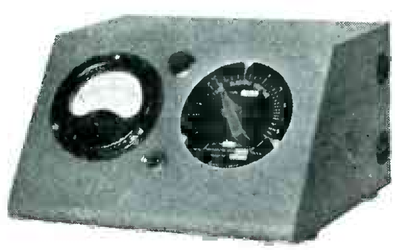
Mixed Grille (9)

POLYPLASTEX UNITED, INC., 92-35 Horace Harding Blvd., Elmhurst, New York, N. Y. Made of a mixture of unwoven plastics and Fiberglas, Synspun radio grille material is available in colors and metallic finishes. Although it is self-supporting, the material is porous up to 70 percent of its surface.



Temperature Controller (10)

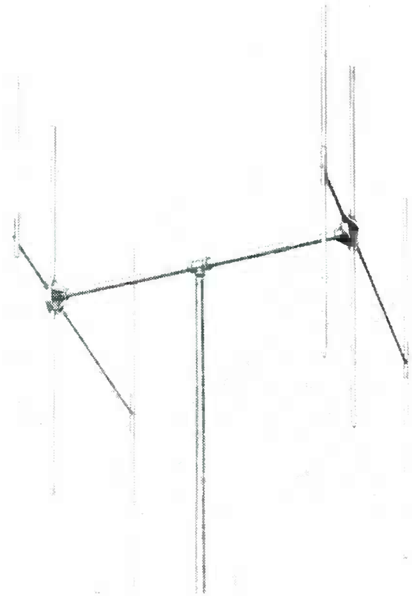
THERMO ELECTRIC MFG. CO., 480 West Locust St., Dubuque, Iowa. A new stepless controller and temperature indicator contains a sensitive thermostatic switch, controlled by a knob on the instrument panel, that



can be set to regulate current input into heating equipment anywhere from 5 to 100 percent time on. The unit compensates for line-voltage changes. Descriptive literature is available.

Point-to-Point Antennas (11)

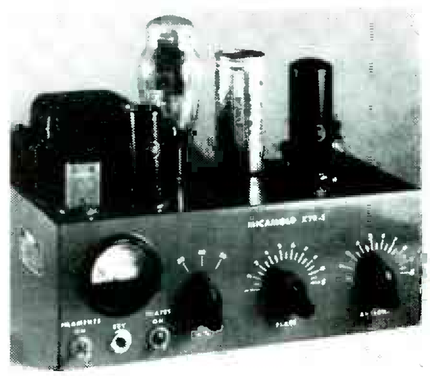
THE WORKSHIP ASSOCIATES, INC., 66 Needham St., Newton Highlands 61, Mass. High-gain antennas previously designed for other services are now available for emergency and fixed service work in the frequency bands 152-162, 72-76, and



30-40 megacycles. Gains for 6 element arrays are rated at 7.6 db; used in pairs the overall gain is 15.2 db. Data sheets tell a more complete story.

Ham Kit (12)

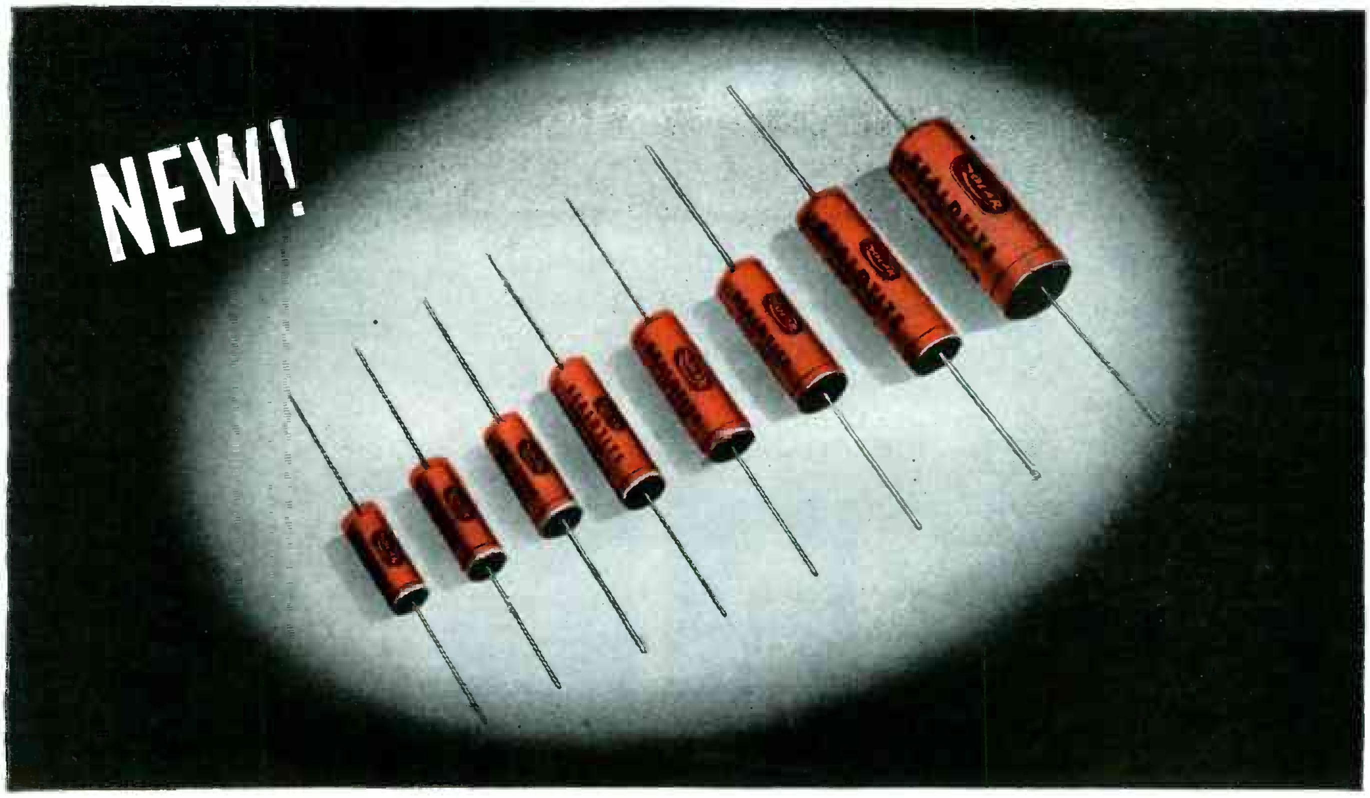
MICAMOLD RADIO CORP., 1087 Flushing Ave., Brooklyn 6, N. Y. A c-w transmitter kit XTR-1 includes all the parts for a 45-watt input transmitter that operates on 20, 40, and 80 meters.



Transcription Equipment (13)

GRAY RESEARCH AND DEVELOPMENT CO., INC., Elmsford, Westchester

(continued on p 197)



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Sealdtite Capacitors, the molded tubulars first pioneered by Solar in 1939, are now truly all-purpose capacitors. The recent introduction of new Hi-Temp molded jackets makes Sealdtite Capacitors a universal choice for both automobile and home radio applications.

More than a year's field trials of more than 5,000,000 Hi-Temp molded Sealdtites in automobile and export receiver applications have proven the superior quality of this latest Solar development in the capacitor art.

Securely sealed against atmospheric moisture by a tough molded armor, Sealdtite Capacitors maintain their exceptionally high insulation resistance throughout their extremely long life. Unlike conventional tubulars, Sealdtites have no cardboard tubes to grow soggy, or internal voids to collect moisture.

Hi-Temp Sealdtite Capacitors have attractive labels in bold, easy-to-read type. Their smooth surface attracts no dust and drips no wax. Investigate today! 3839

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SOLAR CAPACITORS
"Quality Above All"

SOLAR

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

IRE Officers and 1948 Awards, National Electronics Conference, Rochester Fall meeting, propose recording standards


F. E. Terman


J. A. Hutcheson

New IRE Officers

BENJAMIN E. SHACKELFORD, manager of the license department of RCA International Division, New York, N. Y., has been elected president of the Institute of Radio Engineers for 1948. Reginald L. Smith-Rose, superintendent of the radio division, National Physical Laboratory, Teddington, Middlesex, England, will be vice-president.

For director-at-large for the 1948-1950 term, two members were elected: James E. Shepherd, research engineer at Sperry Gyroscope Company, Inc., Great Neck, Long Island, N. Y.; Julius A. Stratton, professor of physics and director of the Research Laboratory of Electronics, MIT, Cambridge, Mass.

Herbert J. Reich, professor of electrical engineering, Dunham Laboratory, Yale University, New Haven, Conn., was elected director to represent the North Atlantic Region.

John V. L. Hogan, president of the Interstate Broadcasting Company, Inc., radio stations WQXR, WQXQ; president of Radio Inventions, Inc.; and president of Faximile, Inc., New York, N. Y., was elected director for the North Central Atlantic Region.


H. J. Reich


J. V. L. Hogan


J. B. Coleman


T. A. Hunter

John B. Coleman, assistant director of engineering of the RCA Division, Radio Corporation of America, Camden, N. J., was elected director for the Central Atlantic Region.

John A. Hutcheson, associate director of research, Westinghouse Electric Corporation, East Pittsburgh, Pa., was elected director for the East Central Region.

Theodore A. Hunter, president of Hunter Manufacturing Company, Iowa City, Iowa, and staff consultant for the psychology department of the University of Iowa, was elected director of the Central Region.

A. Earle Cullum, Jr., consultant radio engineer, Dallas, Texas, was elected director for the Southern Region.

Frederick E. Terman, past president and a Fellow of the IRE, and now dean of the School of Engineering, Stanford University, California, was elected director of the Pacific Region.

Frederick S. Howes, associate professor of electrical engineering and consulting engineer at McGill University, Montreal, Quebec, Canada, was elected director for the Canadian Region.

Microwave Relay Used for Televising Football

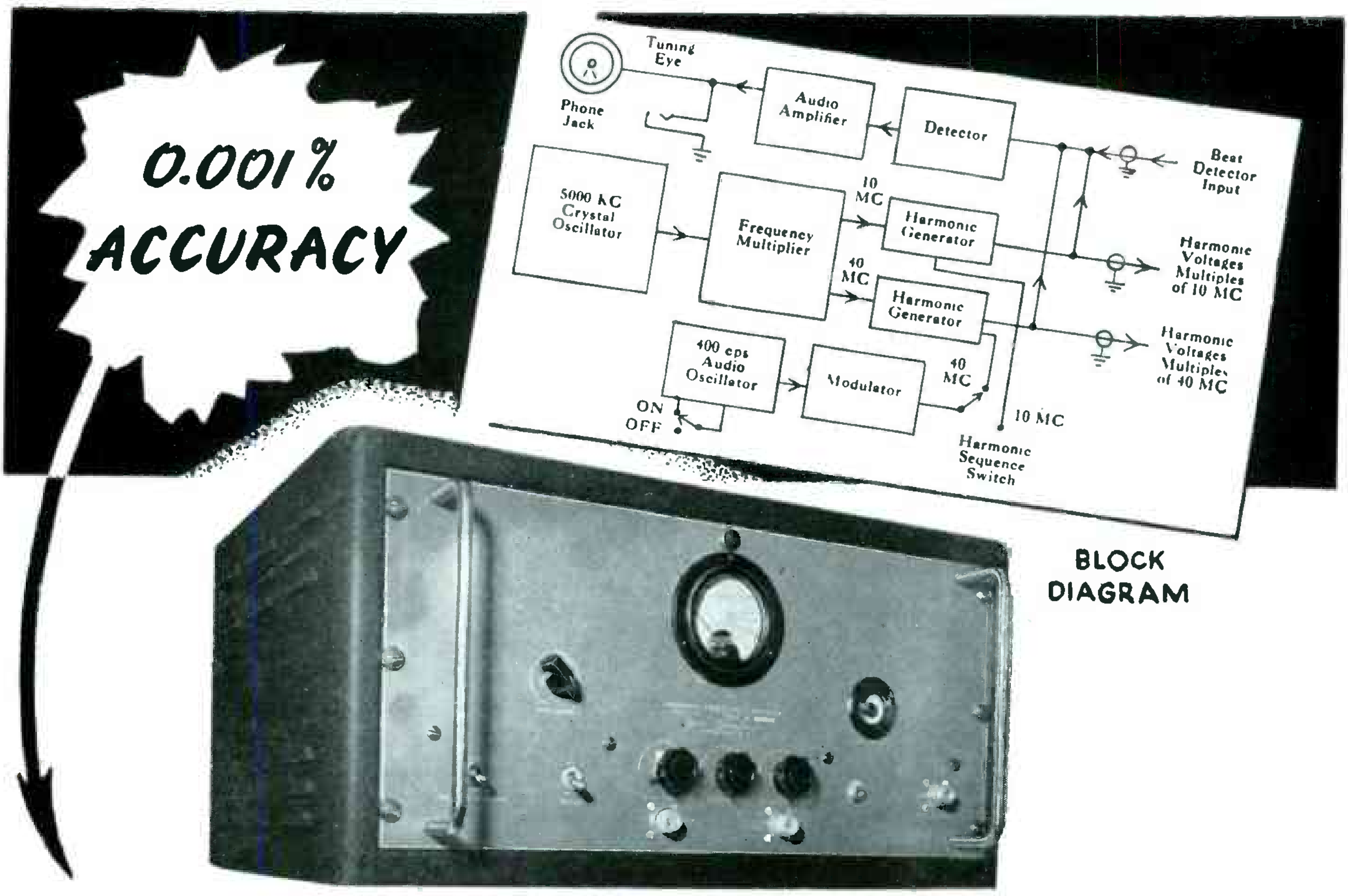
A 70-MILE, microwave three-hop television relay connecting Chicago,


B. E. Shackelford


R. L. Smith-Rose


J. E. Shepherd


J. A. Stratton



BLOCK DIAGRAM

with the IMPROVED LAVOIE C-200 HARMONIC FREQUENCY GENERATOR

The Harmonic Freauency Generator has been improved for frequency standardization of receivers and frequency meters up to and beyond 2000 Megacycles. Also, by means of a beat detector built into the instrument, it is possible to standardize oscillators and signal generators with equal facility.

Further circuit refinements have produced a frequency accuracy of 0.001%, which extends from 100 Megacycles to 2000 Megacycles in either 10 Megacycle or 40 Megacycle steps.

The output voltage is supplied at a UG-58/U 50-ohm connector with output coupling controls to obtain peak performance for a given harmonic. A milliammeter is incorporated in the instrument to facilitate easy adjustment of the output controls. The output voltage may be either unmodulated or modulated with 400 cps internal oscillator. The generator provides output voltages every 10 Megacycles or every 40 Megacycles. This selection is made by a switch on the front panel. The harmonic voltage is in the order of thousands of microvolts for each harmonic with a value of approximately 50,000 microvolts at 100 Megacycles and 1500 microvolts at 1000 Megacycles.

Provision is made for the standardization of signal generators and oscillators by the incorporation of a beat frequency detector in the generator. The output of this beat frequency detector may be monitored, either aurally or visually with a tuning eye indicator.

To facilitate harmonic identification, frequency identifiers can be supplied for any harmonic frequency (multiple of 10 Megacycles) between 100 and 1000 Megacycles. The identifier is adjusted at our factory.

This instrument is supplied with accessories needed for its operation, including tubes, 5 Megacycle crystal, output coupling cable and instruction book.

U H F

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Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

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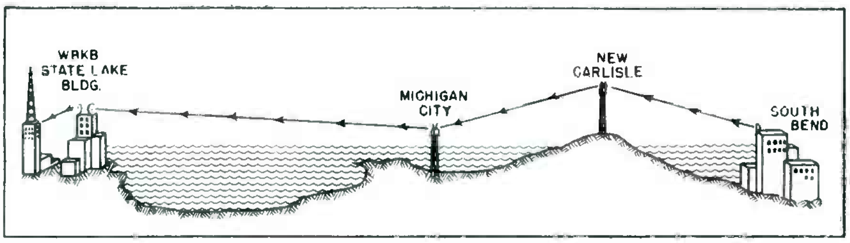


Locations of microwave relay towers used in bringing South Bend television pickups of football games to Chicago

Illinois with South Bend, Indiana brought home football games of the Notre Dame team to television station WBKB for telecasting to the Chicago television audience. The relay equipment was developed by General Electric engineers at Electronics Park, Syracuse, N. Y. and was installed under the direction of Captain Eddy, manager of WBKB.

MEETINGS

MARCH 22–25: IRE Convention and Radio Engineering Show, Hotel Commodore and Grand Central Palace, New York City.

APRIL 7–9: Midwest Power Conference, Sheraton Hotel, Chicago.

MAY 9–14: 1948 Radio Parts Show, Hotel Stevens, Chicago.

IRE Awards for 1948

THE INSTITUTE of Radio Engineers announces that its Medal of Honor for the year 1948 will be awarded 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." Mr. Horle has been a practicing consultant, specializing in industrial standardization in the communications field since 1929. He is chief engineer of the Radio Manufacturers Association, in charge of the RMA Data Bureau. He was elected to Fellow grade in 1925 and in 1940 was president of the Institute.

L. C. F. Horle

S. W. Seeley

S. W. Seeley was named for the Morris Liebmann Memorial Prize for "his development of ingenious circuits related to frequency modulation." He is director of the RCA Industry Service Laboratories in New York City, and was elected to Fellow grade in 1943.

For the Browder J. Thompson Memorial Prize the Board named W. H. Huggins for his paper on "Broadband Noncontacting Short Circuits for Coaxial Lines," which appears in three parts in the September, October, and November issues of the PROCEEDINGS for 1947. He is a radio engineer with the Army Air Forces at the Cambridge Field Station of Watson Laboratories. These awards will be officially conferred upon the recipients at the 1948 IRE National Convention in New York on March 24, 1948.

The following IRE members have been elected to the grade of Fellow:

- M. W. Baldwin, Jr., Bell Telephone Laboratories, New York, N. Y.
- L. H. Bedford, 16 Heathgate, London, England
- H. S. Black, Bell Telephone Laboratories, New York, N. Y.
- R. M. Bowie, Sylvania Electric Products, Inc., Flushing, N. Y.
- D. E. Chambers, General Electric Company, Scotia, N. Y.
- J. B. Coleman, Radio Corporation of America, Camden, N. J.
- A. Earl Cullum, Jr., Consultant Engineer, Highland Park Village, Dallas, Texas
- R. B. Dome, General Electric Company, Bridgeport, Conn.
- B. S. Ellefson, Sylvania Electric Products, Inc., Bayside, N. Y.
- J. J. Farrell, General Electric Company, Schenectady, N. Y.
- H. C. Forbes, Colonial Radio Corporation, Buffalo, N. Y.
- E. W. Herold, RCA Laboratories, Princeton, N. J.
- William Hewlett, Hewlett-Packard Company, Palo Alto, Calif.
- J. A. Hutcheson, Westinghouse Electric Corporation, East Pittsburgh, Pa.
- J. E. Keto, Aircraft Radio Laboratory, Dayton, Ohio
- N. E. Lindenblad, RCA Laboratories, Port Jefferson, N. Y.
- Knox McIlwain, Hazeltine Corporation, Little Neck, N. Y.
- D. W. R. McKinley, National Research Council, Ottawa, Ont., Canada
- L. A. Meacham, Bell Telephone Laboratories, Murray Hill, N. J.
- David Packard, Hewlett-Packard Company, Palo Alto, Calif.
- 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 Company, New York, N. Y.
- J. E. Shepherd, Sperry Gyroscope Company, Great Neck, N. Y.
- D. B. Smith, Philco Corporation, Philadelphia, Pa.

New Atom-Smasher

PLANS for immediate construction of a 200-ton, 60-inch cyclotron on the campus of the University of Washington in Seattle have been announced. The huge atom-smasher and the structure in which it will be housed will cost an estimated $375,000.

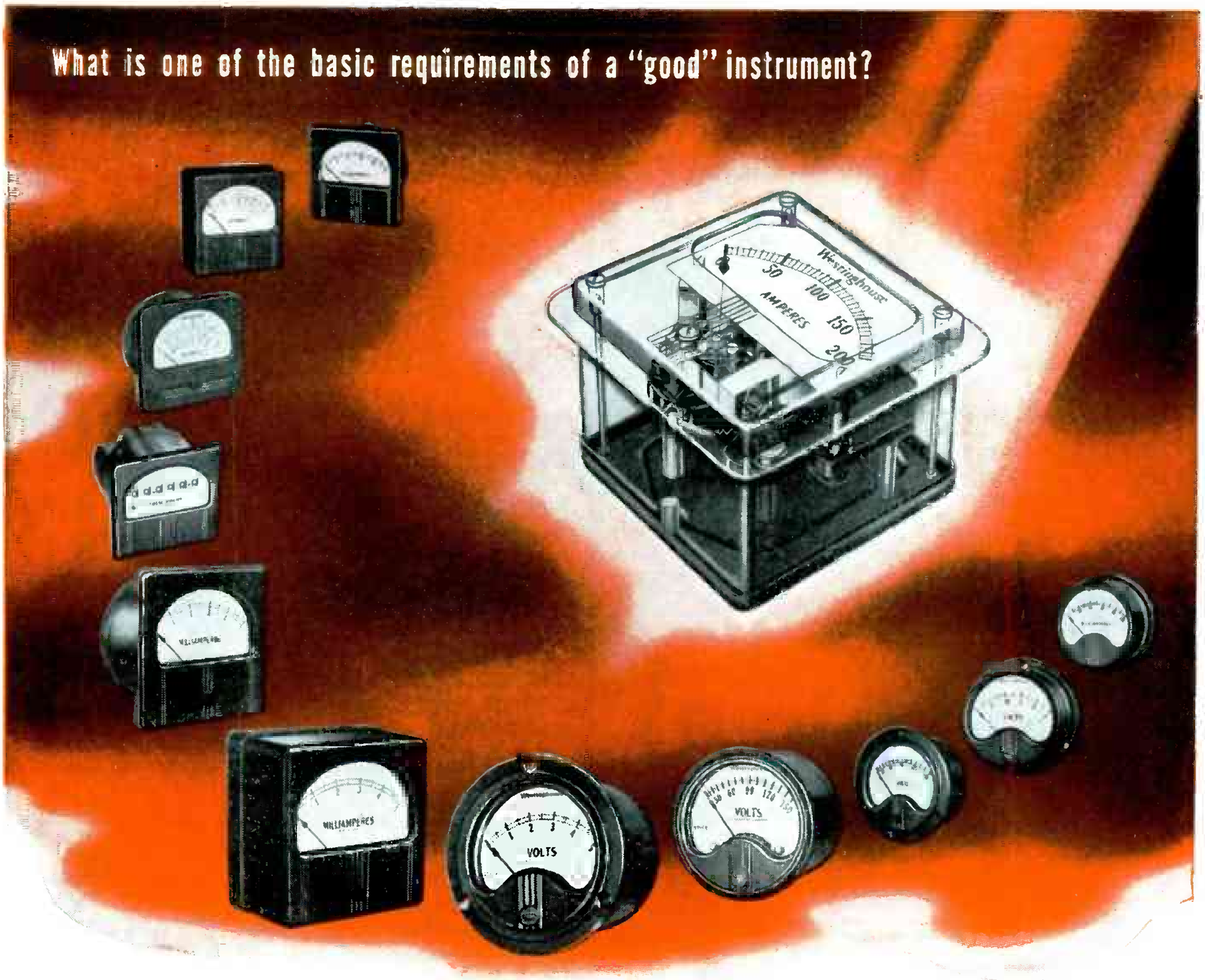
Patterned after the Crocker cyclotron at the University of California, the new cyclotron will be capable of accelerating alpha particles to approximately 40-mev energies and deuterons to approximately 20-mev. The vacuum chamber, the pumps and the huge electromagnet will be underground, to provide protection from radiation.

A large cloud chamber for cosmic-ray studies and a 4,000,000-volt Van de Graaff generator are scheduled for later construction as funds become available.

Disc Recording Standards

A COMPREHENSIVE industry-wide project for the purpose of defining and proposing disc recording and reproducing standards which will be acceptable to and used by all manufacturers and processors of transcriptions and phonograph records has just been launched jointly by the Sapphire Club and the Motion Picture Research Coun-

(Continued on p 224)



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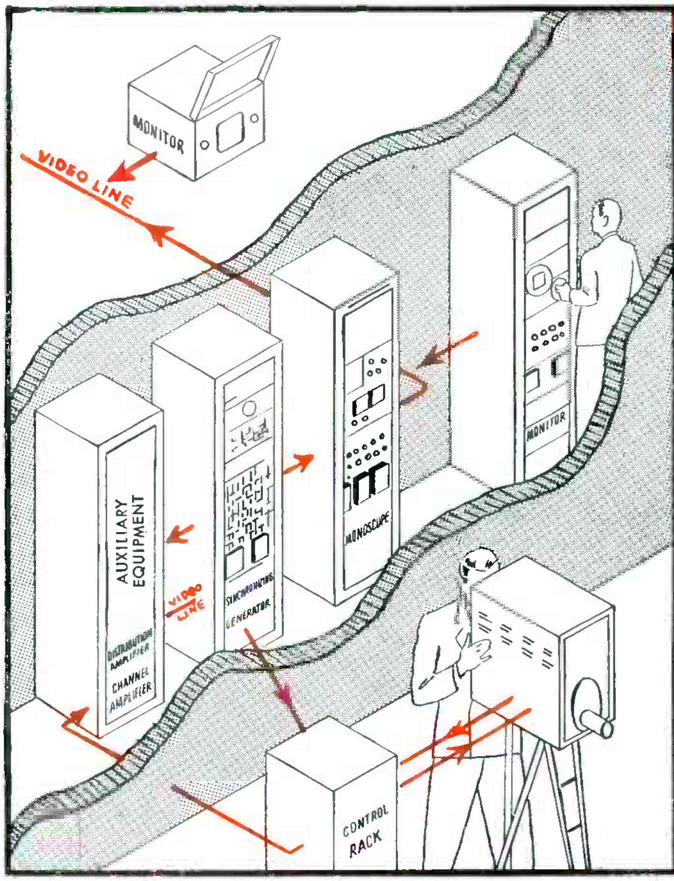


TELEVISION CAMERA

The **MODEL CV-1** Television Camera with built-in electronic Viewfinder is designed to operate over a wide range of light levels with maximum stability and resolution.

FEATURES:

- Five inch electronic Viewfinder
- Image Orthicon Camera Tube
- Three lens turret
- Frequency Re ponse flat to 8 MC ± 1 db
- Mitchel Tripod and Head

A control rack is supplied wtih the Camera and includes a camera control unit, power unit and 30 feet of camera cable. This equipment provides:

- Remote control of Camera Tube
- Frequency Response flat to 8 MC ± 1 db
- Complete Composite Video Signal
- Dual 100 ohm output jacks
- Intercommunication System

SPECIFICATIONS

Signal Requirements: Horizontal and Vertical Driving Pulses 2 volts peak to peak negative, Blanking 2 volts positive, Synchronizing pulses 2 volts negative.

Output: Composite Video Signal 2 volts peak to peak across 100 ohms, black negative.

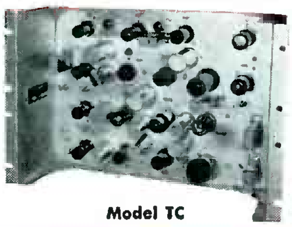
TELEVISION CAMERA CHANNEL AMPLIFIER — Model TC

Designed for black and white or color television camera chains.

Features:

- Used with orthicon or iconoscope camera tubes
- Frequency Response: Flat to 9.0 mc ± 1.5 db. less than 2% tilt for 60 cps square wave
- Dual Output tubes
- Remote gain and black level control
- Gamma correction
- Streaking correction for iconoscope
- Video black level automatically held constant with respect to blanking black reference regardless of average scene brightness

Specifications: Input Level = .02 volts across 75 ohms. Output = 1.0 volts across 75 ohms.



Model TC

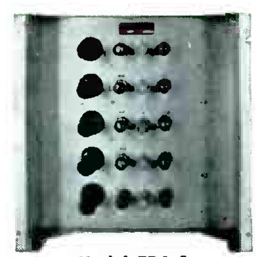
DISTRIBUTION AMPLIFIER — Model TDA-1

Distribution Amplifier is exclusively designed to isolate and distribute television signals over lines for production and station use.

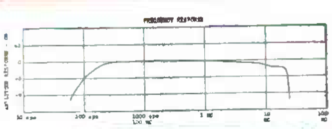
Features:

- 5 individual wide band video amplifiers
- High input impedance permits bridging all 5 amplifiers across same source.
- Positive and Negative signals available at the output.
- Dishpan construction fits a standard rack and facilitates servicing.

Specifications: Output: Undistorted output of 5.5 volts peak to peak across 100 ohms at either positive or negative Polarity. Frequency Response: Flat to 10 megacycles ± .5 db. Overall Gain: 0 DB.



Model TDA-1



20 MC. VIDEO AMPLIFIER

Model V

- Phase Linear with frequency over entire band.
- Flat frequency response from 200 cps to 20 mc. ± 1.5 db.
- Uniform time delay of .02 microseconds.
- Gain of 50 db.
- Frequency compensated high impedance attenuator calibrated in 10 db steps from 0-50.
- Fine attenuator covers a 10 db range.

This unit is designed for use as an oscilloscope deflection amplifier for the measurement and viewing of pulses of extremely short duration and rise time, and contains the Video Amplifier Unit, Power Unit and a Low Capacity Probe.

Specifications: Input impedance; Probe—12mmf ± 470,000 ohms; Jack—30mmf ± 470,000 ohms; Output Impedance 18mmf ± 470,000 ohms each side push pull; Max. Input Volts 500 peak to peak with probe; Max. Output Volts 112 volts peak to peak (push pull); Power: 115 volts 50/60 cps AC Line; Size—19¼"x22"x14¾".

POWER UNIT

Model PT 111

This unit combines all the operational features of the Model PT-111D and provides the following outputs:

- Regulated 250-300 volts DC; 0-400 ma.
- Regulated Negative Bias 150 volts DC; 10 ma.
- Filament Supplies 6.3 volts AC; 8.0 amps. 6.3 volts AC; 8.0 amps.

Polarad *Electronics Company*

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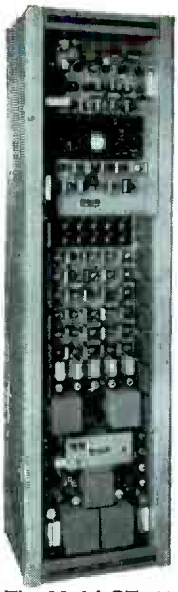
TELEVISION ENGINEERS AND

Studio-Laboratory-Manufacturer

Polarad Electronics Company

SYNCHRONIZING GENERATOR



Model PT 101

- Built-in 3" oscilloscope with synchronized sweeps for viewing Timing and Video output pulse wave forms.
- Synchronized Marker system for checking pulse width and rise time.
- Extreme stability insured by deriving all pulses from the leading edge of master oscillator pulse.
- Fast lock in action for motion picture application.
- Wide band delay line for adjusting delays without distorting pulse wave forms.
- Dispan construction to facilitate servicing.
- Dual output jacks.

OUTPUT SIGNALS:

Composite RMA Video Signal, Camera Blanking, Video Blanking, Horizontal Camera Drive, Vertical Camera Drive, 5.0 volts peak to peak across 100 ohms terminations.

The Model PT-101 provides the entire complement of timing pulses for the complete operation of all broadcast studio equipment and receivers.

SPECIFICATIONS: 525 line, interlaced, 60 fields, 30 frames, RMA Synchronizing pulses held to tolerance specified in the NRTPB report of 1945. Power requirements 115 volts 50/60 cps AC Line voltage.

TELEVISION MONOSCOPE SIGNAL SOURCE

Model PT 102

- Composite RMA Video Signal.
- Wide Band Video Amplifier, maximum 6.0 db. down at 10 mc.
- Dual outputs for feeding two 75 or 100 ohms lines.
- Black Negative or Black Positive outputs.
- Resolution greater than 600 lines.
- Wiring accessibility for ease of maintenance.
- Specifications:
- Output: Composite video signal, 3.0 volts across 100 ohms line.
- Input: Vertical and Horizontal Driving, Camera & Kinescope Blanking, Synchronizing pulses.
- Power: 115 volt 50/60 cps AC line.

Model PT-102 produces a complete composite video signal for testing television equipment from the camera to the receiver. It is especially suitable for transmitting a test pattern during stand by and warm up periods of a station.

PICTURE AND WAVE FORM MONITOR

Model M 102

- Resolution greater than 600 lines.
- 10" Kinescope & 5" Oscilloscope.
- Built-in Bar Generator for checking horizontal and vertical linearity.
- Horizontal and Vertical Pulse Cross phaseable over the entire kinescope.
- May be operated by either driven or composite signals.
- Voltage calibrator for wave form monitor.
- Monitor Section occupies 17½" x 19" panel space and may be mounted at a remote point.
- High Impedance video input.
- All parts readily accessible for quick servicing and testing.
- All controls accessible from the front of the rack.

Model M-102 has the multiple use of high fidelity monitoring of picture signals, and general supervision and investigation of composite video signals at the studio or remote point.

SPECIFICATIONS: Picture Amplifier flat to 8.0 mc ± 1.0 db.; Scope Amplifier flat to 3.0 mc ± 1.0 db.; Input impedance 470,000 ohms; Video input signal 1.0 volt peak to peak. Power Requirements —115 volts 50/60 cps AC line voltage.

PORTABLE PICTURE MONITOR — Model 102 MPS

- Resolution greater than 500 lines.
- 7" Kinescope.
- High Impedance input.
- Weight 50#, Size 9" x 16" x 20".
- Video Amplifier flat to 5.0 mc. ± 1.0 db.
- Kinescope removable from the front and all parts are readily accessible.

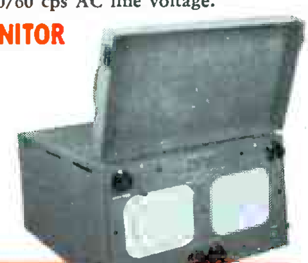
Specifications: Input signal 1.0 volts peak to peak; Input impedance 470,000 ohms; Power—115 volts 50/60 cps AC line.

The model 102 MPS meets the need for a compactly constructed, high fidelity picture monitor of practical size to make it truly portable.

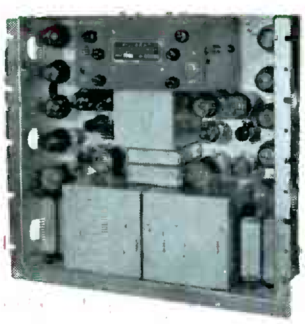
DUAL PORTABLE PICTURE MONITOR

Model 102 MPD

This unit has the same performance and constructional features as the single portable monitor. Model 102 MPD is supplied in two carrying cases consisting of a control unit and the dual monitor-unit. Each monitor may be used independently of the other.



Dual Regulated DC POWER SUPPLY



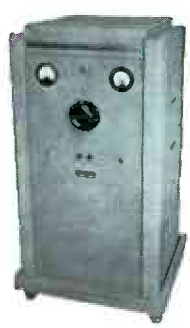
Model PT 111D

Consists of two electronically regulated power supplies which provide DC Voltage loads from 0-400 ma at voltages from 250-300 volts.

- Ripple Content less than .005%.
- Extremely fine regulation.
- No electrolytic capacitors used.
- Impedance less than 1.5 ohms.

Supplied complete with tubes and an 8' heavy duty power cable and may be mounted on standard type relay rack. For general portable use this unit is also available in a metal cabinet with a black crackle finish.

Specifications: Power: 105-125 volts 50/60 cps AC line. Output: 250-300 volts; 0-400 ma.



This unit provides a variable source of high DC voltage and current for use in factory and laboratory.

High Voltage DC POWER UNIT

0-200 Volts, 1.0 Amp — Model KV-2

- Supplied in deluxe metal cabinet finished in gray crackle.
- Mounted on wheels for portability.
- Interlocks, capacitor shorting relay insures the safety of personnel.
- Overload relay protects equipment.
- 0-2000 volt output control located at front panel.
- Output voltage and current metered at front panel.
- Separate High Voltage Switch.

Specifications:

Input: AC Line 115 volts 50/00 cps single phase. Output: 0-2000 DC volts; 0-1.0 amperes. Size: Height 46", Width 22", Depth 18¼", Weight: 303 lbs.

CONSULTANTS TO THE NATION'S GREAT TELEVISION STATIONS

(continued from p 134)

to be keyed, being two voltages 180 degrees different in phase, is passed.

Find Shells in Lumber

METAL FRAGMENTS and unexploded artillery shells will be located in 12 million feet of lumber by an electronic metal detector being built for the U. S. Corps of Engineers for use in timbering and milling operations in the 3,718-acre Marne Forest tract, Fort Lewis, Washington.

Designed to detect any magnetic metallic object ⅝ inch in diameter or larger embedded in a log, the detector consists of an exploring coil system, an electronic detecting circuit, and an alarm system that provides visible and audible signals. The coil has a 60-inch diameter opening through which the logs will be floated and is constructed for immersion in water.

Any magnetic metallic object more than ⅝ inch in diameter, embedded in the logs passing through the coil, creates a voltage unbalance due to changes in magnetic field. The electronic circuit measures the voltage unbalance produced by the field and actuates the visual and audible alarms, indicating the area containing the metal.

Operating continuously at a rate of 10 to 40 feet per minute, the device can scan nearly 20,000 feet of timber per day. The equipment is

Logs will float through the 60-inch coil so that embedded metal and shells will be detected by the electronic equipment

SIMCO-PRECISION

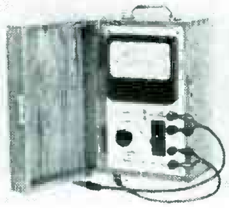
for laboratory and industry

Sidward Model 3A

MILLIOHMMETER

•

ENGINEERED TO MEET THE MOST EXACTING REQUIREMENTS



•

Model 3A is housed in a portable, rugged, hardwood case, with a 4" square meter. Size 9¾" x 6" x 4½".

Resistances can be read as low as 1/1000 of an ohm and as high as 2 ohms on a linear scale calibrated directly in milliohms. Readings simplified by evenly divided scale of 100 equal divisions and two overlapping ranges 0-200 and 0-2000 milliohms full scale deflection.

Unlike conventional low range ohmmeters, the lead resistance problem is eliminated. A breaker relay protects the meter from damage in case the measuring circuit is broken or a resistance greater than the range of the instrument is placed across its terminals.

A simple, accurate and dependable instrument

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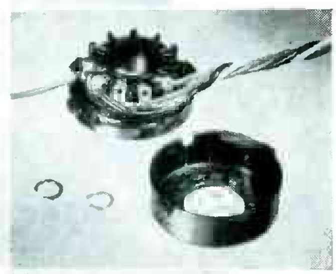
QUALITY SHORT CUT TO MASS PRODUCTION OF TV RECEIVERS...

COMPACT, CUSTOM-WIRED

DUODECAL AND DIHEPTAL



AMPHENOL

CATHODE RAY TUBE SOCKET ASSEMBLIES

• Amphenol custom-wired cathode ray tube socket assemblies are unusually compact. Leads are grouped within the housing in unit cable form and brought through the side of the socket in any of six positions. This effects a further saving of space. High voltage lead may be segregated from main trunk wires. Safety socket cap enclosing all wiring connections is easy to remove. Recessed socket front shields operator or serviceman from high voltages; serves also as a guide for tube insertion. Creepage barriers between contacts provide long leakage paths and positive lead wire separation. *For manufacturer's applications, sockets are furnished in wired assemblies.*

Duodecal Tube Sockets: For most popular television viewing tubes with a maximum of twelve pins on a pin circle diameter of 1.063 inches.

Diheptal Tube Sockets: Made in two sizes, for small (2.050 inch) diameter tube bases, also for medium (2.250 inch) diameter bases. Both provide for a maximum of fourteen pins on a 1.750 inch diameter pin circle.

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reasonably stable to variations in temperature, vibrations, line voltage, frequency, proximity of metal bodies, or motion of metal bodies relatively near the coil assembly. It is designed to operate within ambient temperature range of 30 degrees F without manual adjustment.

The reason why unexploded shells and metal fragments have been found in timber from the Marne Forest tract is unknown.

When timbering started, the contractor encountered two logs in his sawmill, each containing an embedded, unexploded 37-millimeter projectiles, so all timbering and milling operations were suspended immediately.

Because 2,000,000 feet of timber had been felled and was subject to deterioration from insects and rot, the Corps of Engineers tested many types of metal detectors, including mine detectors developed during the war. None proved satisfactory, so a contract was made with the General Electric Company for the electronic metal detector.

Radio Control for Water Works

McGraw-Hill World News

OPERATING at 300 megacycles, a radio system of telephony, telemeasure, and telecommand has been installed at the municipal water works of Yverdon, Switzerland.

Installation of the control equipment coincided with development of a new water supply for the town's 11,000 inhabitants. A pumping station was built on the shore of Lake Neuchatel above Yverdon. Two low-pressure pumps draw water from deep in the lake into the filters of this pumping station. The filtered water is then pumped under high pressure three miles to a reservoir west of the town.

Problem faced was to provide intercommunication among the pump station, the reservoir, and the water system's office in the middle of town. Solution was a fourfold transmission setup consisting of a radio-telephone circuit among the three stations; telemetering and telecommand link, showing changes in the water level of the reservoir, sent to the pump station via the

It's Perfectly Clear why

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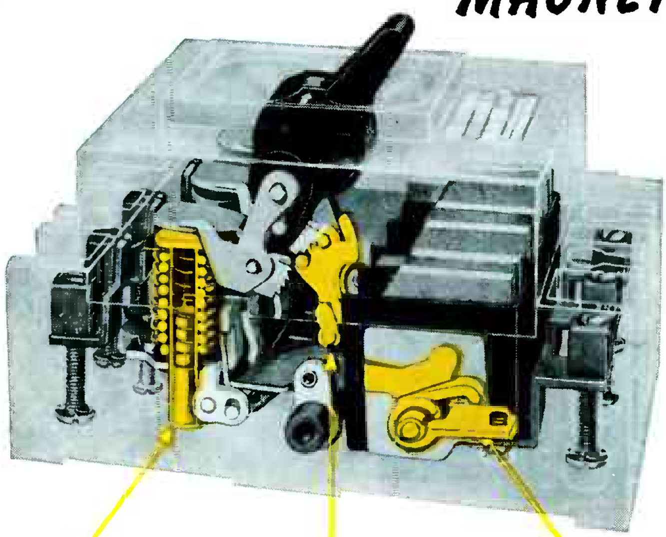
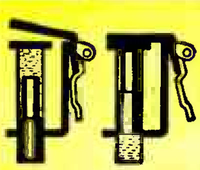
SUPERIOR

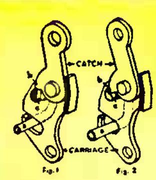


TIME DELAY



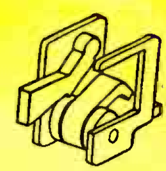
The magnet coil surrounds a hermetically sealed liquid filled cylinder containing an iron plunger which while normally out of the magnetic field moves into it on overloads, the liquid controlling its speed. As the plunger rises to the top of the cylinder, the magnetic flux increases to its maximum. At this point the armature is attracted and operates the latch.

HIGH SPEED LATCH



The armature, on engaging the lower leg of the lock (a) rotates it so that the tooth of the catch (b) passes through the cut portion of the lock (c) and opens the contacts. Of all known latches this one acts with the least amount of friction and mechanical delay. The latch collapses only on short circuit or overload conditions even if the handle is purposely held in the "on" position.

HIGH SPEED BLOWOUT



The stationary contact is coiled around an insulated iron core connecting steel plates to form a U-shaped magnet. On overloads and short circuits, the current flowing through the contact creates magnetic lines which force the arc into the arcing chamber and blow it out. As the value of the current to be interrupted increases, the quenching effect becomes greater due to intensified magnetic field.

The illustration here shows you plainly the advantages of this piece of equipment. In the first place, it is *fully electro-magnetic*, having no thermal elements. It acts *instantly* to break the current on short circuit or dangerous overload. No heat results which might affect the current carrying capacity.

On the other hand, the HEINEMANN Circuit Breaker will *not* trip on starting current, or minor overloads, due to a time delay unit (see illustration) which allows a harmless overload to persist for a safe time limit. Continued overload opens the breaker in time inverse to the ratio of the current. The HEINEMANN Circuit Breaker thus gives maximum yet flexible protection to the circuit.

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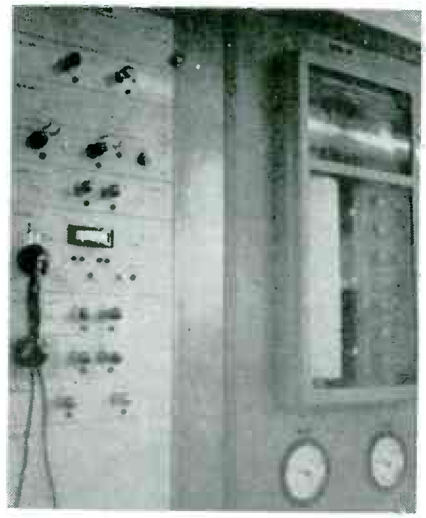

Electronic control panel at the office of the water works

office; and a telemetering channel for the temperatures and levels of the pre-filtered and post-filtered water at the pump station (as well as the length of service of each of the pumps), sent to the office and on to the reservoir.

Straight-line distance between the office and the pump station is 2.17 miles; between the office and the reservoir it is 1.86 miles.

The different audio frequencies used in the equipment provide amplitude modulation of the carrier. The transmitting and receiving installations at each station, installed on the roofs of the buildings, use the following frequencies: office to pump station, 300 mc, pump station to office, 306 mc, office to reservoir, 303 mc, and reservoir to office, 309 mc.

Audio Control Frequencies

The reservoir post sends a supervisory frequency of 2,000 cycles to the pump station via the office. This frequency is designed to inform the personnel whenever there is interruption of the transmission channels. It acts in the two places by means of an impulse amplifier, on a supervisory relay having a normally closed contact.

Measure of the water level in the reservoir is effected by a float with a Rittmeyer transmitter. For variations of level of plus or minus 5 centimeters, this transmits d-c impulses corresponding to the level-up or level-down condition. By means of the telecommand equipment, these impulses interrupt the supervision frequency with a certain

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2.5	2.5	2.5 V.	10	100	10	—10 to	0-2000
10	10	10 V.	100			+52DB	(12 ohms center)
50	50	50 V.	500				0-200,000
250	250	250 V.					(1200 ohms center)
1000	1000	1000 V.					0-20 megohms
5000	5000	5000 V.					(120,000 center)

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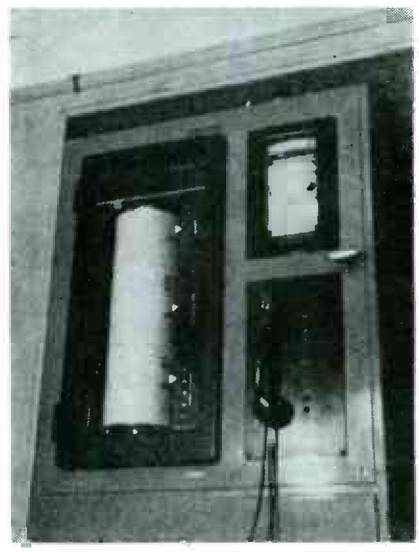
rhythm. The length of the impulses being very short, the supervision relays do not fall and no alarm is given. After amplification in the receiver, these impulses activate the telecommand selectors which retransmit orders to the Rittmeyer recorder.

The measure of the levels of the two tanks of water (filtered and unfiltered) at the pump station is transmitted to the office in similar fashion. The frequency controlling the transmission channels is 1,500 cycles.

When there is an interruption in the reservoir-office or office-pump station links, the supervisory frequency of 1,500 cycles is interrupted. The interruption, in addition to sounding the alarm, stops



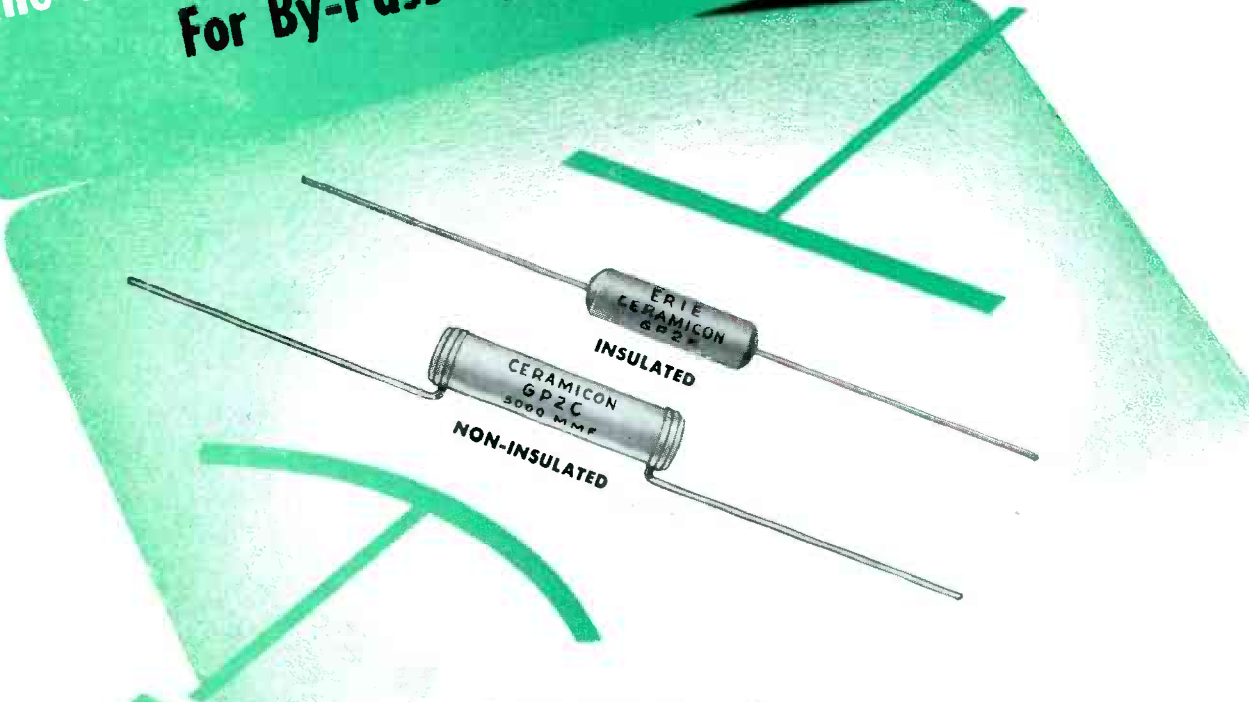
Control panel and Rittmeyer transmitter installed in the pump station

the Rittmeyer transmitter of the reservoir, so that no impulse is lost. Thus the telemeasure of the reservoir water levels is never falsified in case of interruptions to the channel of transmission and the impulses which could not be transmitted are conserved until the reestablishment of the circuit, and then transmitted.

Temperature Given as Frequency

The telemetering of the temperatures of the two water tanks is effected by a frequency-varying device. The principle consists of converting the value to be measured into an audio-frequency current. Each position of the needle of the local thermometer-indicator corresponds to a frequency in the

The Trend is Toward Ceramic Condensers For By-Pass Applications



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The GP (General Purpose) line of Erie Ceramicons does not sacrifice quality in any way whatsoever. Since the line of Erie GP Ceramicons is limited to definite capacity values, it is practical to manufacture large quantities of any given value at one time, with consequent saving in production costs.

Condensers classified as GP1 have a temperature coefficient between +/130 and −1600 P/M/°C and are available up to 510 MMF. Condensers classified as GP2, manufactured in capacities of 150 MMF and higher, may include all of the above dielectrics and, in addition, the Erie Hi-K type.

Erie GP Ceramicons are made in insulated styles in popular capacity values up to 5,000 MMF and in non-insulated styles up to 10,000 MMF. Write for full details.

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range from 2,300 to 2,800 cycles. The office receiver amplifies the variable audio-frequency current and converts it into a direct current proportional to the frequency which operates a meter having a two-color scale installed in the director's office.

A time control unit changes the color registered every 30 seconds and at the same time it connects an oscillator of 3,050 cycles to modulate the transmitter feeding the pump station. There an impulse amplifier geared to this frequency periodically checks a pilot-variometer corresponding to the telemetering transmitter.

Audio Conversion

For radio-telephone communication between the three stations a frequency band of 200 to 2,700 cycles is used. Since these frequencies are already utilized for supervision, telecommand, and telemetering, the spoken audio band is converted by a 6,000-cycle oscillator and a ring modulator into the frequency band from 6,200 to 8,700 cycles so that there is no overlapping of frequencies.

The telephone ringing signal also uses one or another of the supervision frequencies. Depending on which post is calling, it is either the 2,000-cycle or the 1,500-cycle frequency that is interrupted by pressing the call button and which sets off an alarm of short duration serving as a telephone ring.

Produced and set up by Brown Boveri and Co., of Baden, Switzerland, this system has been in operation for two years and is reported to give perfect service.

Cost of the complete installation was $16,500. Similar equipment using cables for transmission would have cost $21,200 and the five miles of cable alone which would have been needed would have cost $19,000.

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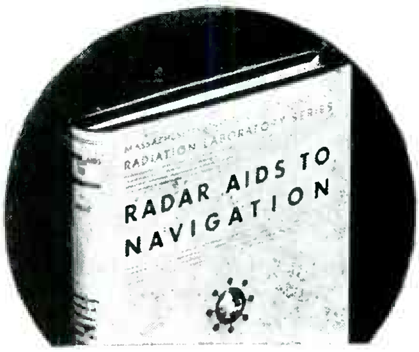

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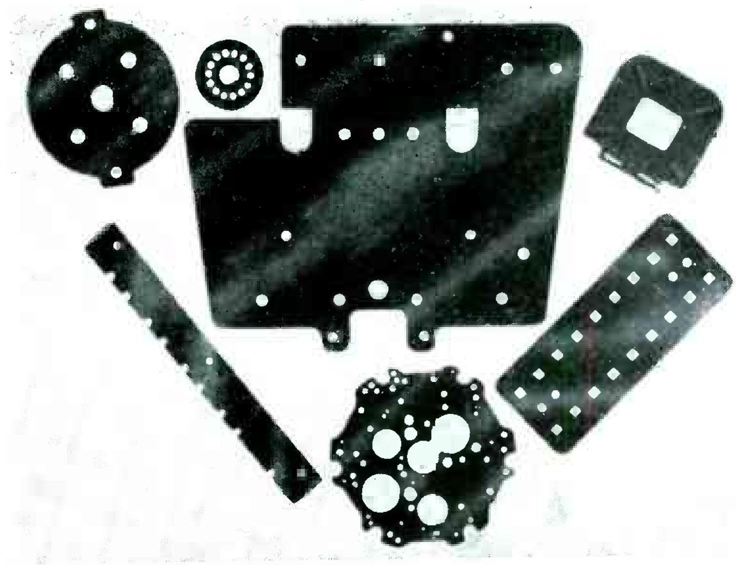

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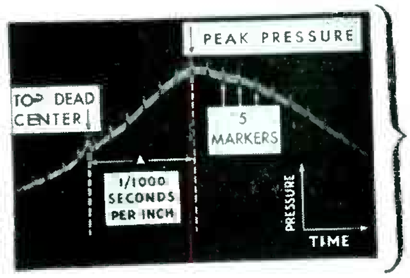

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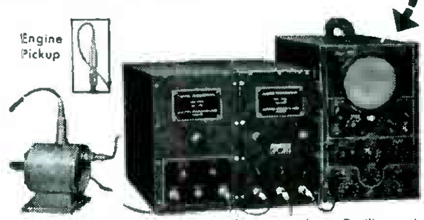

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use this auxiliary relay, the current to be interrupted should be limited to the equivalent of 0.1 ampere at 115 volts. In general, the voltage to be controlled should not be in excess of 115 volts although the wipers and contacts are tested at 1,000 volts a-c rms to the frame.

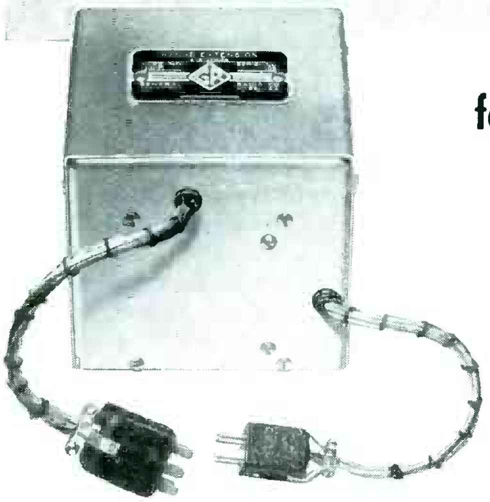
While it may be possible to build a switch for a-c operation, the power required at high speeds and widely varying conditions of application generally dictate d-c operation. Nominal operating voltages are 6, 12, 24, and 48. Both stepping and release magnets are usually equipped with non-inductive shunt windings for spark suppression.

Applications

The availability of three sets of wipers contacting three sets of banks of ten points each, plus the auxiliary (off-normal) contacts, permits this relay to perform functions that would otherwise require many relays. Among these operations are: selection of one circuit path out of ten; consecutive performance of operations in separated circuits; and the production of pulses at accurately spaced intervals.

The stepping switch could be used in a batch weighing device. The sequence could be started by a momentary closure of the start key. This operation would step the switch to position 1 which could operate a relay to open the hopper on bin. No. 1. When the proper weight has been reached, a limit switch on the scales can close the circuit to *RM* and advance the switch to position 2. Thus, relay and hopper No. 1 would return to normal while relay and hopper No. 2 would be energized. When the cycle of separate weighings is completed, the last limit switch closes the release circuit restoring the switch to normal for the next complete cycle.

Accurately spaced intervals can be developed. The start or operate key may be replaced by a cam contact on a small synchronous motor timer. Thus, if pulses are received at one-second intervals, the bank contacts will be successively closed at one-second intervals. A relay connected to terminal 5 will then be closed five seconds after the cycle is initiated. A locking key in series



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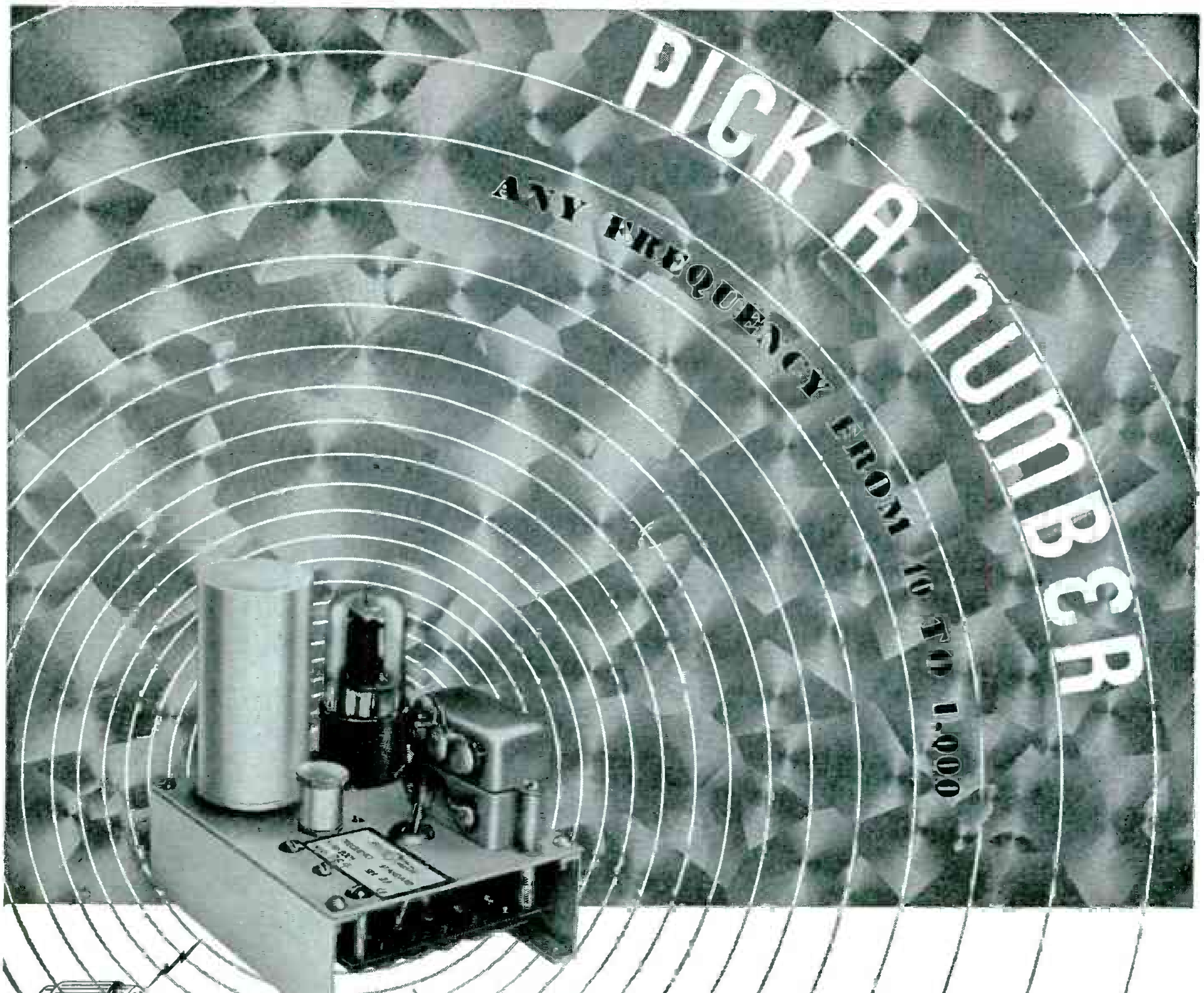
with *RM* and the motor cam can be used to start the operation, but unless some means has been provided to synchronize this key with the motor, then the first step will occur at some indeterminate time and the end operation will have to be started from step one and stopped at the later desired point.

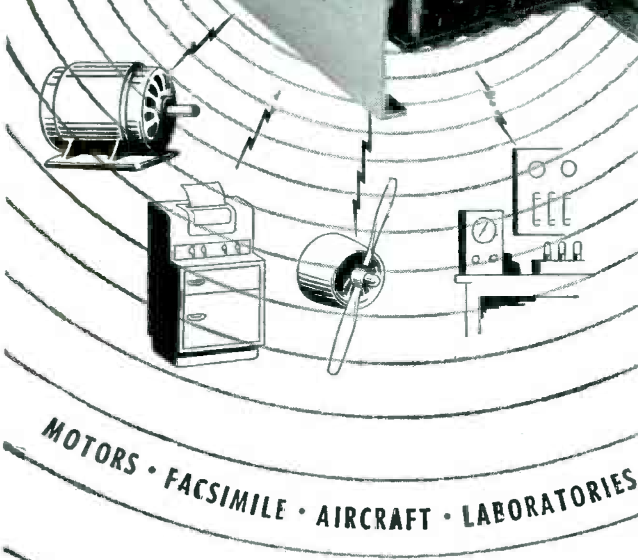
Data on Telephone Type Relays

In forming stepping-switch circuits for particular applications, it is sometimes necessary to use fast operate, slow operate, and slow release relays in conjunction with the stepping switch. Fast telephone-type relays have operate speeds from 0.001 to 0.025 second and release speeds from 0.005 to 0.050 second. Here, the operate time is the interval required for the magnetic flux to build up sufficiently to move the relay armature in addition to the time required for the relay armature to actuate the contacts. Maximum speed is obtained when the coil inductance is at a minimum, permitting the magnetic flux to rise at a maximum rate. In cases where coil current must be kept low, but maximum speed is desired, a winding is provided which will develop approximately twice the required ampere turns to operate the relay.

Slow-operate relays have a low-resistance copper ring or slug encircling the coil core on the armature end of the relay coil. When the coil is energized the flux being built up in the magnetic circuit links the low resistance copper ring. This change in flux through the copper slug results in an electromotive force and associated current in the slug which builds up an opposing flux. This opposing flux introduces a delay in operate time. By increasing the coil core gaps, spring tension, and inductance of the relay coil, contact closures may be varied from 0.010 second to 0.100 second.

The slow-release relays are also controlled by a copper slug, but the slug is placed at the heel end of the coil, or opposite end from the armature. In this case, spring tensions and core gaps are set at a minimum. When the coil circuit is closed, flux which does not link the copper slug operates the armature, giving fast operation. However, when the coil circuit is opened the electromotive force and associated current in the





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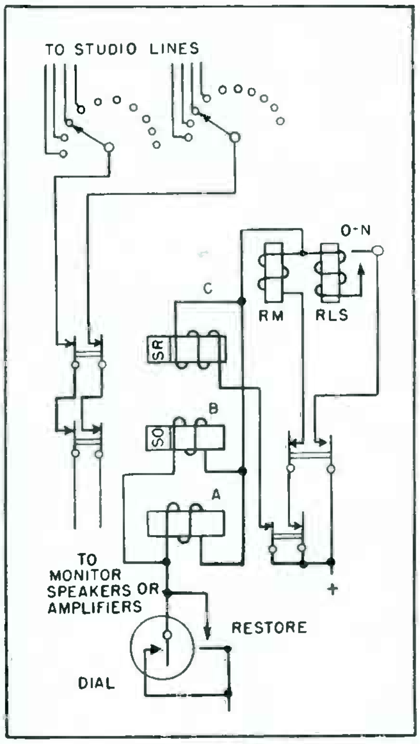
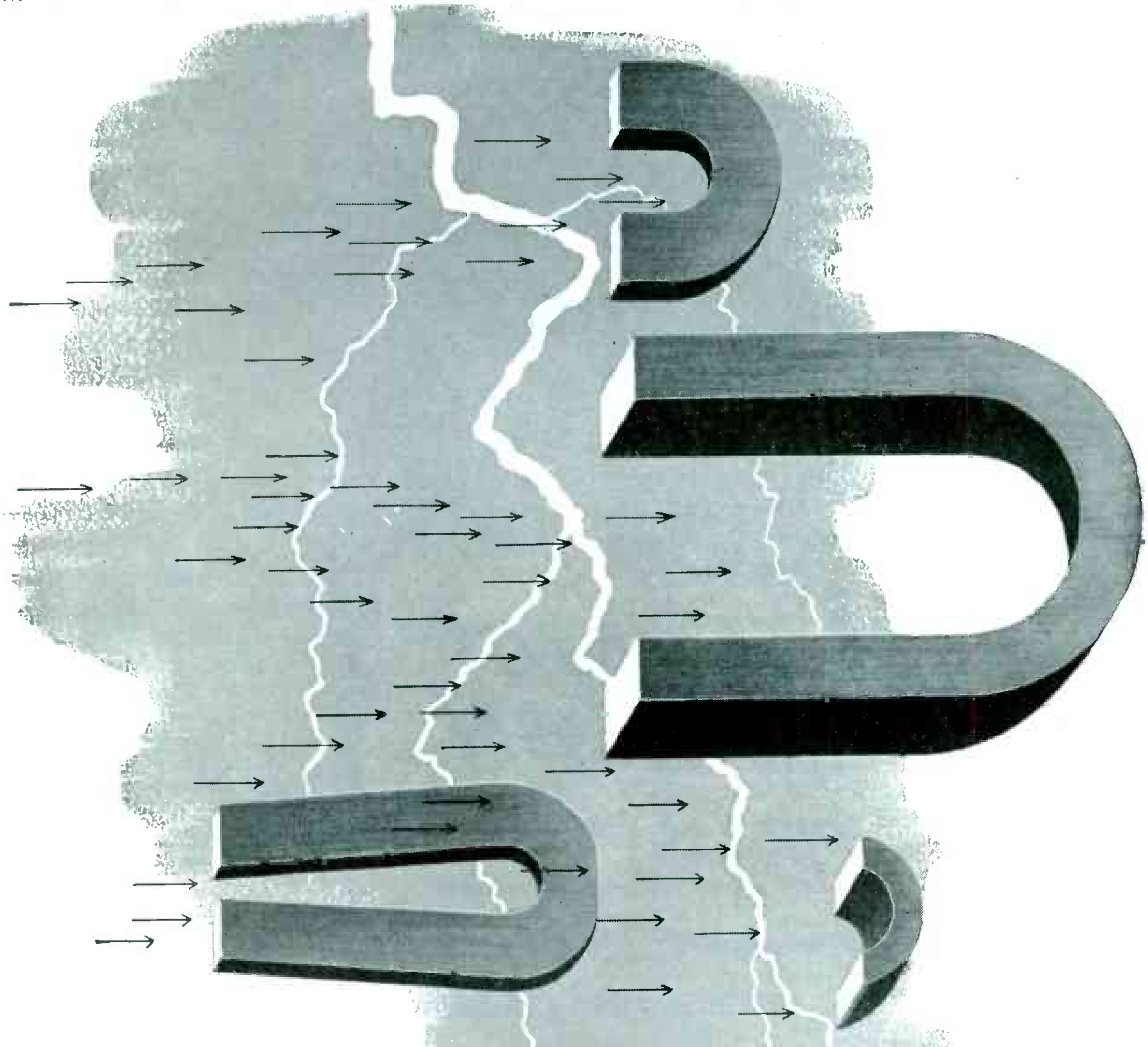


FIG. 2—Stepping-switch circuit for selectively monitoring a number of studio channels

slug tends to keep the flux in the core and delays the release of the relay. Release times up to 0.400 second may be obtained.

Stepping Switch Applications

In the radio industry, a common selection application is to the monitoring of studio channels, as illustrated in Fig. 2. Closures of the dial contacts operate relay *A*. This relay, in turn, operates rotary magnet *RM* to step the wipers, and relay *C* to open the wiper circuit during rotation. Relay *C*, being slow to release, remains operated until the end of the series of dial impulses. Relay *B* is sufficiently slow to operate to remain normal during the transmission of the short dial impulses. However, the longer manual closure of the restore key operates relay *B* to actuate release magnet *RLS* and release the switch. Break contacts on *B* again open the wiper circuit during rotation to guard against the previously mentioned breaking of currents by the wipers as well as to avoid the momentary energizing of the nonselected circuits. Make-before-break contacts could be used to ground the amplifier during this rotation if the signal level is low and stray pickup or charging currents would prove ob-



jectionable. By connecting power to these contacts one can arrange for the turning on or off of receivers or transmitters, or the selection of transmitter frequencies.

Another selection method, shown in Fig. 3, is commonly called closed-circuit dialing as contrasted with open-circuit dialing in Fig. 2. Closure of the initiating switch closes the line circuit and operates relays *A* and *B*. Dial impulses in this system appear as interruptions of the circuit, and relay *A* follows or repeats these interruptions. Relay *B*, being slow to release, remains operated during this cycle. The rotary magnet *RM* is energized from the back contact of *A* through the make contact of *B*. Relay *C* functions in parallel with *RM* to open the wiper circuit during rotation. Opening of the start key allows relays *A* and *B*

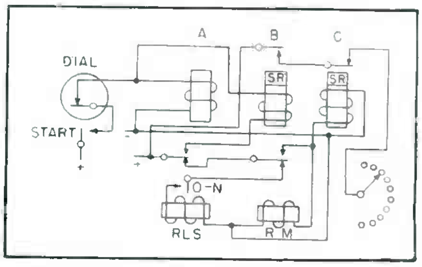


FIG. 3—Closed-circuit dialing system operates on interruptions of current in relay *A*

to restore and close a circuit through back contacts to the release magnet *RLS*. The off-normal contacts *O-N* open the release circuit as soon as the wipers have returned home, thus preventing continuous energizing of *RLS*. The wiper circuit is again opened during rotation by contacts on *B*. Sometimes it is necessary to insure that only one series of dial impulses will be registered. The circuit shown in Fig. 4, by the addition of relay *D*, accomplishes this purpose. The first pulse to *RM* is transmitted through springs 1 of relay *A*, 2 and 3 of relay *B*, 1 and 2 of relay *D* to *C* and *RM* in parallel. Operation of *C* operates *D* from springs 4 and 5 of *C* to coil of *D*. Relay *D* locks upon operaation of its own springs 3 and 4. Subsequent pulses to *RM* fail to find a path through contacts 1 and 2 of *D* but go through contacts 4 and 5 of *C*. Relay *C* remains operated during the short interval between pulses, but having released at the end of the series cannot again be

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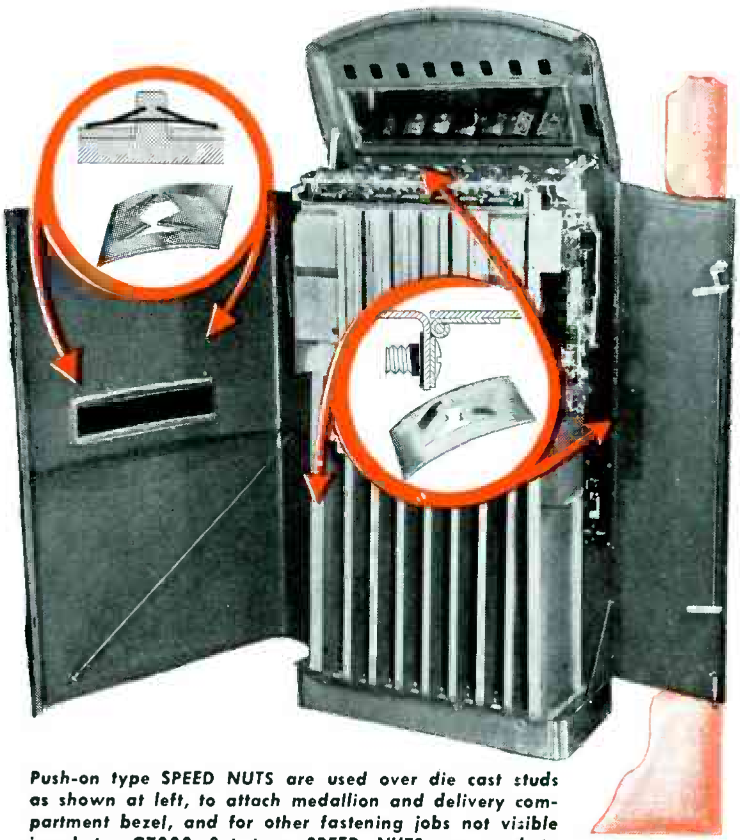

Push-on type SPEED NUTS are used over die cast studs as shown at left, to attach medallion and delivery compartment bezel, and for other fastening jobs not visible in photo. C7000 flat type SPEED NUTS are used to attach hinges to top cover, bottom frame and doors.

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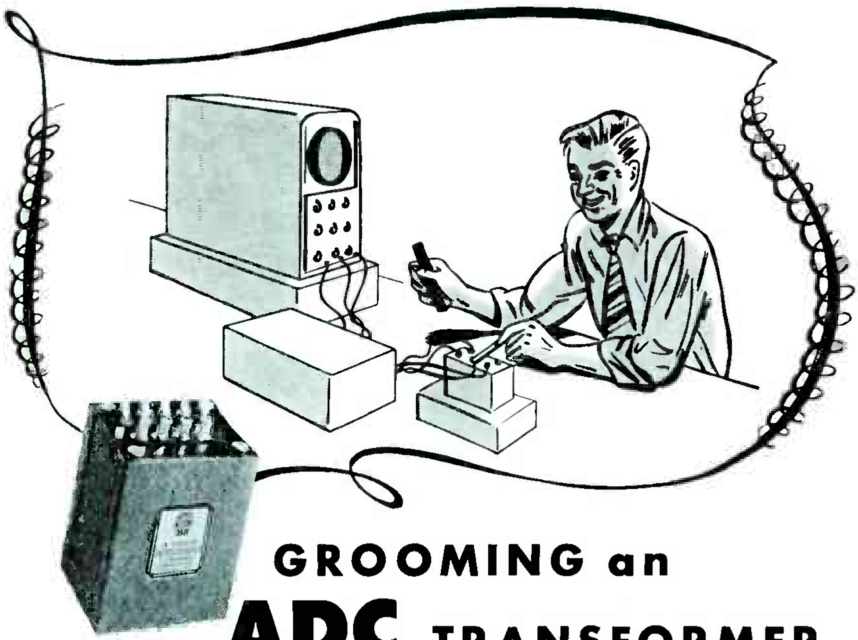


operated since springs 1 and 2 of *D* are held open, since *D* is locked in the operated position. Therefore, there is no path for pulses to *RM* and thus any subsequent series of impulses prior to complete reset will not affect the wiper setting.

Another dialing combination is shown in Fig. 5. In order to avoid the use of a start key, the off-normal springs on the dial are used to close the line circuit. The release is automatic, but is accomplished just as a new dialing starts. To allow time for this operation, the first dial impulse is absorbed and an additional one is inserted at the end of the sequence to keep the numbering system in step. Relay *A* operates when the line circuit is closed by the off-normal springs of the dial, and in turn operates *B* through springs 2 and 3 of *A*. Relay *RM* is energized from this same source through 1 and 2 of *C* and the closed off-normal springs (if the wipers are off the home position). When *A* releases on the first dial interruption, *D* operates from 1 and 2 of *B* and 4 and 5 of *A*. Relay *B* does not release on these short interruptions because of its slow release feature. Relay *C* operates when *A* again reoperates from 2 and 3 of *A*, 1 and 2 of *D* and 6 and 7 of *C*. It locks from 1 and 2 of *B* through 5 and 7 of *C*. When *A* again restores on the second interruption, *RM* is energized from 1 and 2 of *A* and 3 and 4 of *C*. Thus, while the dial has opened the circuit twice,

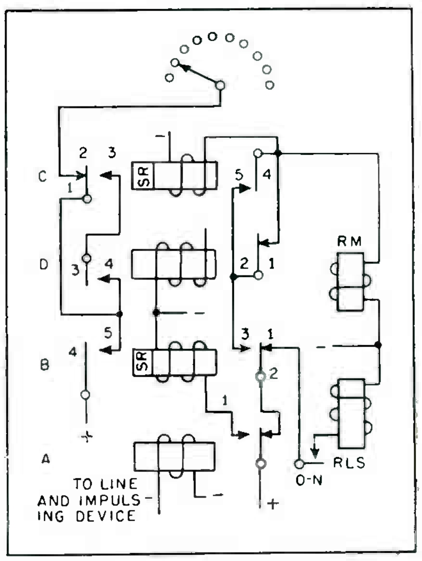


FIG. 4—This circuit will respond only to a single series of dialed impulses; complete reset is required before another impulse series can be registered

17,363 HOURS ON THE AIR

AT WQXR, RADIO STATION OF THE NEW YORK TIMES

WQXR AND WQXQ
THE RADIO STATIONS OF
The New York Times
730 FIFTH AVENUE · NEW YORK · 19 · CIRCLE 5-5566

May 2, 1947

Mr. C. J. Harrison
Federal Telephone & Radio Co.
Clifton, N. J.

Dear Mr. Harrison:

In connection with our order for another F892R tube, you may be interested in the performance of these tubes.

Federal #27366 Type F892R was removed from service after 17,363 hours of operation.

The tube was in perfect operating condition but it was felt that it had exceeded normal life expectancy. We would not venture to say how much longer this tube could have remained in service. After 17,363 hours of operation, the cost per hour justified its retirement.

Yours very truly,

R. D. Valentine
R. D. Valentine
Chief Engineer

RDV:ac

F-892R Forced-air-cooled

F-892 Water-cooled

That's PROVED PERFORMANCE for Federal's F-892R AM Broadcast Tube

THIS F-892R power amplifier tube was installed in WQXR's 10-kw transmitter on February 5, 1943—removed from service on December 22, 1945, after 17,363 hours on the air!

It's operating records like this—long life and enduring performance—that have made Federal tubes the first choice of so many broadcast station engineers and operators all over the country. The F-892R power amplifier—and the corresponding F-891R modulator—are forced-air-cooled tubes which have consistently set the standards for performance in 10 kw AM transmitters. Water-cooled types of equivalent rating are also available.

These—like all Federal tubes—reflect 38 years of pioneering, research, and manufacturing experience. Their outstanding service is made possible by Federal's exacting performance requirements and rigid acceptance tests—including *two* searching X-ray tests which reveal any hidden flaws or imperfections.

Whenever you want extra operating economies and long uninterrupted service, specify broadcast tubes by Federal. For complete technical data on the F-892R and F-891R tubes, write to Federal today—Dept. B513.

FTR
An IT&T Associate

Federal Telephone and Radio Corporation

100 KINGSLAND ROAD, CLIFTON, NEW JERSEY

KEEPING FEDERAL YEARS AHEAD... is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

In Canada: — Federal Electric Manufacturing Company, Ltd., Montreal.
Export Distributors: — International Standard Electric Corp., 67 Broad St., N. Y. C.

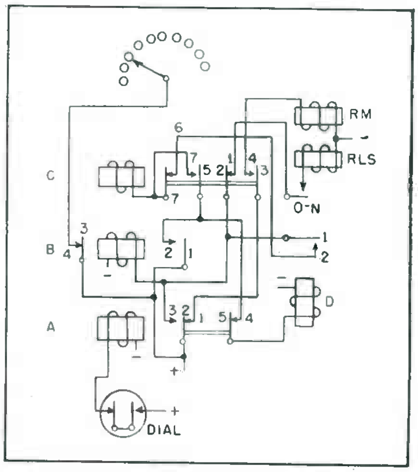


FIG. 5—This circuit requires no start key. Automatic reset is accomplished as each new dialing begins

RM has operated only once. However, when *A* restores at the end of the dialing cycle *RM* is again energized over the same circuit path as previously. *B* releases after an interval, restoring *C* and *D*. Restoration of *C* opens the circuit to *RM* at 3 and 4 of *C*. Thus, a final step is given to the wipers to make up for the one missed at the beginning.

Associated with Fig. 5 is a valuable tool of the circuit designer known as the timing chart shown in Fig. 6. Along the left side is a tabulation of the relays used, plus the initiating device. Horizontal lines are then drawn to indicate periods of current flow and relay operation. As the circuit is closed from the dial, *A* coil is energized and its contacts operate. This in turn, energizes *B* and *RLS*. The opening of *A* after closure of *B* energizes *D*, and so on. Thus we have a circuit sequence as well as a description and check on the operation. If it later develops that other functions must

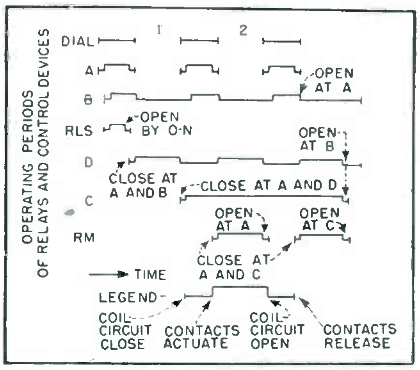
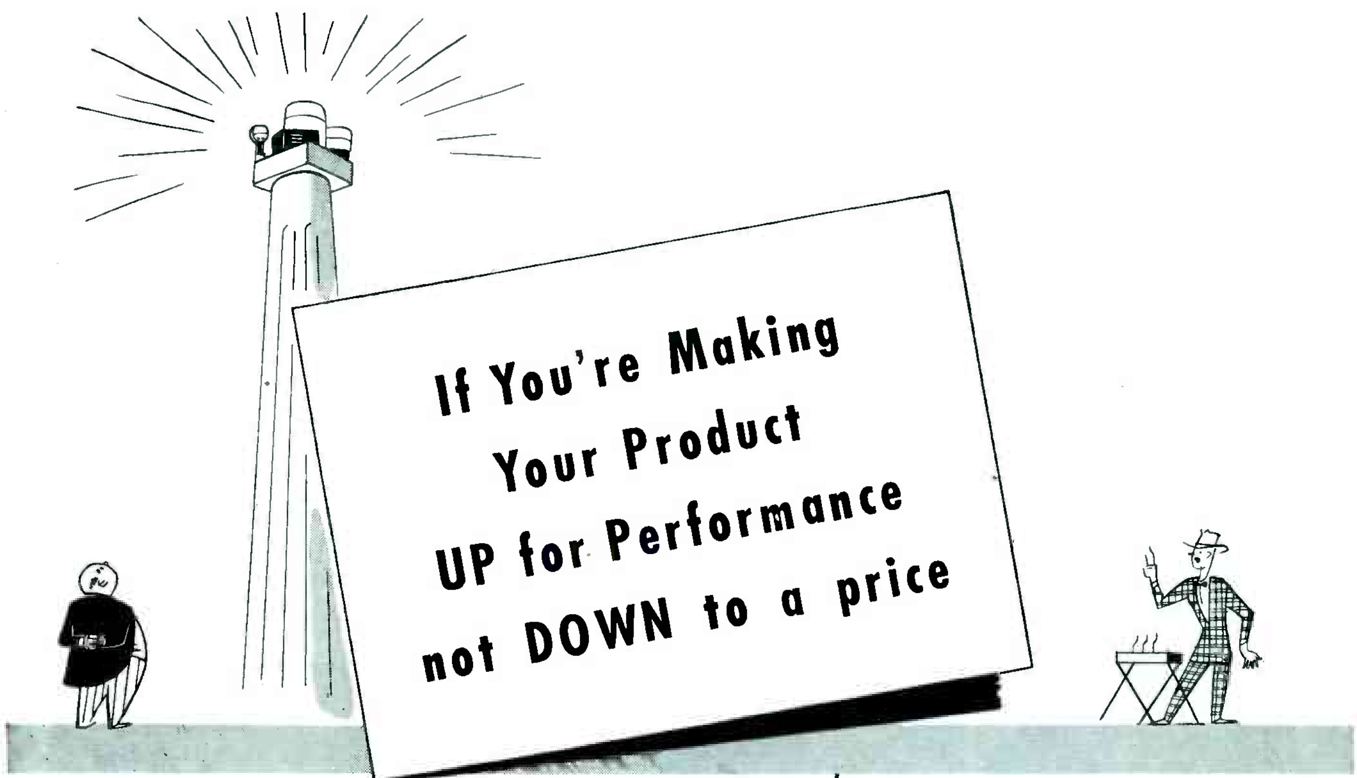


FIG. 6—Timing chart shows periods of relay operation, and is useful to designer in determining where to add relay contacts for particular operations at specified times



INSIST

ON PERMANENTLY INSULATED ROCKBESTOS WIRES AND CABLES

Your customers may take wire performance for granted in your product—*but you can't.* Apart from the black eye wire failures can give an otherwise good brand name, today's sky-high servicing and replacement costs can put a heavy overload on operating expenses.

Profit margins *go up* and servicing costs *go down* when Rockbestos wires, cables and cords *go in!* If your product generates heat or is used in high ambient temperatures that shorten the life of the wiring, remember that asbestos insulated Rockbestos wires and cables will operate *continuously* at high rated temperatures. They *won't* dry out, become brittle, crack or flow. They *won't* deteriorate when exposed to grease, oil or corrosive fumes. They *will* provide longer life and greater current capacity through high heat resistance.

Whether your product is large or small—sold to consumers or industry—there's a *permanently insulated* Rockbestos wire, cable or cord that will improve performance and increase profits. For recommendations or engineering assistance write to the nearest district office or:

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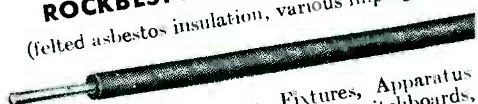
ROCKBESTOS PLAIN ASBESTOS
(felted asbestos insulation, various impregnants)



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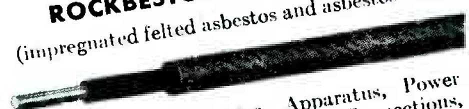
ROCKBESTOS ALL-ASBESTOS
(impregnated felted asbestos and asbestos braid)



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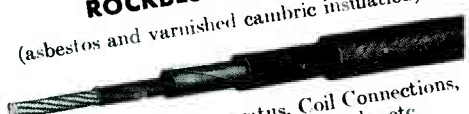
ROCKBESTOS A.V.C.
(asbestos and varnished cambric insulation)



For Switchboards, Apparatus, Coil Connections, Motor Leads, Resistors, Power Leads, etc.

From these three basic Rockbestos constructions 125 different permanently insulated wires, cables and cords have been developed to give better and longer service under severe or unusual operating conditions.

ROCKBESTOS

PERMANENTLY INSULATED ROCKBESTOS WIRES AND CABLES

THE WIRE WITH PERMANENT INSULATION

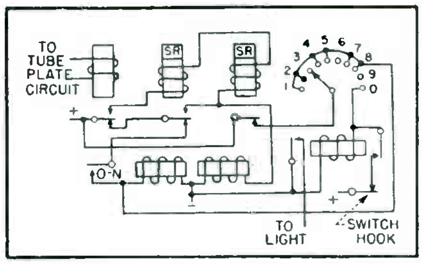


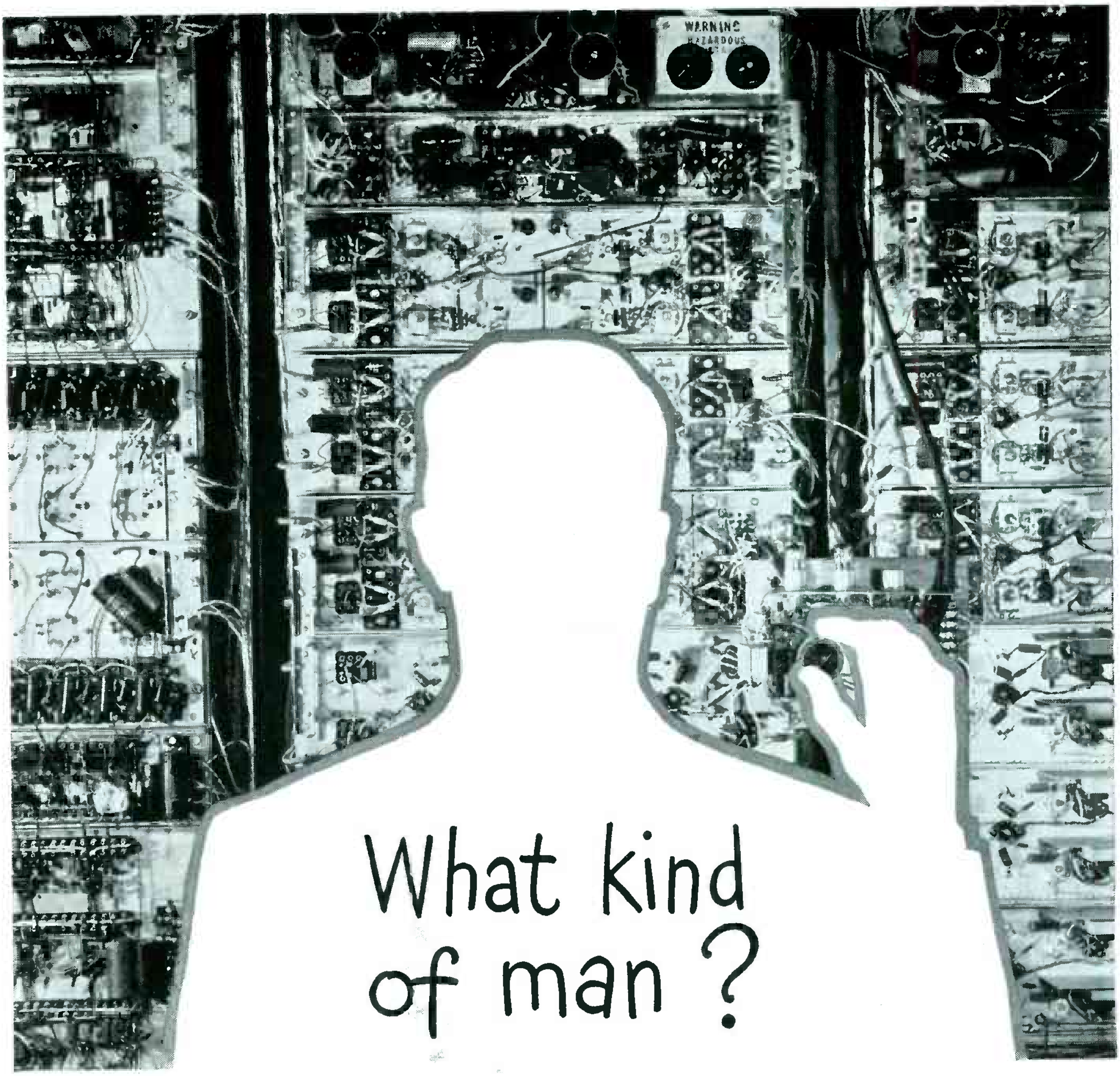
FIG. 7—This selective calling circuit for mobile radio installations, is set up to respond to dialed combination 3331

be performed at certain specific instants, an examination of the chart will reveal what relays are operated or normal at that time and contacts can be added accordingly.

Selective Calling

Figure 7 shows the circuit in use by the Link Radio Corporation for the selective calling of mobile radio equipment. A photograph of this unit is shown in Fig. 8. This circuit is very similar to that shown in Fig. 3 except for the addition of bank strapping so arranged that if the wipers stop on certain points, a release circuit is established from the back contact of *C* through the wiper to *RLS* to restore the switch. The circuit is shown strapped for the number combination 3331. If this number is dialed in order, the wipers will arrive at position 10 since bank contacts 3, 6 and 9 are not connected to the restore circuit. When the wiper arrives at 10, a circuit is closed to relay *S* which locks through the hookswitch contacts and also sounds an alarm.

Relay *A* is in the plate circuit of a receiver tube arranged to be sensitive to a calling tone transmitted only during this selection or calling period. The tone is interrupted by a dial or other calling device. When the tone is removed at the end of the calling period, *A* and *B* restore to actuate *RLS*. It should be noted that as many as 88 of these units using four-digit numbers totaling ten may be operated on the same system with no ambiguity. Thus only one switch will arrive at the tenth position while all others will have stopped on a nonconnected point at least once, and will thus have restored. On the other hand, dialing selected two-digit numbers will close desired groups of circuits; dialing zero will bring in all units. For example, the number 46 will


WARNING
What kind of man ?

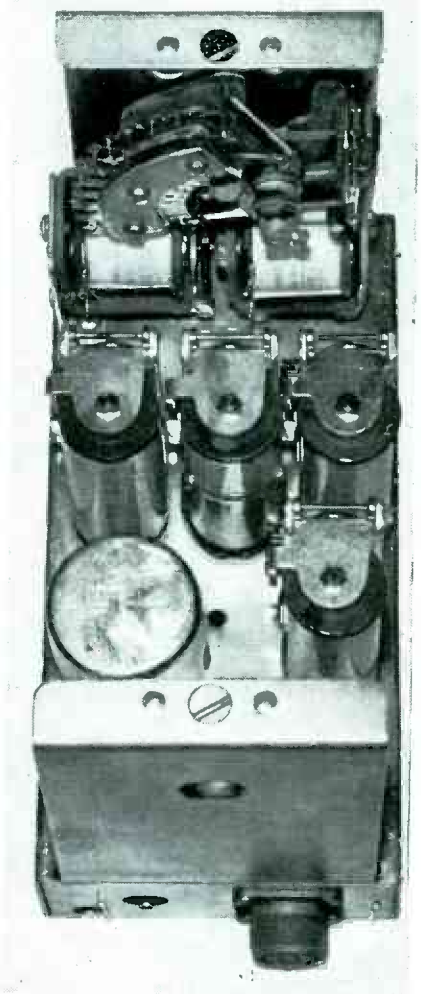


FIG. 8 — Mobile stepping-switch unit. Circuit is shown in Fig. 7

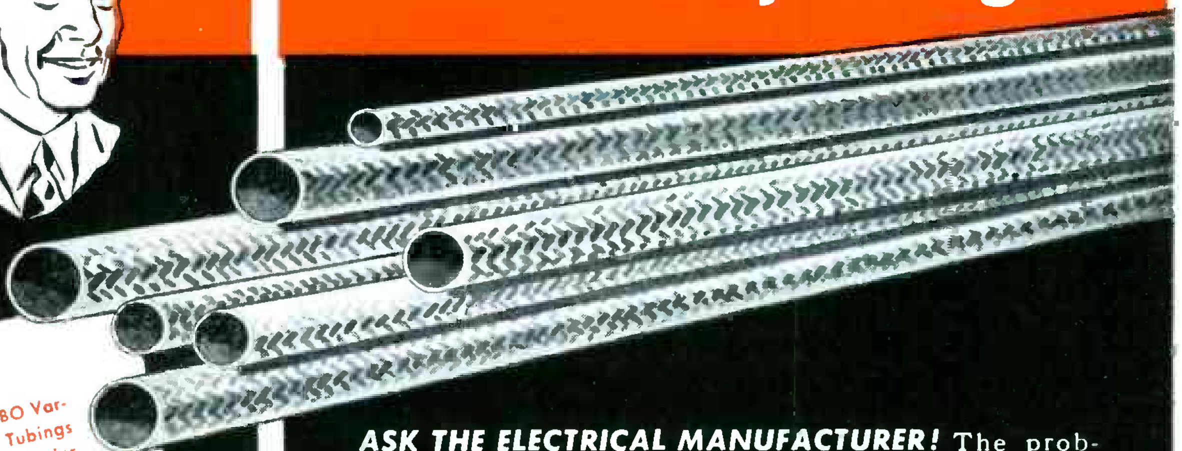
select all units of which the first two digits add to 4. In this manner, the system may have seven subgroups for dispatching of semigeneral information. In a Fire Department System, for example, battalion chiefs could be in one group, engines in another, and so forth.

Speed of operation is an important factor in the application of stepping switches. The standard switch will readily follow standard 10- and 20-pulse dials, and it is possible under ideal conditions of pulse ratio and voltage to realize a speed of 35 steps per second. Since the coils have definite operate and release times, unless the control pulses have sufficient length, the magnet will not step. If the space between pulses is too short, the magnet will not be restored before the next pulse arrives. In standard control dials, the ratio between the closed circuit time and the combined open and closed circuit time is 62 percent.

VARNISHED TUBING*

IF IT'S TURBO — IT SAFEGUARDS!

...keeps the volts where they belong!



* TURBO Varnished Tubings in two superior grades—Magneto Grade—7000 V; Radio Grade — 4000 V. Dielectric breakdown ASTM test.

ASK THE ELECTRICAL MANUFACTURER! The problem—to supply an insulating tubing flexible enough to sleeve over electrical conductors without cracking or peeling... strong enough to withstand pulling and tearing... uniform enough to insure smooth fit... highly resistant to heat, flame, acids alkalies and other reagents... AND, at the same time, an almost ideal dielectric. That's the problem... and the result—TURBO Varnished Tubing—a superior cotton braid insulator processed with impregnating varnishes... recommended for most insulating requirements. Note: Check the other TURBO insulating products listed below.

Fibrous Glass Tubing.......... Fabricated of flexible fibrous glass yarn braided and impregnated with flexible varnishes and baked to form an ideal insulator, highly resistant to most reagents and to physically and electrically destructive elements. Four grades (ASTM Test) from 1200 V. to 7000 V.

Saturated Sleeving.......... An all purpose insulation for any but the higher dielectric ranges. Varnish impregnated cotton yarns. Flexible, strong, resistant to acids and oils. Good moisture and flame resistance. Dielectric breakdown—1200 V., per ASTM test.

Mica & Mica Products.......... All forms—plate, block, segments, films. Rigid control in all stages—grading selection, fabrication and testing insures uniformity and quality in finished products. Meets all tests involving physical and electrical stability. Specific problem-collaboration is invited.

Varnished Tubing.......... A superior braided cotton insulation featuring saturation impregnation of flexible varnishes. Strong, flexible, non-peeling, non-cracking, moisture, oil, acid and flame resistant. Dielectric breakdown ASTM test—Magneto grade—7000 V., Radio grade—4000 V.

TURBO

WILLIAM BRAND & COMPANY

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ELECTRON ART

(Continued from p 138)

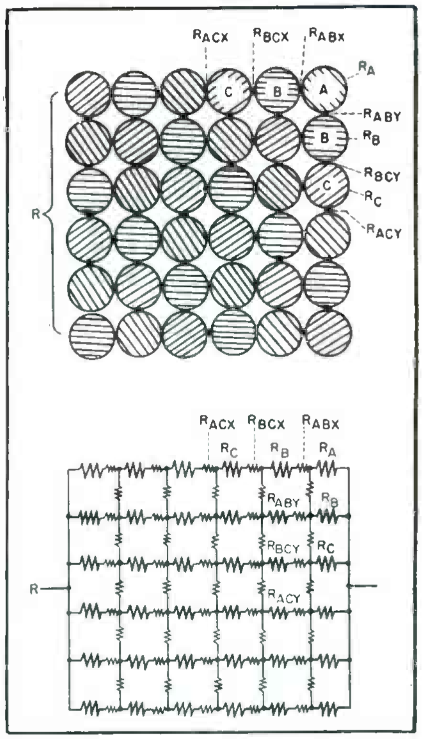


FIG. 1—Representation of sintered semiconductor and its equivalent circuit

tests were made on conductors of copper-graphite mixtures. Two sizes of electrolytic copper particles were used: coarse particles of 44 to 74 microns, and fine ones of fairly uniform (90 percent) 2 microns. The crystalline graphite was in two sizes: coarse particles of 10 microns, and fine ones of 2.5 microns. Eighteen different compositions were dry mixed, compacted at 20 tons per square inch, and sintered in nitrogen at 1,000 C for 3 hours. Figure 2 shows the characteristics of the various compositions. So far as re-

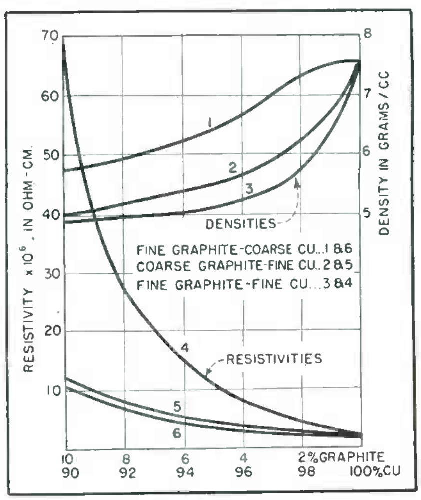
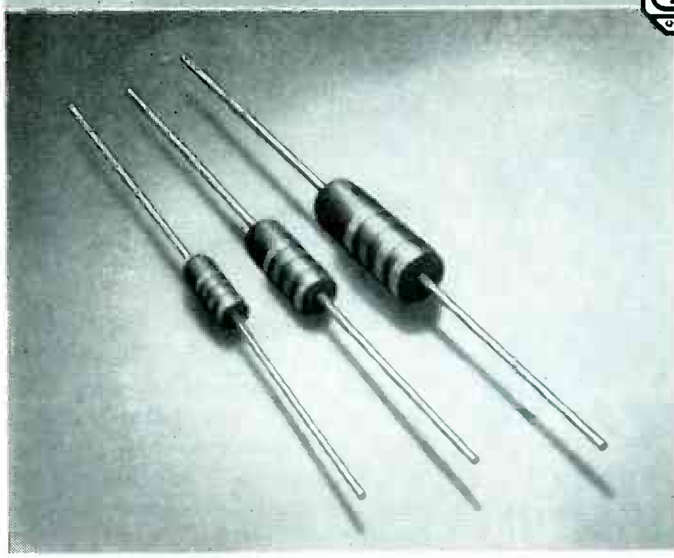
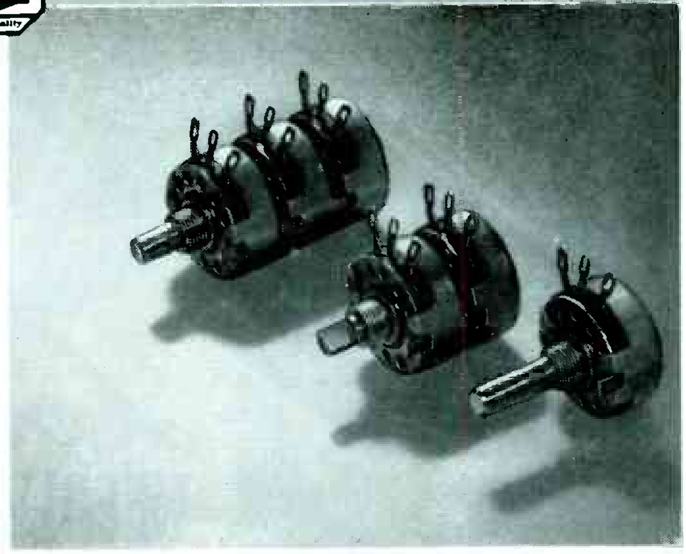


FIG. 2—Particle size affects resistivity, increasing it as particle size decreases

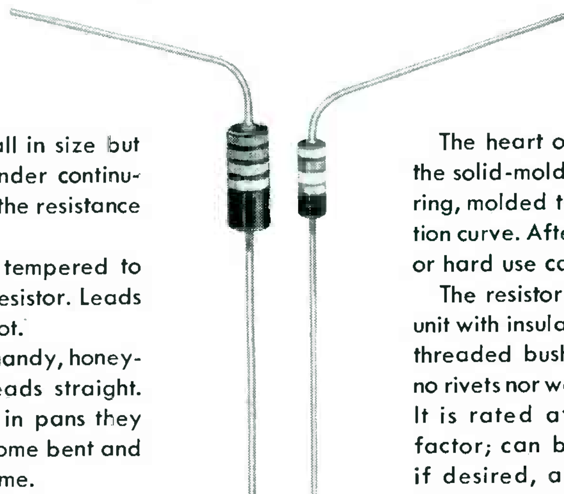
FIXED RESISTORS **ADJUSTABLE RESISTORS**





The ALLEN-BRADLEY LINE of RADIO RESISTORS

—not affected by heat, cold, moisture, or age



Bradleyunit resistors are small in size but "tops" in load and life tests. Under continuous 100% load for 1000 hours, the resistance change is less than 5%.

The leads are differentially tempered to prevent sharp bends near the resistor. Leads are easily formed to fit any spot.

Bradleyunits are packed in handy, honeycomb cartons that keep the leads straight. When resistors are kept loose in pans they are hard to pick up. Leads become bent and tangled, and assemblers lose time.

The handy honeycomb cartons prevent leads from tangling and save time.

Bradleyunits are made in ½-watt and 2-watt sizes in standard R.M.A. values from 10 ohms to 22 megohms. One-watt Bradleyunits are available in values from 2.7 ohms to 22 megohms.

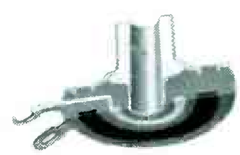
SIZES OF UNITS

Rating	L	D
½-w	3/8"	9/64"
1-w	9/16"	7/32"
2-w	11/16"	5/16"

The heart of the Type J Bradleyometer is the solid-molded resistor element. It is a thick ring, molded to provide any resistance-rotation curve. After molding, heat, cold, moisture, or hard use cannot affect it.

The resistor element is molded as a single unit with insulation, terminals, face plate, and threaded bushing in ONE piece. There are no rivets nor welded nor soldered connections. It is rated at 2 watts with a big safety factor; can be furnished with line switch, if desired, and with any shaft extension.

Type J Bradleyometers can be obtained in single, dual, or triple unit constructions. The Type JW Bradleyometer is a watertight unit for special weatherproof control applications.



Sectional view of Bradleyometer molded resistor element.

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis.

ALLEN-BRADLEY

FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

sistivity is concerned, there is little difference between mixing fine graphite with coarse copper or coarse graphite with fine copper. However the resistivity is much greater in a mixture of exclusively fine particles than in one of fine and coarse particles. Therefore, it appears that the contacts constitute the greater part of the total resistance.

Effects on resistivity and temperature coefficient were studied by varying the amount of zirconium dioxide (ZrO_2), talc ($3MgO \cdot 4SiO_2 \cdot H_2O$), and the type and particle size of graphite. The compositions were dry mixed, compacted at 10 tsi, and sintered as before. Figure 3 shows that the resistivity can be varied from 10^{-1} to 10^{-7} ohm-cm, and the temperature coefficient, indicated by the numbers on the curves, varied from highly positive through zero to negative. The temperature coefficients indicated on the graph were obtained by measuring resistivities at room temperature (25 C), heating the samples to 200 C, and again measuring the resistivities. The figures on the graph indicate the percent of this resistance change relative to the resistance at room temperature, positive figures indicating an increase in resistance with temperature, negative a decrease. Samples of lowest resistivities contained fine crystalline graphite. Whereas in the previous test, small particle size gave high resistance, in this test, small particle size gave low resistance. The relation between particle

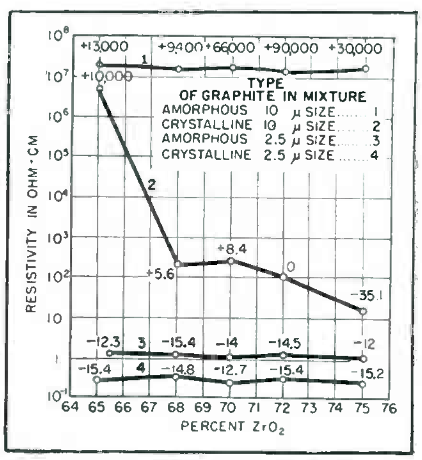
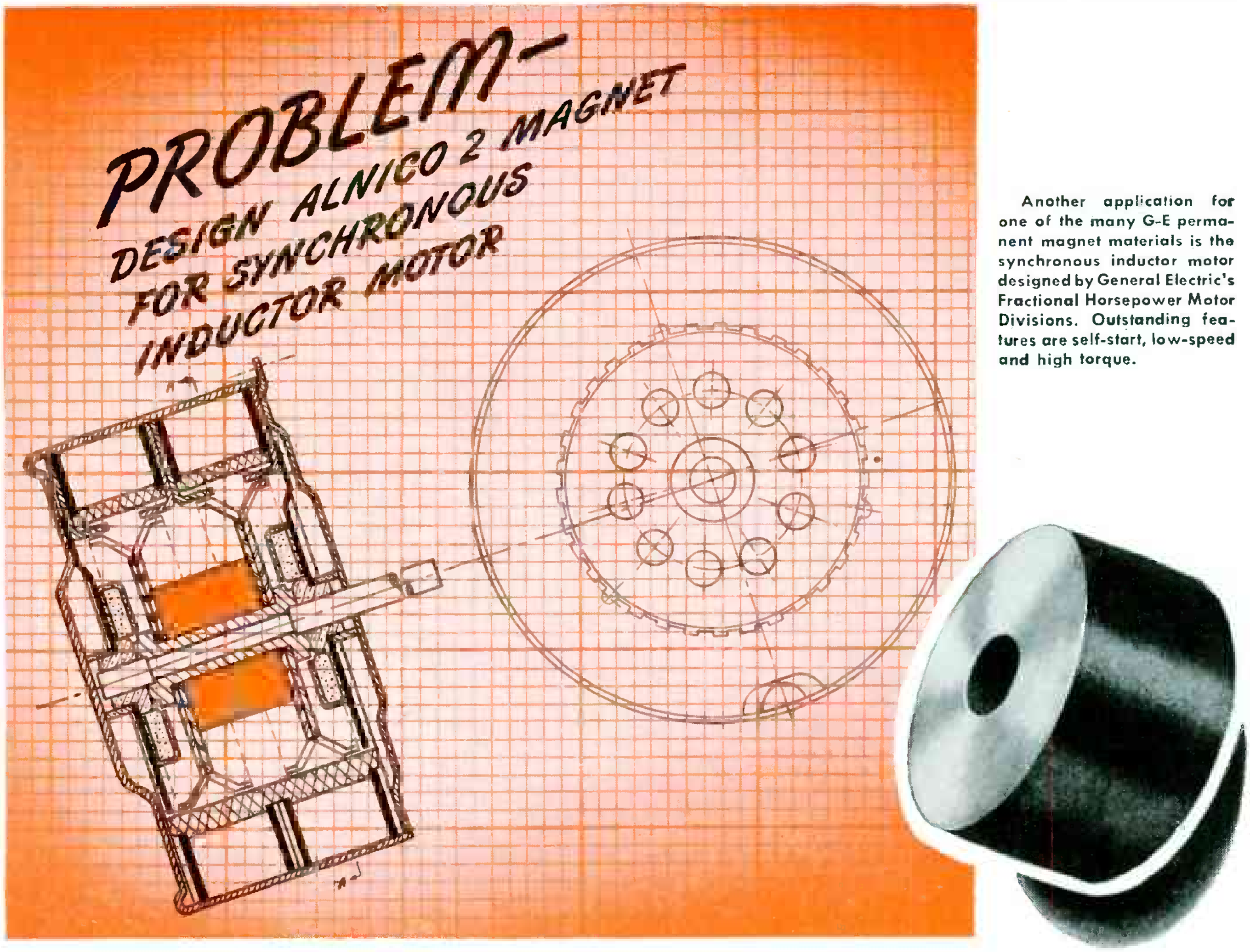


FIG. 3—Resistivity and temperature coefficient can both be varied widely

YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS



Another application for one of the many G-E permanent magnet materials is the synchronous inductor motor designed by General Electric's Fractional Horsepower Motor Divisions. Outstanding features are self-start, low-speed and high torque.

The Magnet that Governs Time

Used widely in industrial timing applications such as traffic signals, motor-operated valves and recording instruments, the G-E self-starting synchronous inductor motor derives its d-c excitation from an ALNICO permanent magnet within the rotor structure. Available in fractional-horsepower sizes, this motor is essentially an inductor alternator operating as a motor with the rotor torque and inertia so designed that it will start and lock in step with the alternating field in one-half cycle.

In addition to the large group of CAST and SINTERED ALNICO permanent magnets, General Electric now offers you greater flexibility of magnet design with the ductile alloys, CUNICO, CUNIFE, and SILMANAL and lightweight nonmetallic VECTOLITE. Be assured of receiving magnets of the highest uniform quality resulting from precise G-E production methods, accurate testing and rigid inspection.

Let us help you with your magnet application problems. General Electric engineers, backed by years of research and magnet design experience, are always at your service. *Metallurgy Division, Chemical Department, General Electric Company, Pittsfield, Mass.*

ANNOUNCING . . . a NEW standard line of G-E ALNICO permanent magnet HOLDING ASSEMBLIES. There are hundreds of places in the factory, store, home and workshop where these powerful magnetic devices can be used to advantage. For complete details, send for our new bulletin.

METALLURGY DIVISION, SEC. FA-1
CHEMICAL DEPARTMENT
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.

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NAME .... TITLE ....
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PERMANENT MAGNETS

GENERAL ELECTRIC

CD48-JA1

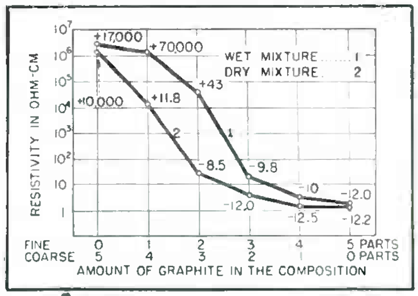

FIG. 4—There is some correlation between resistivity and temperature coefficient

resistance and contact resistance determines the effect of particle size. The samples in the second test with coarse crystalline graphite showed the smallest change in resistance when heated. Materials with practically zero temperature coefficient can be produced in this way.

Distribution of particles in the mixture greatly affects the electrical properties. To study the effect of mixing, identical batches were dry mixed and wet mixed. Wet mixing distributes the particles more uniformly than dry mixing. Samples consisted of uniform amounts of ZrO_2-talc and 5 parts of graphite made of various proportions of coarse (10 micron) and fine (2.5 micron) crystalline graphite. The graph of the results Fig. 4, suggests that temperature coefficient is somehow connected with resistivity, being zero in the region between 10^2 and 10^3 ohm-cm for this particular composition of materials. The correlation between resistivity and temperature coefficient was verified by selecting a series of samples prepared in the same manner but having different resistivities because of nonuniform particle distribution from the dry mixing technique. The low-resistance samples had negative temperature coefficients, the high ones had positive.

Sintering temperature also affects the electrical properties, as shown in Fig. 5. Samples were of ZrO_2-talc and 5 parts crystalline graphite in the fineness shown on Fig. 5; compacted at 10 tsi and fired for 2.5 hrs at the indicated temperatures. The test shows that, although resistivity is largely dependent on particle size, it can be influenced by sintering temperature. Also, in this case the temperature coefficient is larger for higher sintering temperatures, and, in con-

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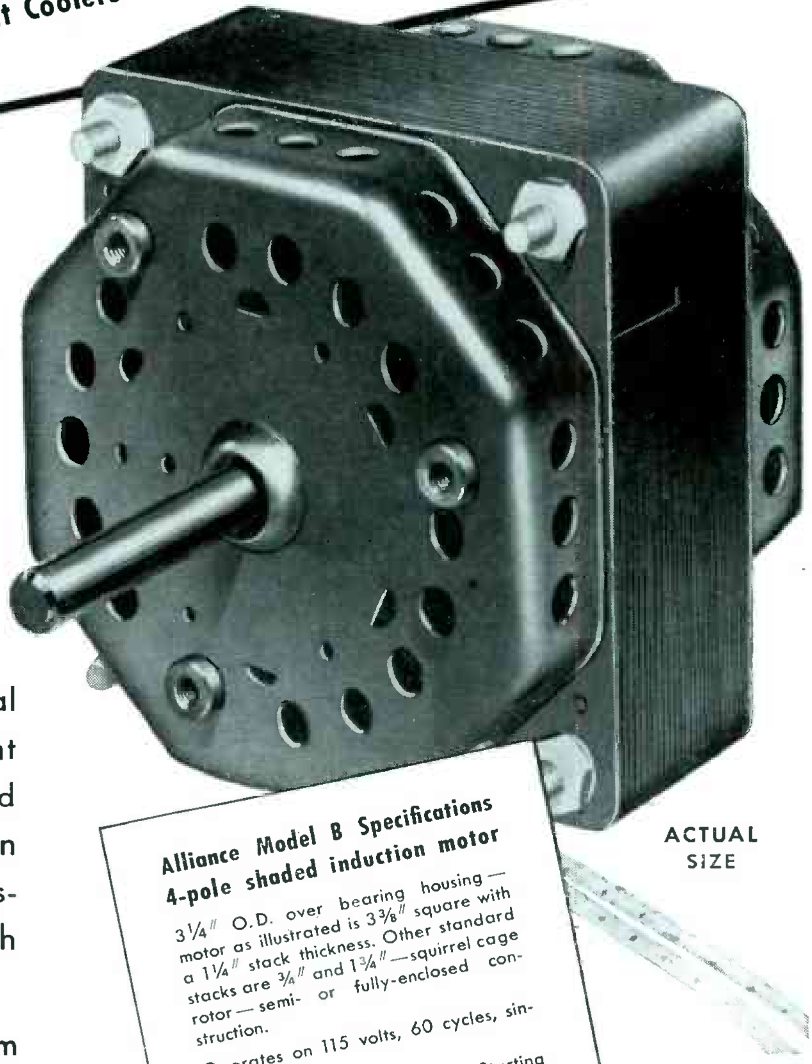


ACTUAL SIZE

Alliance Model B is another new, 4-pole shaded type induction motor. It is especially adapted to fan blades and other mechanical loads.

This motor is made in three standard stack thicknesses with variable horsepower ratings for particular operating conditions such as fan loads—other mechanical loads—continuous or intermittent duty. And to futher meet varied load requirements, Alliance Model B can be supplied semi-enclosed as illustrated or completely enclosed with oil tubes and oilers.

With a range of power ratings from 1/100 h.p. up to 1/25 h.p. and a speed of 1550 rpm, Model B, like all Alliance motors lends itself to mass production at low cost.

Alliance Model B Specifications
4-pole shaded induction motor

3¼″ O.D. over bearing housing—motor as illustrated is 3⅜″ square with a 1¼″ stack thickness. Other standard stacks are ¾″ and 1¾″—squirrel cage rotor—semi- or fully-enclosed construction.

Operates on 115 volts, 60 cycles, single phase.

Weight as shown 4½ lbs. Starting torque approx. 40% of torque at full load rating. Can be made with single or double 5/16″ shaft. Construction is simple but rugged throughout.

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY · ALLIANCE, OHIO
Export Department: 401 Broadway, New York 13, N. Y., U. S. A.

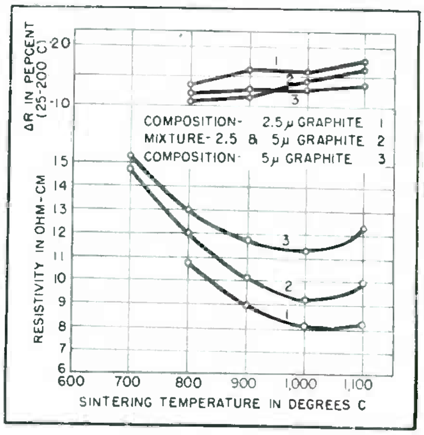


FIG. 5—Resistivity is a complex function of sintering temperature

trast to the conclusions from the preceeding tests, temperature coefficients can be different for samples having equal resistivities.

Although these examples are of specific composite materials, they show that sintered ceramic semiconductors can be developed in a wide variety of resistances and temperature coefficients to meet numerous requirements. (Paper originally presented at National Research Council Conference on Electrical Insulation, September 1947. Cambridge, Mass.)

Radiosonde Potential Gradient Measurements

By R. E. Belin

*Electronics Section
Dominion Physical Laboratory
Wellington, New Zealand*

Measurement of the natural potential gradient below, in, and above cumulo-nimbus clouds was carried out with a modified radiosonde. Potential gradient was measured by point discharge from a collector shown in Fig. 1. The current of

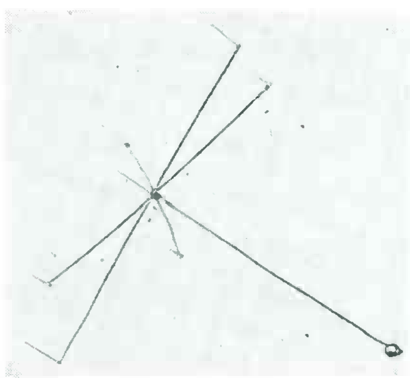
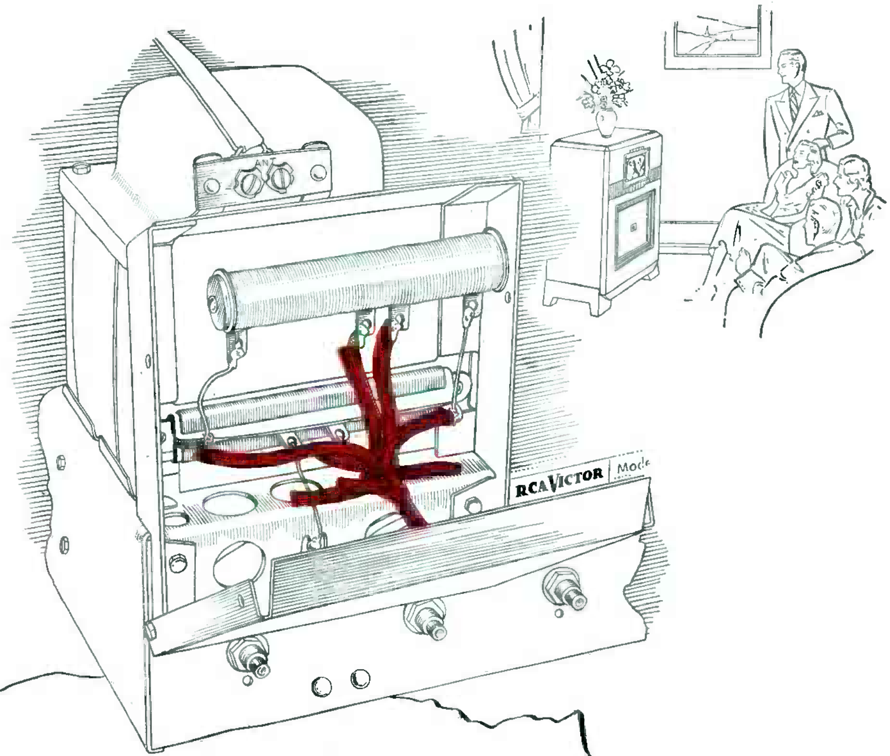


FIG. 1—Two collectors of the construction shown here were used at either end of a long wire to obtain a current proportional to the square of the potential gradient



What this little Sleeving Means to RCA Victor

Look at the chassis of this new RCA Victor television receiver and see how careful "big" companies are about a "little" item like insulation.

The leads to the bleeder resistors in this new television set require a non-combustible insulation with a high degree of flexibility. Temperatures encountered are well over 100°F. That's why RCA Victor engineers selected BH Extra Flexible Fiberglas Sleeving. With BH Fiberglas Sleeving, they not only meet Underwriter's specifications but also provide an extra measure of protection. BH Fiberglas Sleeving is used by RCA Victor in seven production and developmental models of television receivers.

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the discharge was used to control the squegging frequency of a radiosonde, the modified version of which is shown in Fig. 2. The sonde served to relay to a ground recording station.

Collector Discharge

If two sharp points, oriented in opposition, are connected by a conductor and placed in an electric field of suitable magnitude, point discharge will take place. If a large resistance is placed in series with the connecting wire, the discharge current will be

$$i = A\,(F^2 - M^2)$$

where F is the existing potential gradient (greater than M), and M is the minimum gradient required for discharge; A is a constant depending mainly on the sharpness, number, and separation of the points, and, to a lesser degree, on the series resistance.

The discharge current flowing in the resistance produces a voltage that the modified radiosonde measures to transmit a corresponding signal. To calibrate the discharge system, the collectors, connected by the intended series resistor, were placed in an adjustable electrostatic field produced between two large, parallel metal sheets. With these particular collectors, point discharge began at three volts per centimeter. This minimum value had no relation to the number of points, but once discharge was initiated, the current was proportional to the number of points.

Point discharge is also a function

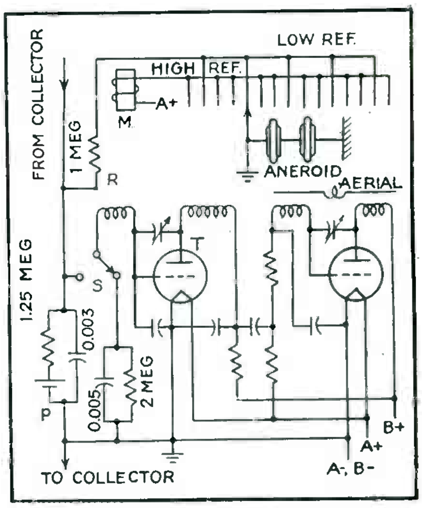

FIG. 2—The radiosonde circuit. Electromagnet M operates switch S

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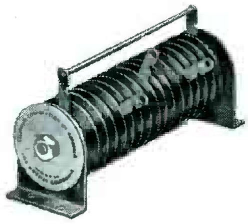

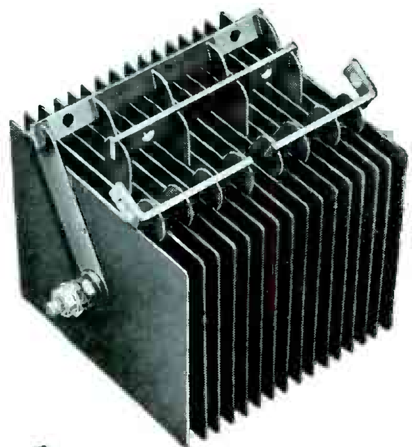

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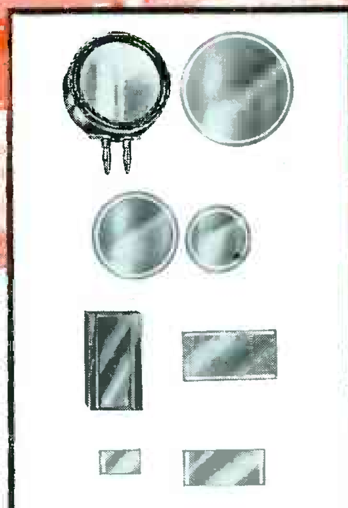

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of pressure, having been shown by Tamm to be related as

$$\frac{i}{i_0} = \left\{\frac{P_0}{P} - \left(\frac{V}{10^5}\right)^{1/3} \ln \frac{P_0}{P}\right\}^2$$

where i and i_0 are the currents at pressures P and P_0 respectively, where, for example, P_0 is the pressure at ground level when the sounding equipment is released. Because the radiosonde also measures the pressure, the actual value of potential gradient during flight can be determined.

Modified Radiosonde

The squegging frequency of the oscillator is determined by the resistance-capacitance combination in the grid circuit, or by the voltage drop developed across the resistor by bias battery P and the point discharge current from the collectors. The switch S introduced an additional resistance-capacitance network into the oscillator which, with a cyclic introduction of resistance R, served to produce a coded sequence of frequency changes dependent on the barometer switch. Thus, it was possible to determine both the pressure and the vertical course of the balloon.

Two collectors with points oriented in opposition were connected, with the radiosonde midway between them, by a 30-gage wire wrapped about a hemp string for strength. The length of this wire, that is, the vertical distance between collectors, was nine half wavelengths of the radiosonde carrier, corresponding to 64 feet. The upper collector was fastened 10 feet below a neoprene balloon that carried the entire equipment aloft. The transmitting antenna consisted of a half-wave dipole fastened parallel to the collector wires, but separated from them by standoff insulators of cork (for lightness) impregnated in polystyrene solution.

Figure 3 shows a typical record obtained by releasing the apparatus beneath a cumulo-nimbus cloud with fracto-stratus formation below. The curve shows the potential gradient variations with altitude, beginning at the ground with 4 v/cm positive; that is, downward. The curve is actually smoothed from the data, there being fluctuation probably caused by variations

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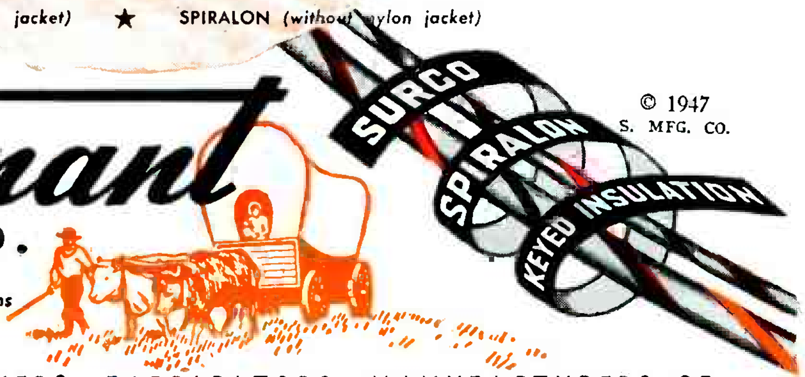

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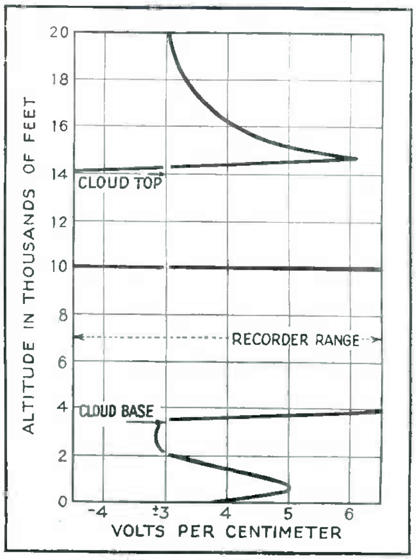

FIG. 3—Record of potential gradient variations with altitude

in the state of ionization with altitude and humidity variations.

The method is applicable to many problems relating to potential gradient measurement. With a greater separation between collectors, measurements could be made in clear weather. The radiosonde could be modified to include measurement of humidity and temperature, thus making it possible to obtain reliable quantitative data on potential variation. The author is indebted to Dr. K. Kreielsheimer for his valuable assistance.

Electromagnetic Amplifiers

MAGNETIC AMPLIFIERS and saturable core reactors can be advantageously used instead of electronic tubes, especially in industrial control. Design and application of these and other nonlinear circuit elements depend on an understanding of both electric and magnetic circuit fundamentals. A bibliography of articles providing such a background concludes this discussion. The listings were suggested by readers in response to the partial bibliography published with the recent article on magnetic amplifiers (ELECTRONICS, p 124, Sept 1947).

Constant-Current Supply

Basic operation of a magnetic amplifier, such as the one illustrated below, is shown by the constant-current supply circuit. Power from a source subject to unwanted variations is delivered at constant

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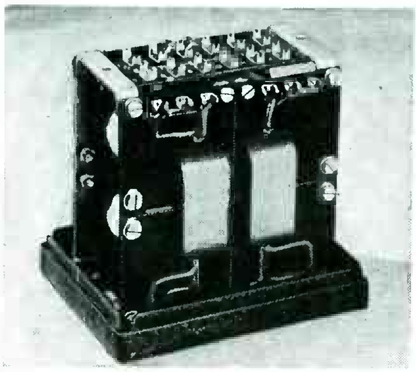
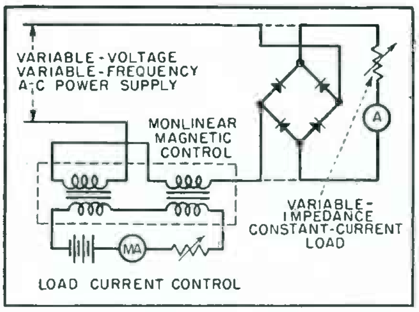


Magnetic amplifier, with case removed, as made by Electro Methods Ltd. (London), enables a few hundredths of a watt to control several watts output (McGraw-Hill World News photo)

current to a load. If direct current is required at the load, it is obtained by the rectifier bridge as shown. If the load requires alternating current, the rectifier bridge is omitted and direct connections made to the load as shown by the dashed lines.

The magnetic control consists of twin saturable reactors of sharply nonlinear voltage-current characteristics. By means of auxiliary windings excited from a controllable d-c, these reactors can be biased to saturation or above. The reactors then have the characteristic of drawing a current from the power source (a-c) the average value of which is directly proportional to the control current (d-c). Thus, only changes in the control circuit can produce changes in the output current of the reactors. Any change in the power supply voltage is counteracted by a change in the voltage absorbed by the reactors. According to the design of the magnetic circuit, any output wave shape from sharp peaks to flat tops can be obtained, the latter being used if the output is to be converted to d-c.

Representative performance of such a magnetic control designed for a full rated output of 2.5 watts with 0 to 20 ma d-c control is 0 to 1 amp a-c or d-c output for an input of 4.5 volts. A 33-percent variation of input power voltage is reduced by the control to a 1.5 percent variation of full rated current output. The magnetic control is comparable to a triode, the control windings corresponding to the grid, with the power supply, a-c windings, and load corresponding to the plate circuit. However, the magnetic circuit is a current device, directly



Magnetic amplifier is usually used for regulation or control

analogous to the d-c magnetron whereas the triode is a voltage device.

Magnetic Amplifier Design

Although the change of inductance with core saturation provides a qualitative understanding of the operation of magnetic amplifiers, the changing inductance during a cycle of operation and the instantaneous energy exchanges must be analysed if a quantative design is to be made. Amplifiers so designed provide power gains of from 1,000 to 100,000 per stage, and have response times from a second to a small fraction thereof, depending on the inductance of the control windings. Although most amplifiers are designed for operation at commercial power frequencies, they are more compact and faster if designed to use higher (400 cps) frequencies.

The basic amplifier element is a high-permeability core on which are several windings. In operation, the a-c output of such an amplifier is peaked on one half cycle and flattened on the other. With two reactors in series opposition, the output will be symmetrical. For self excitation, the a-c flowing in the load of the amplifier can be rectified and applied to the control winding. Under such conditions, auxiliary d-c bias can be used to shift operation to the desired portion of the hysteresis characteristic, or the self excitation can be treated as positive feedback to increase the amplification, or as negative feedback to increase the stability. If sufficient positive feedback is introduced, the amplifier will have a region of instability in which the gain is very high, giving trigger action.

Because the magnetic amplifier is a power-operated device, the impedance of the signal (control) source should match that of the control winding for optimum performance. Likewise, the load should be matched to the amplifier. The load amplifier can be matched to the power source by a conventional transformer, which can be built as part of the electromagnetic circuit. One of the great advantages of the magnetic amplifier, in addition to its ruggedness, is the complete isolation of input and output circuits. Greatest amplification can be obtained with resistive loads. If desired, two amplifiers can be connected in push-pull to give zero load current at zero control signal. Response time of magnetic amplifiers can be shortened by incorporating first differential positive feedback.

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Many readers helpfully called the following articles to our attention. The list, although by no means complete, nevertheless constitutes a starting point for anyone seriously interested in the subject; in addition to articles directly concerned with magnetic amplifiers, there are papers on related magnetic problems, and descriptions of equipment utilizing amplifier principles. The entries are roughly in reverse chronological sequence. Most of them include references to other literature.

Among those making suggestions for this bibliography are T. A. Rogers, Univ. of Calif., Los Angles, L. F. Roehmann, Anaconda Wire & Cable Co., and particularly M. E. Frank, Navy Electronic Lab., San Diego, Calif. The foregoing text is based on information supplied by Mr. Porter of Electro Methods Ltd., London, England.

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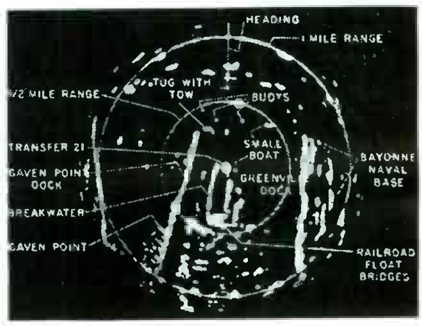
Survey of New Techniques

APPLICATION of radar to harbor craft enabled the New Haven Rail-

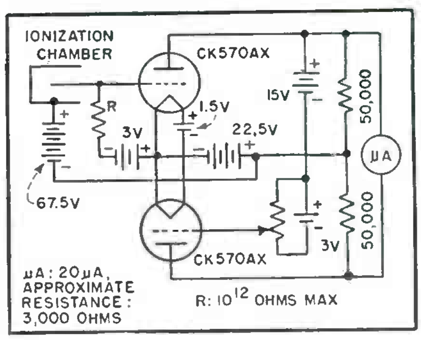
Railroad tug uses radar to assure continuous operation regardless of weather Radar indicator shows location of familiar landmarks and harbor traffic

road's tug "Transfer No. 21" to operate when all other New York Harbor shipping was at a standstill, Oct. 16–17. Using the new Sperry Gyroscope surface search radar on the one-mile range scale, buoys as close as 45 yards are visable on the



12-inch ppi. Without this radar facility the tug would be hampered five or six days a month during the winter. About 50 railroad tugs move over 3,000 cars on floats daily in the New York vicinity.

Ionization Electrometer



As printed on p 182, Nov 1947, the grid resistor of this Zeus ionization chamber electrometer circuit was omitted; the circuit here is correct

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NEW PRODUCTS

(continued from page 142)

Co., N. Y. A new line of professional recording and transcription equipment includes a record lift to aid in cueing, the Model 300 transcription turntable, a recording drive, and the groove indicator Model 151A illustrated. This indicator allows the operator to locate a preselected word or sound on a record instantly.

Midget I-F (14)

STANWYCK WINDING CO., 102 South Landers St., Newburgh, N. Y. Type SM-107 455-kc i-f transformers use Formex wire wound on powdered-

iron cores. They are mounted in a ¾-inch square can 1⅜ inches high. Performance data can be obtained from the manufacturer.

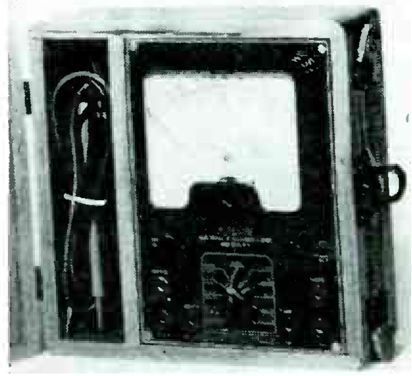
Radioactive Sampler (15)

TRACERLAB, INC., 55 Oliver St., Boston, Mass. Type SC-9A lead-shielded

sample changer and preamplifier provides a means of fast, accurate counting of a large number of radioactive samples. Provision is made for mounting calibrated foil absorbers between sample and Geiger tube.

Volt-Ohm-Milliammeter (16)

ELECTRONIC MEASUREMENTS CORP., 423 Broome St., New York, N. Y. The Volometer Model 120 has an alternating voltage sensitivity of



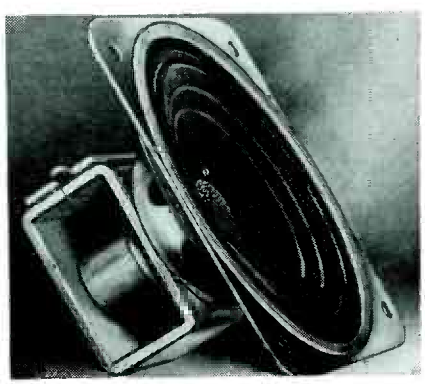
10,000 ohms per volt and a resistance range from 0.2 ohm to 300 megohms. Accurate to 1 percent up to 1 megacycle, the new unit uses an easily replaced battery.

Ignition Analyzer (17)

BENDIX-SCINTILLA Co., Sidney, N. Y. The electronic Ignition Analyzer gives a cathode-ray-tube indication of faults in ignition systems and permits a quick check on ignition adjustments. Fully portable, it operates on 115 volts 60 to 400 cycles.

Small Loudspeakers (18)

WM. J. MURDOCK Co., 158 Carter St., Chelsea 50, Mass. Type L301



3-inch and L401 4-inch permanent-magnet loudspeakers for original and replacement use use 1.47-ounce Alnico V magnets, RMA-standard 3.2-ohm voice coils, and preformed cones. Special impedance values are also available for intercommunication applications.

Choke (19)

J. W. NEWTON CO., INC., 234 Seventh Ave., New York 11, N. Y. The type 23 choke is a small inductor for use in midget microphones, hearing aids, and similar applications. With a maximum current

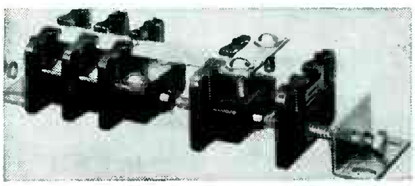
carrying capacity of 2 ma, the unit has an inductance of 16 henrys at 0.5 ma d-c, but can be furnished up to 70 henrys. Weight of the choke illustrated is ½ ounce.

Wow Meter (20)

FURST ELECTRONICS, 800 W. North Ave., Chicago 22, Ill. Model 115 is a direct indicating instrument for the measurement of variations and fluctuations of the speed of phonograph turntables and similar mechanical or optical equipment. Described at length in a technical bulletin, the device is adaptable to auxiliary apparatus such as direct-inking oscillograph or a vibration analyzer.

Build-Up Terminal Block (21)

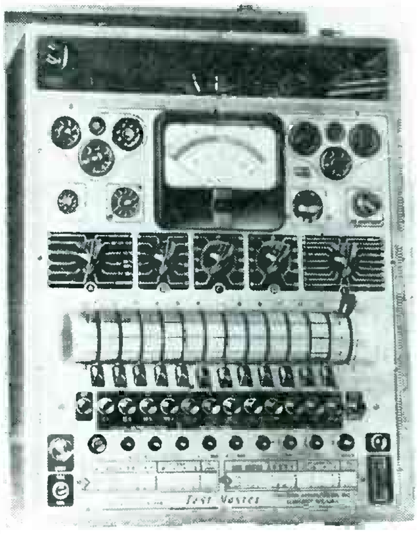
CURTIS DEVELOPMENT & MFG. CO., 1 North Crawford Ave., Chicago 24, Ill. The type B terminal blocks



illustrated can be built up in the desired number of units from 1 to 14. They are sold in kit form and are described in Bulletin DS-118.

Master Tester (22)

PRECISION APPARATUS CO., INC., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y. Series 10-20 Test Master is a dynamic type tube



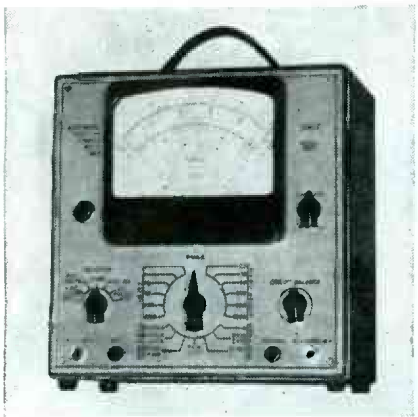
tester that accommodates 12 elements and can be used for all standard receiving and low power transmitting tubes including acorns, Noval 9-pins, and dual-capped high-frequency amplifiers. A new 1948 catalog describes this as well as other equipment.

Improved Attenuator (23)

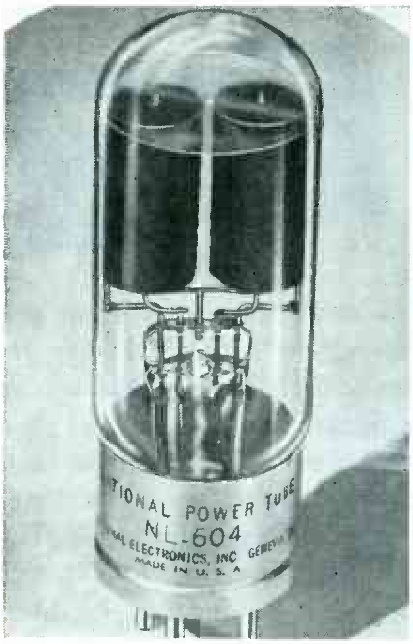
DAVEN CO., 191 Central Ave., Newark, N. J. A one-piece molded terminal board with tinned brass lugs is now included as a standard feature of the company's line of controls.

Test Meter (24)

TRIPLETT ELECTRICAL INSTRUMENT Co., Bluffton, Ohio. Model 2450 volt-ohm-milliammeter has a high input



impedance, d-c range up to 1,000 volts and a-c up to 5,000 volts. Resistance can be measured to 1,000 megohms. A cathode follower circuit is used at the input. Power supply is regulated.

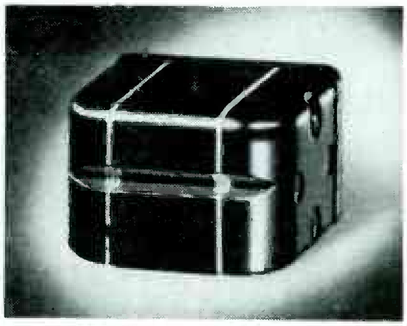


Industrial Rectifier (25)

NATIONAL ELECTRONICS, INC., Geneva, Ill., Type NL-604 full-wave rectifier tube has a quick heating filament. It is rated for 250 volts output at 2.5 amperes d-c. A gas and mercury filling gives quick starting over a broad temperature range. The tube has been designed for electronic motor control circuits.

Wire Recording Heads (26)

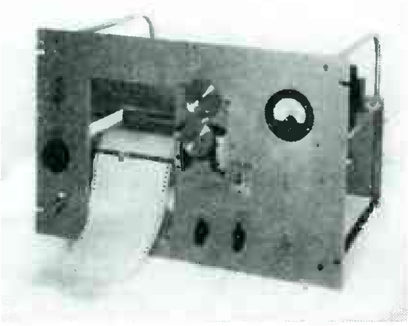
SHURE BROTHERS, INC., 225 W. Huron St., Chicago 10, Ill. Type



WR16 wire recording head illustrated is one of three types available for recording and playback.

Audio Recorder (27)

SOUND APPARATUS CO., 233 Broadway, New York 7, N. Y. Model FR-1 frequency response recorder used in audio measurements is now available for rack mounting. The device has two motors, one or two



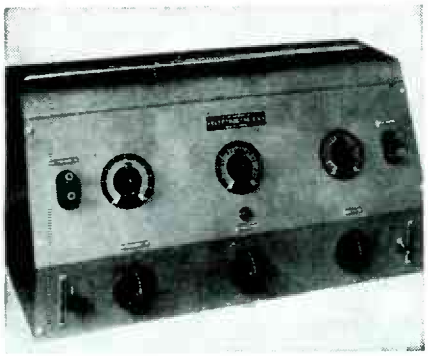
paper speeds as desired, and provision for mechanical linkage to the oscillator used in making the measurements.

Cueing Attenuators (28)

SHALLCROSS MFG. CO., Collingsdale, Pa. A new line of attenuators has a special switching mechanism to transfer input to a pair of separate output terminals for cueing. Any standard ladder, bridged-T, straight-T, or potentiometer can be thus equipped. The cueing position is at the extreme counterclockwise end following the off position.

Pulse Generator (29)

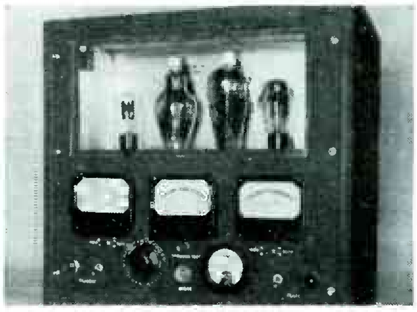
ELECTRODYNE CO., 899 Boylston St., Boston 15, Mass. Model 471 pulse generator produces rectangular pulses at rates from 0.5 to 1,000 cps with internal trigger. An external positive trigger of 20 volts can also



be used. Pulse duration is adjustable from 25 to 950 microseconds. Maximum amplitude is 50 volts in 10,000 ohms.

Welding Tube Tester (30)

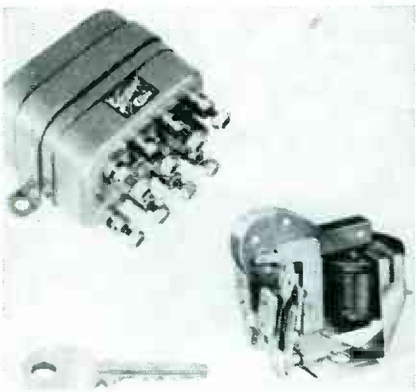
SIERRA ELECTRONIC CORP., San Carlos, Calif. A new tester designed specifically for welding control tubes indicates emission, internal



shorts, and by means of a cathode-ray oscilloscope that can be attached, the life expectancy of the tube under test.

Aircraft Relay (31)

COOK ELECTRIC CO., Chicago 14, Ill. Type Hy-G 400-cycle relay has been designed for stable operation under accelerations as high as 30 g. Practically any spring combination can be obtained and the whole assembly can be supplied in a hermetically



sealed container. A bulletin is available giving detailed information.

Electronic Transcriber (32)

DICTAPHONE CORP., 420 Lexington Ave., New York 17, N. Y. An improved electronic transcribing machine, model BE, for business office use has just gone into production.

It is described in leaflet P-775. Use of the vacuum-tube technique makes possible several refinements not possible with mechanical recording.

A-M and F-M Tuner (33)

MEISSNER MFG. DIV., Mt. Carmel, Ill. Covering the a-m and high-frequency f-m bands, a new tuner illustrated is now available. Designed to work into an audio system,

the frequency response of the tuner is flat within plus or minus 2 db from 3 to 15,000 cycles.

Hum Filter (34)

KALBFELL LABORATORIES, INC., 1076 Morena Blvd., San Diego 10, Calif. Model 502-A bridged-T hum filter

for high-impedance instruments such as oscillographs eliminates stray 60-cycle pickup even when open leads are used. Filters can also be supplied for other frequencies, such as 120 cycles. Price is $8.50.

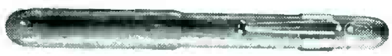
Industrial Socket (35)

AMERICAN PHENOLIC CORP., 1830 South 54th Ave., Chicago 50, Ill. Type 146-116 electron tube socket accommodates tubes with the RMA

superjumbo base as well as 411 and similar bases. Mounting above or below a horizontal panel is possible. Contact resistance is less than 0.001 ohm at 25 amperes.

Radiation Exposure Meter (36)

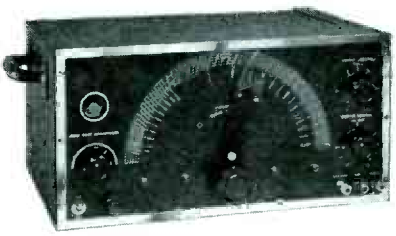
INSTRUMENT DEVELOPMENT LABS., 223 West Erie St., Chicago, Ill. Model 3340 pocket ionization cham-



ber is similar in appearance to a fountain pen and is used by laboratory operators working with radioactive materials as a check on their exposure.

Sweep Oscillator (37)

CLOUGH BRENGLE CO., 6014 Broadway, Chicago 40, Ill. The new model 182A Audiomatic Generator has a



sweep rate of from 5 to 8 seconds for the semiautomatic testing of amplifiers, speakers and similar equipment. By sweeping a standard oscilloscope a visual plot of frequency-amplitude characteristics is presented.

Miniature Selenium Rectifiers (38)

RADIO RECEPTOR CO., Inc., 251 West 19th St., New York 11, N. Y. A new line of miniature selenium rectifiers to replace rectifier tubes in a-c and d-c battery portable radio receivers, console radios and vibrator supplies are now in production. Detailed specifications are available from the manufacturer.

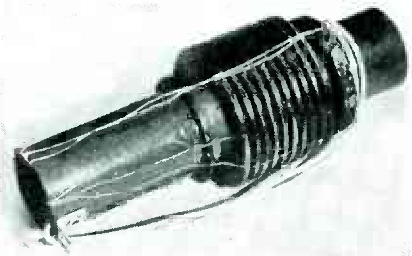
VHF Plane Radio (39)

GENERAL ELECTRIC CO., Syracuse, N. Y. A new vhf personal plane transmitter type AT-3A has been designed as a means of communicating with tower and radio range

stations. Operating from a 12-volt battery, the unit has an output power of 1 watt. It has a range of about 50 miles at 5,000 feet on any of the six vhf channels assigned to this service.

R-F Power Coil (40)

ELECTRONIC ENGINEERING SERVICE, Box 72, Ridgewood, N. J. A line of



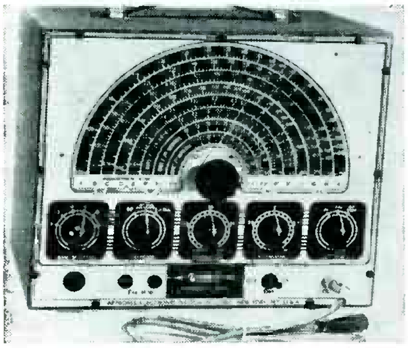
r-f power supply transformers for use in television receivers, cathode-ray oscilloscopes and similar equipment includes output voltage ratings of 1, 2.5, 4, 5, and 10 kilovolts, all rated at 250 microamperes. Each includes primary, secondary, feedback, and rectifier filament windings. Coils are treated with Q-Max and sell for from $2 to $8 depending on voltage.

Cable Tester (41)

ALLEN B. DU MONT LABS., INC., Passaic, N. J. The cable tester operates on the same core-loss principle as the cyclograph. The test coil used is connected by a short length of cable to the small oscillator unit located close to the wire rope under test. The oscillograph unit is usually kept at a distance from the actual test. The frequency response of the circuits has been adjusted to give optimum performance at the test frequency used in the inspection of wire rope.

Signal Generator (42)

APPROVED ELECTRONIC INSTRUMENT CORP., 142 Liberty St., New York, N. Y. Signal generator model A-



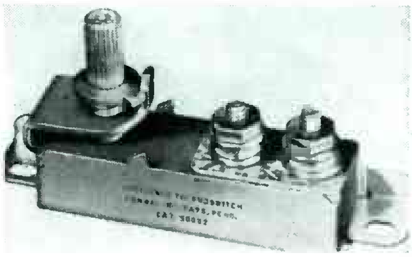
200 with a frequency range from 100 kc to 75 mc, equipped for operation with either external or internal (440-cycle) modulation, uses four receiver type tubes. The equipment has been recently modified.

Public Audio (43)

BARDWELL & McALISTER, INC., Box 1310, Hollywood 28, Calif. A new series of public address systems, as well as sound and recording equipment for the motion picture industry is described in a catalog recently issued.

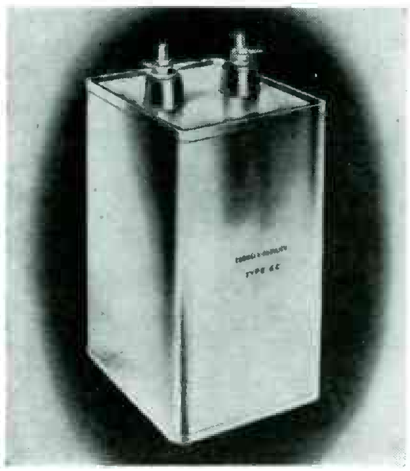
Appliance Thermostat (44)

FENWAL, INC., Ashland, Mass. Two new Thermoswitches providing control over the temperature ranges 175 to 600 F, and 50 to 500°F have a maximum loading of 1,200 watts on 110-volt 60-cycle lines. Additional information on uses and characteristics of these thermostats is available from the manufacturer.



Television Capacitors (45)

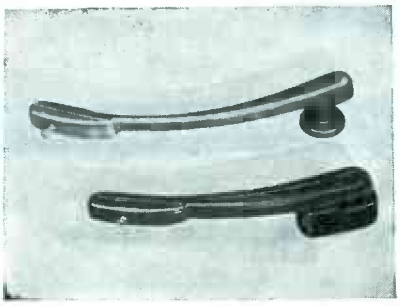
CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. A new series of television capacitors impregnated and filled with Dykanol and hermetically sealed is now



available in various capacitance and voltage ranges. The type GC1A00 illustrated is a filter type.

Reluctance Pickup Arm (46)

AMPLIFIER CORP. OF AMERICA, 396 Broadway, New York 13, N. Y. Two types of pickup arm for use with the GE variable reluctance



pickup are now in production. Model 160GE is for recordings up to 16 inches in diameter, while the less expensive model 120GE is for use with recordings up to 12 inches.

Photoflash Transformers (47)

UNITED TRANSFORMER CORP., 150 Varick St., New York 13, N. Y., has announced a new series of transformers designed especially for

photoflash use. The series includes a transformer for use from 110-volt lines, one for battery-powered application, and a trigger type to be used in conjunction with either. Leaflet No. PF contains circuits and other design details.

Polar Recorder (48)

AIRBORNE INSTRUMENTS LAB., INC., Mineola, N. Y. Designed originally to plot aircraft antenna patterns,

the type 116 recorder can be used to plot voltage on either a linear or logarithmic scale as radial distance against angular position. It can be provided in either rack-mounted or portable form.

Battery VTVM (49)

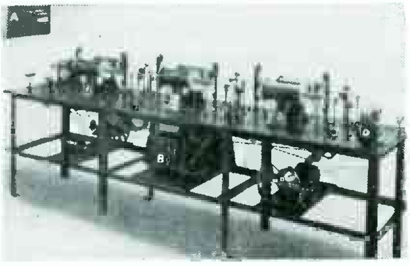
RADIO CORP. OF AMERICA, Camden, N. J. The Battery Voltohmyst type WV 65-A is a selfcontained vacuum tube voltmeter using internal batteries. A neon lamp flashes during the period that the instrument is in operation to warn that the battery is in service. A crystal probe extends the voltage range to frequencies as high as 100 megacycles. Total weight is 9 pounds.

10-Kw F-M (50)

RADIO CORP. OF AMERICA, Camden, N. J. Type BTF-10B 10-kw transmitter now in production uses grounded-grid circuits for operation in the 88 to 108 megacycle band. Modulation is accomplished at low-power r-f level by means of a push-pull reactance tube circuit. A separate frequency control circuit maintains the transmitter on the assigned carrier frequency. Provision is made for switching the antenna to the intermediate power amplifier so as to facilitate maintenance or repairs on the final stage.

Filament Coater (51)

EISLER ENGINEERING CO., INC., Newark 3, N. J. Equipment for coating wires used as filaments in



electron tubes is now available with six controlled-heat furnaces and a variable-speed winding device.

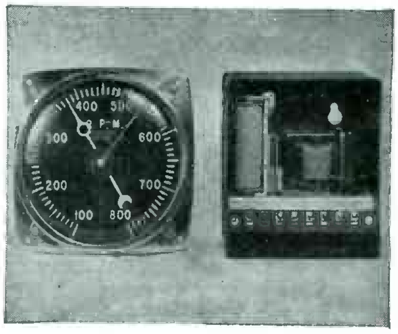
Strain Indicator (52)

NOSKER ENGINEERING PRODUCTS, Yellow Springs, Ohio. Model 5 strain indicator is a portable direct-reading instrument for measuring

static strain from as many as 10 wire-strip strain gages. Bulletin 5 gives details.

Tachometer Control (53)

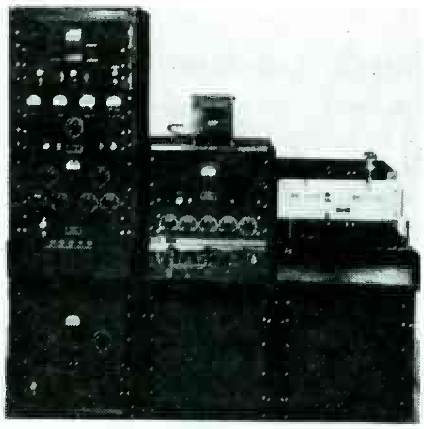
JONES MOTROLA CORP., 432 Fairfield Ave., Stamford, Conn. A centrifugal type tachometer is equipped with an electronic control using one tube. When a predetermined speed has been reached the device shuts off the equipment or sounds an alarm. The model 210 equipment



can be supplied with an indicating dial in any terminology desired and a six-figure counter to give the total run is likewise available.

Mass Spectrometer (54)

PROCESS AND INSTRUMENTS, 60 Greenpoint Ave., Brooklyn 22, N. Y. Model M 60 mass spectrometer illustrated is a 60-degree type in which mass scanning is performed manually by varying the accelerating



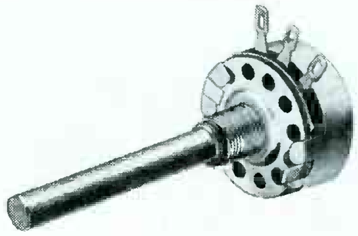
voltage. Ion beam intensity for each mass is measured by a null-point method. Bulletin sheet MS 1 gives further details.

Chemical Level Control (55)

PHOTOSWITCH INC., 77 Broadway, Cambridge 42, Mass. Level control type 10CB1X has been designed for general application with particular consideration of chemical processing problems. Two probe rods are required for high and low level points. The output circuit will handle 2 amp at 115 v.

Molded Composition Pot (56)

OHMITE MFG. CO., 4974 West Flournoy St., Chicago 44, Ill. A new 2-watt potentiometer type AB is car-



ried in sixteen stock resistance values from 50 ohms to 5 megohms. It is fully described in Bulletin 131.

Folded Dipole (57)

RADIO CORP. OF AMERICA, Camden, N. J. Type 288 folded-dipole antenna is supplied with a 5-foot wooden mast and all mounting brackets and hardware necessary for installation.

Airlines Transmitter Meter (58)

GABLES ENGINEERING, Box 751, Coral Gables, Florida. Designed for airlines use to check percentage of modulation and relative field strength, the Model G-232 modulation meter is completely selfcontained, uses neither batteries nor tubes, and covers the frequency range 300 kc to 300 mc with an accuracy better than 5 percent.

Self-Tuning H-F Converter (59)

AJAX ELECTROTHERMIC CORP., Ajax Park, Trenton 5, N. J. The 20-kw high-frequency converter for induction heating and melting features simple controls, safety interlocks, and streamlined housing. The electrical circuit of the converter is self-tuning, with frequencies varying from 20,000 to 80,000 cps, depending on the size and shape of the furnace coil to which it is connected. Power supply is single phase a-c, usually 208, 220, or 440 volts.

Welding Timer (60)

PHOTOSWITCH, INC., 77 Broadway, Cambridge 42, Mass. Electronic welding timer Type 30CR3 is designed for interval timing of welding operations over a range of 3 to 120 cycles. It is recommended for all general-purpose spot welders and fulfills the specifications of NEMA Class 1A Timers. It is applicable

to manual, air or motor operated welding equipment requiring either beat or non-beat operation.

High-Voltage Ignitron (61)

GENERAL ELECTRIC CO., Schenectady, N. Y. Type GL-5630 rectifier is suitable for applications requiring up to 3,000 kilowatts of d-c power. Peak forward or inverse voltage is 20,000 volts, peak current is 200 amperes and average current 50 amperes.

High-Fidelity Amplifier (62)

ALLIED RADIO CORP., 833 West Jackson Blvd., Chicago 7, Ill. The new Knight, 20-watt, phonograph amplifier has less than 2-percent harmonic and less than 8-percent intermodulation distortion at maximum

output. Tone controls are provided but set in the normal position response is flat within plus or minus 1 db from 20 to 20,000 cycles. Various output impedances are furnished.

Airflow Switch (63)

JENCKES KNITTING MACHINE CO., ROTRON DIV., 180 Weeden St., Pawtucket, R. I. An airflow switch used with forced-air-cooled transmitting tubes can be mounted with a single screw. A lightweight vane protruding into the air stream sustains contact for pressures developed at air velocities of from 1,000 to 2,600 feet per minute. With a contact rating of 5 amp a-c at 250 volts, the switch guards against stalling of the blower or obstructions in the ducts.

Beacon Antenna (64)

GENERAL ELECTRIC CO., Syracuse, N. Y. The type EY3A high-gain beacon antenna is designed for two-way radio communication in the 152 to 162 megacycle band. The multi-element antenna has a power gain of two and a half over a coaxial dipole. The array is contained in a weatherproof housing, has a circular azimuth pattern and an impedance of 50 ohms.

Grid-Control Rectifiers (65)

CONTINENTAL ELECTRIC CO., Geneva, Ill. Types CE-320 and CE-322 are mercury-vapor and gas filled. Principal ratings of the CE-320: filament, 2.5 v, 9 amp; max average current, 2.5 amp; max peak current, 30 amp; max peak inverse voltage, 1,250 v. The CE-322, also used in welding control, motor control and similar operations has ratings as follows: filament, 2.5 v, 20 amp; max average current, 6.4 amp; max peak current, 80 amp; max peak inverse voltage, 1,500 v.

Bayonet Sockets (66)

DRAKE MFG. CO., 1713 Hubbard St., Chicago, Ill. A new line of improved double-contact candelabra bayonet type socket assemblies has recently been announced. They are

completely described in a new catalog just issued on the complete line of assemblies.

Capacitance Bridge (67)

SYLVANIA ELECTRIC PRODUCTS, INC., 500 Fifth Ave., New York 18, N. Y. Type 125 capacitance bridge suitable for measuring tube interelectrode capacitances provides a range from 0 to 100 micromicrofarads. Ground to lead or jig capacitances can be tuned out when the combined values do not exceed 25 $\mu\mu$f.

Cable-Type Transformer (68)

AMPERITE CO., 561 Broadway, New York 12, N. Y. A new cable-type input transformer can be used for coupling a low impedance microphone to a standard high-impedance amplifier input. Frequency response is within plus or minus 2 db from 50 to 12,000 cycles.

Xenon Rectifier (69)

ELECTRONS, INC., 127 Sussex Ave., Newark 4, N. J. Type EL6B is a new xenon gas rectifier particularly applicable to industrial service such as motor control, magnetic devices

and other loads requiring large amounts of d-c power. Rectifiers using the tube can be built for d-c output up to 440 volts, 12.8 amperes single phase or 650 volts, 19 amperes polyphase.

Permeability Tuners (70)

AERMOTIVE EQUIPMENT CORP., 1632 Central St., Kansas City, Mo. Three types of permeability tuners are now available to the set manufacturer and distributor. Types A210 and A230 consist of a tuned antenna and oscillator circuit with a tapped oscillator coil to match. The type A260 replaces a single-section capacitor and antenna coil. Each unit is individually packaged with complete instructions and a circuit diagram.

Strip Chart Recorder (71)

WHEELCO INSTRUMENTS CO., 847 W. Harrison St., Chicago, Ill. The Capacilog is designed for the measurement, indication, control, and permanent record of variables in the process industries. Operating on 115 or 230 volts, 25, 50, or 60 cycles, it is available in a wider number of models using a variety of control systems. Maximum power consumption is 60 watts.

Literature

(72)
Testing Equipment. Hewlett-Packard Co., 1513A Page Mill Road, Palo Alto, Calif. Eleven new instruments developed since 1945 are briefly mentioned in a folder recently issued. They include voltmeters, oscillators, audio and high-frequency equipment, for testing or monitoring.

(73)
Wire Recorder. Magnecord, Inc., 304 West 63rd St., Chicago 21, Ill. A brochure describing the Magnecorder professional wire recorder type SD-1 indicates overall response, distortion curves, and method of operation.

(74)
Ten-Turn Pot. Gibbs Div., Geo. W. Borg Corp., Delavan, Wis. The Micropot is a linear, wire-wound potentiometer that can be supplied in several resistance values and finds use as a circuit component in such applications as servomechanisms. Write for details.

(75)
Turntables. Rek-O-Kut Co., 140 Grand St., New York 13, N. Y. Two

new folders have been released that describe dual-speed turntables, overhead cutting mechanisms, and accessories of interest to audio engineers.

(76)

Connectors, Mines Equipment Co., 4215 Clayton Ave., St. Louis 10, Mo. Bulletin MC107 describes connectors particularly adapted to mining, railroad, and maritime operations.

(77)

Electric Plants. D. W. Onan & Sons, Inc., Minneapolis 5, Minn. Form A-138 is a 16-page catalog covering electric plants ranging from 350 to 35,000 watts a-c. In the d-c type, selection ranges in 115-volt models run from 600 to 10,000 watts, and in 230-volt models from 3,500 to 10,000 watts. Battery charging plants are also described.

(78)

Shipboard Radar. Radiomarine Corp. of America, 75 Varick St., New York 13, N. Y. Designed for commercial shipping requirements, the CR-101 shipboard radar uses the 3.2-cm shf band and has a 12-inch c-r scope. See Bulletin MS-15 for an illustrated description complete with dimensional diagrams and specifications.

(79)

Carrier Communication Units. Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 30, Pa. Booklet B-3882 illustrates and describes the type JY power line carrier equipment. Included are the two frequency duplex, manual simplex, and automatic simplex transmitter-receiver assemblies with their component parts.

(80)

Tubing. Superior Tube Co., Norristown, Pa. A 15-page folder with quick reference chart and other data on various types of fine small metal tubing clearly outlines this company's services and products available to the electronic industry.

(81)

Glass Fibers. Glass Fibers Inc., Waterville, Ohio. The makers of Vitron glass fibers present a brochure describing products used in the textile, wire, electrical, and plastics industries.

(82)

Plastic Tubing. Wm. Brand & Co., 276 Fourth Ave., New York 10, N. Y. A new extruded plastic tubing type REL-16 is heat-resistant although thermoplastic. A laboratory report is available.

(83)

High Current Resistors. Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y. Sales bulletin 35 describes Edgeohm, Barohm, and Loopohm resistors for high current applications.

(84)

Capacitor Catalog. Solar Capacitor Sales Corp., 1445 Hudson Blvd., North Bergen, N. J. Catalog SC-2 is the complete new 1948 offering of capacitors and radio noise filters.

(85)

Television Studio Equipment. Television Projects, Inc., 24 Walnut St., Newark 2, N. J. A packaged television rehearsal studio equipment is available for schools, department stores, or as auxiliary equipment for broadcasters in demonstration programs. Send for a 6-page brochure that lists equipment comprising the assembly.

(86)

Material Inspection. North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y. Entitled "Inspecting Incoming Material" a folder suggests procedures to be followed from the time material arrives in a plant until it is finally accepted or rejected.

(87)

Television Broadcasting. Allen B. Du Mont Laboratories, Inc., 42 Harding Ave., Clifton, N. J. Two attractive catalogs have recently appeared, one covering an image orthicon chain and the other the so-called master series television transmitter. Complete details and specifications together with illustrations will make it easy for the prospective broadcaster to choose equipment and file application.

(88)
F-M Transmitter. Radio Engineering Labs., 35-54 36th St., Long Island City 1, N. Y. The Quadriline 10-kw f-m transmitter is pictured in a 4-page brochure that lists its principal characteristics.

(89)
Church Amplifiers. Riggs & Jeffreys, Inc., 73 Winthrop St., Newark 4, N. J. In a recent 12-page brochure the many units and combinations of Electron Bell amplifying devices for churches are described. Also included is a full list of prices. Installation costs will be furnished on request.

(90)
Recording Equipment. Rek-O-Kut Co., 146 Grand St., New York 13, N. Y. Several items of recording equipment such as a new 12-inch dual speed turntable and overhead cutting mechanism are listed in a 4-page illustrated catalog sheet.

(91)
Test Speaker. Coastwise Electronics Co., Inc., 130 North Beaudry Ave., Los Angeles 12, Calif. Ferret model 721 test speaker provides a substitution unit that can be matched to any output transformer. A sheet also describes the substitution choke and capacitor.

(92)
Supervisory Systems. The Autocall Co., 4747 Tucker Ave., Shelby, Ohio, has released a new catalog on supervisory systems for both public utility and industrial power plants. In it is described the printing recorder, which automatically prints a complete log record of all station operations when there is trouble or when an unusual condition of equipment is involved. Also included are various styles of annunciators.

(93)
Millisecond Relay. Stevens-Arnold, Inc., 22 Elkins St., South Boston 27, Mass. The high-speed d-c relay operating at less than a milli-

second has been further improved with a shielding coil between operating coil and contacts. Catalog 105A gives details and prices.

(94)

Industrial Photoelectric Equipment. Worner Electronic Devices, Rankin, Ill. A 10-page catalog is now available listing various types of photoelectric controls for industry. Burglar alarms, combustion controls, and amplifiers are described.

(95)

Replacement Transformers. Crest Transformer Corp., 1834-36 W. North Ave., Chicago 22, Ill. Developments and refinements, resulting from extensive war production research on replacement transformers, are reflected in a catalog recently issued.

(96)

Coaxial Switches. Designers for Industry, Inc., 2915 Detroit Ave., Cleveland 13, Ohio. Several types of coaxial switches, their vswr-frequency curves and physical characteristics are outlined in a leaflet that will be of interest to all engineers using coaxial cables.

(97)

Laminated Plastics. General Electric Co., Pittsfield, Mass. Complete information on the manufacture, application engineering and properties of all types of Textolite laminated plastics may be found in a new 64-page booklet. Listed therein are 44 different grades of the sheet material along with their electrical, physical and mechanical properties.

Microwave Catalog. DeMornay-Budd, Inc., 475 Grand Concourse, New York 51, N. Y. Available to firms in the electronic and allied fields when requests are made on company stationery is a new loose-leaf catalog describing a line of microwave test equipment for the X and K bands as well as standard components for the X band. Sections 1 and 2 of the company's Electronics Catalog are now available. These 36 pages are devoted to a discussion of introductory concepts to microwaves that engineers will find useful reading.

NEWS OF THE INDUSTRY

(continued from p 146)

cil of Hollywood, under the cochairmanship of John K. Hilliard of Altec Lansing Corporation and J. W. Bayless, chairman of the subcommittee on processing standards.

Joint meetings of the Club and Council have already produced a body of recommended standards as well as the first of a series of questionnaires to be reprinted and circulated among all organizations affected by the standardization project. First questionnaire to be sent out is a glossary on disc recording and processing terms, entitled "List of Preferred Terms for Disc Recording."

Rochester Fall Meeting

COMMITTEE ACTIVITIES of the IRE and RMA for the 1947-48 season got into full swing at the Rochester Fall Meeting held November 17-19 with an attendance of 856. Of most direct and current interest to radio manufacturers is the liaison provided by the RMA Safety Committee with the Underwriters Laboratories. Until U.L. has revised their recommendations to embrace features found in a-c/d-c and television receivers, the Safety Committee will endeavor to reconcile safety requirements with design trends.

Much technical information on receiver and instrument design was presented in the 16 papers of the six well attended technical sessions. However the chief function of the Fall Meeting is to provide an informal and sociable opportunity for engineers to exchange views in and out of committee sessions. Topics of conversation tended toward use of miniature tubes, persisting scarcity of basic materials (especially steel and copper), the growing cost of production, and the expansion of television.

At a nontechnical session E. F. Carter of Sylvania Electric Products examined the responsibilities of engineers in today's economy. The full attendance and numerous comments from the floor indicated that, although engineers are of many different opinions on the subject, they all recognize the importance of individual participation in shaping national and local policies.

F. S. Barton, representing Brit-

ish radio interests, spoke at the Fall Meeting Dinner. British radio effort, he said, is being directed toward developing lighter equipment for use on remote broadcast pickups and improving existing facilities. Next day he showed a motion picture of robot manufacture of an inexpensive, single channel receiver for the British export trade. Most of the technical papers have or will shortly be published in radio magazines.

Chicago Conference

MORE than 2400 electronic engineers, technicians, educators, and students registered to attend the sessions of the National Electronics Conference which was held November 3, 4, and 5 at the Edgewater Beach Hotel in Chicago, according to final figures from the Conference Committee. At this meeting, 78 papers were presented, and the products and publications of 44 manufacturers, publishers, and organizations were displayed.

Activities were opened with a general meeting presided over by W. L. Everitt, head of the electrical engineering department at the University of Illinois and executive vice-president of the conference. At this general meeting, George D. Stoddard, president of the University of Illinois, stated that we cannot escape from science and technology—that the choice before us is one of "science and civilization versus science and destruction". Speaking next, L. V. Berkner of the Joint Research and Development Board pointed out that future developments in our field will lie in the solution of "systems problems". As examples, he cited the need for general solutions to the problems of safe air navigation and rail freight dispatching. Recognizing that some systems problems can be of too large magnitude to be dealt with by one organization, he urged the industry voluntarily to form combined research groups.

Of the exhibits of equipment, 45 percent included components and equipment useful for both communications and general industrial users; 30 percent exhibited apparatus specifically designed for com-

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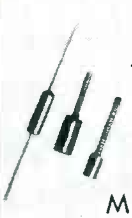

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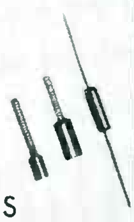

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munications applications, including three wire recorders and one tape recorder; 20 percent displayed equipment for laboratory or test purposes; 5 percent of the exhibits showed purely industrial applications.

Among papers attracting wide attention were H. H. Scott's discussion and demonstration of his dynamic noise suppressor (ELECTRONICS, December 1947), a description and striking demonstration of an ultrasonic device for guidance of the blind, by F. H. Slaymaker and W. F. Meeker of Stromberg-Carlson, and a paper on the capacitron —a device for projecting high-velocity electrons in air—and its efficacy in preserving food, presented by Wolfgang Huber of Electronized Chemicals Corporation.

Airline Uses ILS

As a further step toward greater regularity of airline flights, United Air Lines has completed arrangements for use of manual instrument landing approach procedures (ILS) in its regular operations, effective November 15.

All 500 of United's flight captains have been checked out in the use of ILS, and necessary glide path and localizer receivers and cross-pointer instruments have been installed in the company's fleet of 125 Mainliners.

Although ILS is designed to permit landings under conditions of reduced ceiling and visibility, United does not propose lowering its minimums until greater ILS operational experience is obtained, probably sometime after the first of the year.

A total of 21 airports along United's coast-to-coast and Pacific Coast system have been equipped by the CAA for ILS operations.

Marine Corps Needs Electronics Technicians

FORMER electronics technicians in the Marine Corps who have been discharged since September 1, 1945, can now re-enlist at the same rank held at the time of discharge. The only exception is in the case of mas-

ter sergeants inactive for more than 24 hours, who will be reappointed to the grade of technical sergeant.

Greatest need is for former Marines with the following specification serial numbers: 648, signal electrician; 649, radio technician; 759, radio technician, vhf; 774, airborne radar technician; 775, radar technician; 878, radar-radio technician, aviation; 879, radar-radio repairman, aviation.

BUSINESS NEWS

TECHNICAL APPLIANCE CORP. has moved from Flushing, N. Y. to its own plant building at Sherburne, N. Y. with over 30,000 square feet of space for production of TACO antennas and systems, as well as radio-electronic specialties.

GENERAL ELECTRIC CO. announces installation of two-way f-m radio communication equipment on four ferryboats and at land terminals of the Chesapeake Bay Ferry System, near Annapolis, Md.

INTERNATIONAL INSTRUMENTS, INC., New Haven, Conn., has been formed from the Instrument Division of the M B Mfg. Co. for production of a specialized line of midget meters and allied equipment.

SPERRY PRODUCTS, INC., manufacfacturers of ultrasonic and electrical nondestructive testing and measuring instruments and rail flaw detector cars, will move its manufacturing plant and general offices from Hoboken, N. J. to Danbury, Conn. when construction of their new building is completed during the summer of 1948.

RADIO CONDENSER CO., Camden, N. J., has acquired the business conducted until now by its affiliate, Western Condenser Co., Watseka, Ill.

AIRADIO INC., Stamford, Conn., announces a change of ownership and management, wherein Jay Sullivan succeeds J. B. Cobrain as president and treasurer.

ELECTRONIC MEASUREMENTS CORP. has moved to new and larger quarters at 423 Broome St., New York

City, and will enlarge its line of electronic test equipment and instruments.

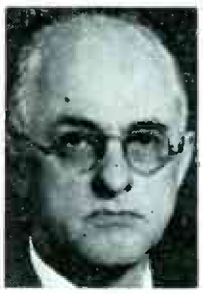
VANGTRONIC CORPORATION now has its general offices and development laboratory at 237 John St., Bridgeport, Conn.

LABORATORY FOR ELECTRONICS, INC. is moving into larger quarters at 11 Leon St. in Boston, Mass.

PERSONNEL

E. K. JETT, FCC Commissioner, will head the U. S. delegation to the Provisional Frequency Board sessions beginning Jan. 15, 1947 in Geneva, Switzerland, and lasting for about a year and a half. This board will review the allocations making up the new international frequency assignments, in compliance with the Atlantic City Telecommunications Conference.

JOSEPH P. MAXFIELD, recently retired from Bell Telephone Laboratories after pioneering in research and practical development of sound transmission, recording, and reproduction, is now serving as consulting engineer to Altec Lansing Corporation, New York City.


J. P. Maxfield


W. C. Johnson

WILLIAM C. JOHNSON, executive vice-president of Allis-Chalmers Mfg. Co., Milwaukee, Wisc., was elected president of the National Electric Manufacturers Association at the annual meeting of the association in Atlantic City.

ROGER B. COLTON, who retired from active service with the Army with the rank of Major General, was elected vice-president of Federal Telephone and Radio Corp.

IRVING MEGEFF is now project engineer with United States Television

Mfg. Corp., New York, N. Y. He was at one time engineer in charge of mechanical design at Philharmonic Radio Corp.

A. L. McINTOSH succeeds Paul D. Miles as chief of the Engineering Department's Frequency Allocation and Treaty Division. Mr. Miles has been designated as the U. S. member on the New International Frequency Registration Board in Geneva, Switzerland and has been elected as the first chairman of the board.

DUDLEY B. CLARK, formerly president and general manager of Electron Equipment Corp. in South Pasadena, is now director of Clark Electronic Laboratories, Inc., Palm Springs, California, a research and development organization concerned with design of power tubes, gas turbines, and large industrial tube controls.

L. G. BURNELL, chief engineer of United Transformer Corp. for over a decade, has joined his brother's organization, Burnell & Co., Yonkers, N. Y., as a partner and chief engineer.

EDWARD E. LEWIS has been elected president of Colonial Radio Corp., Buffalo, N. Y., wholly owned subsidiary of Sylvania Electric Products Inc.

C. M. JANSKY, JR., of the engineering firm of Jansky & Bailey, Washington, D. C., has been appointed engineering counsel of the FM Association, 921 12th St. NW., Washington, D. C.

JACK J. KAHGAN, formerly project engineer at Radio Receptor Co., Inc. and chief civilian Signal Corps inspector for the upper Manhattan area, has joined Shaw Associates, New York, N. Y. as technical adviser and writer on electrical and electronic advertising accounts.

EDITOR'S NOTE: Apologies to M. W. Scheldorf of Andrew Co. and W. L. Barrow of Sperry Gyroscope Co. for the transposition of captions under their pictures on page 264 of the Nov. 1947 issue.

NEW BOOKS

Radar Aids to Navigation

Volume 2 of the MIT Radiation Laboratory Series, edited by John S. Hall and written by 33 authors. McGraw-Hill Book Co., New York, 1947, 389 *pages,* $5.00.

THIS VOLUME is one of the four "systems" books of the series and for that reason excludes highly technical details, to concentrate upon uses and limitations of the radar technique. When the authors find it desirable to furnish additional proof of their statements, they refer to the appropriate volume in the series dealing with the subject. This treatment makes for smoother reading and permits inclusion of all navigational systems in use or those projected for possible commercial application. The title is a misnomer only in that the editor has wisely seen fit to include nonradar navigational aids such as radio ranges, direction finders, gee, the various loran applications, Decca, and consol. This volume should be of greatest general usefulness because it is addressed not only to the electronic engineer but also to engineers in other fields interested in applying the radar technique to surveying, aerial mapping, or height finding. Airline and shipping executives, along with communications experts, will be more easily able to evaluate the claims of competing air and sea navigating and piloting systems after studying the book.

Specifically, the volume is made up of four parts: introduction; airborne radar; ground-based radar; shipborne radar. The 82-page introduction briefly reviews what radar is and gives the rudiments of its electronic mechanism, besides covering the nonradar aids noted above.

The airborne radar section covers the mapping technique, determination of drift and ground speed, and beacon navigation. Anticollision devices and pulsed or frequency-modulated absolute altimeters are included in a chapter on special aids. The special design considerations for aircraft installations are summarized along with the most important economic aspects.

A hundred odd pages devoted to

ground-based systems should prove helpful to those who have so far been unable to resolve in their own minds the technical differences among proposed beam approach and traffic control aids. There is no definitive answer, but the basic components of even such ambitious plans as Teleran are described, though not specifically named.

Navigation and pilotage by radar aids is undoubtedly going to have importance at sea or along the coast long before planes can begin to make significant use of the technique. Shore lines return strong echoes so that superposition of a radar pattern on a map is easy. The last chapter devotes more than half its length to this and other means of pilotage, finishing with a discussion of physical equipment.

The book is well illustrated, although the halftones suffer because of inferior paper stock or poor printing. The line drawings have been handled with great care, all lettering being stamped in type.

It will doubtless be some time before another such book, composed by authors each an expert in his field, can be compiled by any editor.
—A.A.MCK.

F-M Simplified

By MILTON S. KIVER, *D. Van Nostrand Co., Inc.*, 1947, *347 pages*, $6.00.

THIS BOOK is the third of the author's simplified series directed toward the service man and hobbyist. Five sections of several chapters each cover frequency modulation from fundamentals to receiver alignment. Included are sections on transmitter and receiver principles. Recent as well as past developments are included, such as the Phasitron and the ratio detector.

However, in places the statements are somewhat questionable. Near the bottom of page 150 is the comment, "As is well known, the total value of capacitors in parallel is less than either one." (The total capacitance is greater; the total capacitive reactance is less than for either one.) Again, in describing how phase modulation also produces frequency modulation, the author writes, "Finally, at the zero point (360 degrees), the modulation disappears and the frequency of the carrier is once more at its central value." Actually at the time when phase-modulated carriers pass through their central positions, their frequencies are changing most rapidly, as the diagram to which the author refers shows. Incompleteness is another fault, as illustrated in the section on limiter alignment where the author states that care must be taken not to saturate either limiter, but gives no suggestion as to how one can know when saturation sets in.

Because of the type of shortcomings illustrated above, one cannot rely on this book. For those who want merely a smattering of the subject, shortcomings of the types cited may be no objection, but certainly for those who hope to progress to a practical understanding of frequency modulation this book is inadequate, especially because it is without references to more authoritative literature.—F. R.

Elementary Nuclear Theory

By H. A. BETHE. *John Wiley and Sons, Inc., New York, N. Y.*, 1947, 147 *pages*, $2.50.

A STORY is told of an eminent mathematician who, in presenting a paper to a mathematical society, had to interrupt lecturing for ten minutes in order to check his assertion that a certain equation was "obvious." Just as the mathematician's equation was "obvious", so to the reader who is not well grounded in nuclear physics is Dr. Bethe's book "elementary."

A compilation of notes taken from twenty lectures delivered by Dr. Bethe at G-E's Research Laboratory, the book treats only certain aspects of nuclear theory. This treatment, rather than being purely theoretical, is entirely empirical, as the author himself points out. The work begins with a statement of basic facts about nuclei, including definitions, nuclear notation, and concepts of nuclear reactions and the energy equivalent of mass. Chapters on the size of nuclei, disintegration, spin and statistics, and beta disintegration and the neutrino complete the first section covering descriptive theory of nuclei. A 76-page section discusses the quantitative theory of nuclear forces, and is followed by 24 pages covering topics not related to nuclear forces. A table of elements with data on their isotopes completes the book.

Although a wealth of material is surveyed, unfortunately terms are not always defined, nor is sufficient descriptive material included to make the meaning of new terms clear to the uninitated. For example, nuclear spin is introduced on page 11, but a definition and discussion of spin is not included until page 15. If the concise outline form of this volume were expanded, if introductory material were included to orient the nonphysicist reader, and if symbols and terms were always clearly defined, then this work would be meaningful to the average engineer. In its present form, however, it is of value only to workers in nuclear physics.
—E.M.R.

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Books Received for Review

TELEVISION, VOLUME III (1938-1941). Published by RCA Review, Radio Corporation of America, RCA Laboratories Division, Princeton, N. J., 1947, 486 pages, $1.50 paper-bound and $2.50 cloth-bound. This consolidated record of past developments by RCA engineers in the field of television was ready to go to press in late 1941 but was not published because of the war. The papers, some printed here without prior publication, are divided into four groups: pickup; transmission; reception; general. In addition, there are summaries of papers published elesewhere during the specified period, along with summaries of papers in two previous volumes of this Television series, now out of print.

TELEVISION, VOLUME IV (1942-1946). Published by RCA Review, Princeton, N. J., 1947, 510 pages, $1.50 paper-bound and $2.50 cloth-bound. Fourth volume on television in the RCA Review Technical Book Series, presenting papers by RCA engineers dealing with pickup, transmission, reception, color television, military television, and general topics, plus summaries of papers published elsewhere and a bibliography of some 275 technical papers by RCA authors covering television and closely related subjects and published during the period 1929-1946. Of particular significance are papers giving technical details of the Block, Ring, and Mimo airborne television projects evolved for secret wartime purposes.

MAGNETIC CONTROL OF INDUSTRIAL MOTORS. By G. W. Heumann, Control Engineering Division, General Electric Co. John Wiley & Sons, Inc., New York, N. Y., 1947, 589 pages, $7.50. An application book, explaining performance of motors, characteristics of control devices, and functions of commonly used control circuits for individual motors and for whole production lines. One chapter deals specifically with electronic devices, and the entire book gives essential background data for electronic motor control applications.

DIAL CORD STRINGING GUIDE. Howard W. Sams & Co., Inc., Indianapolis, Indiana, 1947, 128 pages, $.75. Collection of 552 dial cord stringing diagram covering most 1938 to 1947 radio receivers, indexed by manufacturer and model number and supplemented by a chapter of general notes on replacement of dial cords.

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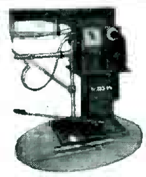

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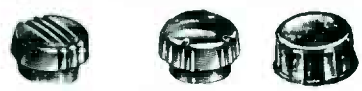
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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Citizens Radio

DEAR SIR:

THE NOVEMBER issue of *Electronics* has really shown your mettle. The article about the lack of progress in the field of "Citizens Radio" sums up the thing that has been my pet personal gripe for some time. It takes someone with the initiative you fellows have shown to keep the industry alert.

I have for some time been plotting a course of action very similar to the one taken by Mr. Hollis and assistants. The approach here was almost identical except for a very few minor technicalities so that I am going to switch over and copy as closely as possible your design, then, when the system is in operation, deviate to try my own angles.

One problem quite apparent from the start here in the remote West is the lack of the latest available components. One classic example is that there is no source of supply here for the button condensers used in your design. We are also not familiar with the Winchester standoff insulators and the solder in glass feed-thru insulators. The small Johnson trimmer condensers are too new to be on the local jobbers' shelves.

The lack of these items is a challenge to us local fellows to show what can be done.

Again let me commend you for your progressive publication and my personal thanks to Mr. Hollis for his share in this venture.

W. A. MAISEL
Portland 11, Ore.

Shielded Room

DEAR SIRS:

THE method of locating grounds in shielded rooms by means of an oscillograph, mentioned on page 134 of ELECTRONICS for October, 1947,

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seems quite complicated. A method of avoiding such grounds during construction would be to connect a battery and bell in series to the two shields. A nail driven through both shields would provide immediate indication of the short.

L. M. LEEDS
General Electric Company
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Electronism

DEAR SIRS:

MR. JAMES N. SMITH has made an excellent suggestion in proposing the use of the word "Electronism" to denote an electronic device or an electronic "gadget."

As a patent lawyer who is considerably in contact with electronic patents, I have struggled desperately to find a simple word such as the one suggested. In drafting a patent application I have had to be enormously repetitive in using the expression "electronic device."

No longer will my claims read "An electronic device comprising an electronic tube, input circuit means, output circuit means. . . ." Mr. Smith's "Electronism" makes the future look markedly brighter.

WILLIAM R. MEREDITH
Barrister-at-Law
Ottawa, Canada

Beta-Ray Gage

DEAR SIRS:

I SHOULD like to make an addition to my article, Beta-Ray Thickness Gage, which appeared in the October 1947 issue of ELECTRONICS.

Acknowledgment is due to Westinghouse Electric Corporation, in whose research laboratories the equipment described was built, and to W. E. Shoupp, head of the Electronics Department of the Westinghouse Research Laboratories, who holds the basic patent on beta-ray thickness gages, and under whose competent direction the work progressed.

OTTO J. M. SMITH
University of California
Berkeley, California

"FEW NEW INVENTIONS can be expected in the future, as practically everything has been invented." Said in 1886, by the U. S. Commissioner of Patents.

(Continued on page 256)

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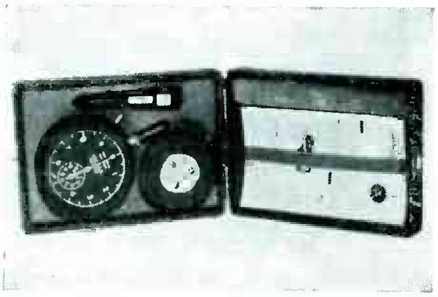

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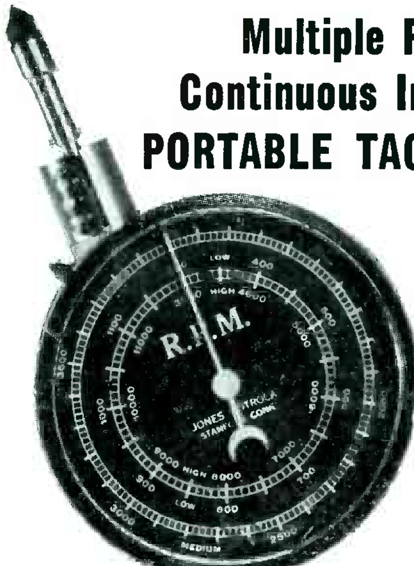
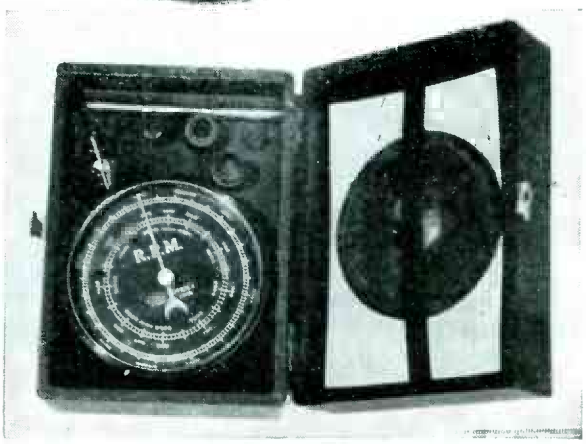


2/3 Actual Size



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0–36 V.A.C.	0–28 V.D.C.	10 AMP	13.95
0–36 V.A.C.	0–28 V.D.C.	15 AMP	19.95
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0–18 V.A.C.	0–7 V.D.C.	10 AMP	4.95
0–18 V.A.C.	0–7 V.D.C.	15 AMP	6.95
0–18 V.A.C.	0–7 V.D.C.	20 AMP	8.95
0–18 V.A.C.	0–7 V.D.C.	25 AMP	10.95

Input From	Output From	Current	Price
0–36 V.A.C.	0–14 V.D.C.	3 AMP	$2.95
0–36 V.A.C.	0–14 V.D.C.	5 AMP	4.95
0–36 V.A.C.	0–14 V.D.C.	10 AMP	7.95
0–36 V.A.C.	0–14 V.D.C.	15 AMP	10.95
0–36 V.A.C.	0–14 V.D.C.	20 AMP	13.95
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6F8	1.10	77	.75	HY75	1.25
6G6	1.10	78	.75	HC615	1.25
6H6	.69	79	1.10	OZ4	1.25
6J4	1.50	80	.53	RK60	1.25
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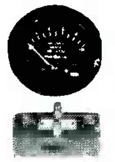

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Blower 6 v. AC or DC hi speed blower made by John Oster. Rated at 5000 RPM—1.8 AMP—made for continuous duty—1½" overall diameter—1" blower output—1¼" blower intake **$5.95**

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We can supply power xtals of any frequency ground to .02 tolerance in any type of holder for any surplus or standard transmitters or test equipment as well as any receiver IF frequency. Prices on request—write to our engineering department.

ROTARY SWITCH—3 deck 9 position non-shortening ceramic wafers. Each.......... **$1.25**

All Prices f.o.b. N. Y. C.

NIAGARA RADIO SUPPLY CORP.
160 GREENWICH STREET, NEW YORK 6, N. Y.

CREDIT EXTENDED TO RATED ACCT'S

TELEVISION AND TEST EQUIPMENT BARGAINS

YOUR TELEVISION HEADQUARTERS

TELEVISION FOUNDATION KIT

The television foundation kit consists of the most essential (and expensive) parts needed in the construction of a television receiver starting with the high voltage power supply, for the picture tube, right through to the antenna. The kit contains the high voltage picture tube transformer (for five or seven inch tube), 2x2 filament transformer, low voltage transformer for the receiver, cathode ray filament transformer, filter choke, 6.3 filament transformer for the 16 six volt tubes along with the five volt transformer for the 5U4. The two high voltage filter condensers, blocking oscillator, transformer all R.F.'s sound and video I.F.'s peaking coils, discriminator transformer. Rectifier tubes 2x2 and 5U4, the picture tube 5BP4, al all aluminum Elincor dipole antenna are also included. Of course there is the easy-to-follow 26-page instructions book, with a large 12 by 18 schematic diagram. The instructions include television theory, circuit functions, explain scanning, give preliminary voltage measurements, parts layout and final adjustment of the television receiver which facilitates easy alignment without the use of elaborate test equipment. The only knowledge necessary to build this set is the ability to read a simple schematic diagram. Most radio men will have many or all of the minor parts not included in the foundation kit... **$34.75**

Remaining set of necessary tubes............$16.95

TRANSVISION TELEVISION KITS

12" Kit—Complete with all tubes—a real honey **$289.50**

7" Kit—Thousands of satisfied users **$159.50**

RAY-ELECTRON COIL KIT

INCLUDES:

1 Oscillator Tank Coil. 1 Antenna Coal, 6 RF Tuning Coils, all mounted on Switch Assembly Plate: 5 Video IF Coils, Shielded, Permeability Tuned: 1 Shielded Discriminator Coil: 3 Video Peaking Coils, and Instruction Manual containing Circuit Diagram for 20 Tube Seven Inch Picture Tube Set, together with detailed Assembly Instructions, and Parts list.

The design of these Coils makes it possible to obtain satisfactory operation within the ENTIRE service range of ANY Television Station. Complete.... **$23.50**

NEW TELEVISION COIL KIT 510

Build a 10" or 15" television receiver. • Complete kit of permeability tuned video IF, RF, and Sound Coils for high quality television receiver designs. Contains all necessary coils for 3 stages 4 mc. wide video, 2 stages sound, discriminator, peaking, oscillator, and RF. Complete instructions included
Priced at Only **$9.95**

NIAGARA COMPONENTS CONDENSERS

CF 45 1 mfd—3500 volt DC	$ 1.98
CF 48—.05 mfd—2500 volt DC	1.09
CB 18—.25 mfd—4000 volt DC	2.95
ER25AD—dual 25 mmf per sect. variable condenser	2.04

SOCKETS

11 prong isolant scope socket	$ 0.39
Octal socket	.12
Special hi. voltage socket for 2x2	.59

TRANSFORMERS

TS.6—Scope transformer—2500 v. @ .4 a., 2.5 v. @ 1.75 a., 6.3 v. @ .6 a.	$ 9.95
TS.5—Western Electric—D303184—hi. volt 4200 v. @ 9 ma lo. volt. 640 v. @ 200 ma—fil. 6.4 v. @ 5 a., 5.4 v. @ 3 a., 5.1 v. @ 3 a., 2.5 v. @ 1.75 a.—complete television hi. & lo. volt. trans. in one compact oil filled unit—will handle any television tube	12.95
TCH 2—Scope transformer 1750 v. @ 4 ma and matching fil. trans. 6.3 v. @ .8 a., 2.5 v. @ 1.75 a.	7.95
HF 16—Filter choke 10 hy @ 150 ma	1.95
LC 2—25 ma R.F. choke	.59

MISCELLANEOUS

Pots—all sizes less switch	$0.69
Pots—all sizes with switch	1.09
Trimmers—single 3—30mmf	.20
dual 5—50mmf	.35
High voltage wire—50 ft. roll	1.00
Peaking coil	.45

Complete Line of Television Components in Stock

Write for Free Listing

5TP4 PROJECTION TUBE

Perfectly operating condition but with very slight imperfection. Ideal for engineers, experimenters, inventors, or school instructors. Regular price of these tubes is $65.00—
Special Bargain **$20.00**

10BP4 TUBE

Individually Packed **Special—$39.60**

35' TELESCOPING ANTENNA MAST

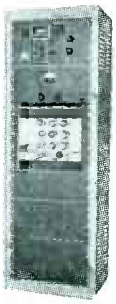
Engineered for Television and FM, Increases Signal Strength, Reduces Interference & Improves Reception in Remote Areas. This unit is made of beam gauge steel and Telescopes from 6 feet to 35 feet simply and easily.

Features

- A new ALL ANGLE foot bracket for use on flat or peaked roof to 90 degrees.
- All necessary parts such as screw eyes, bolts, double galvanized guy wires (360 ft.) cut to length.
- New NUT-LOCK guy wire clamps (vibration proof).
- GRIP-TITE tube clamp, eye bolts serving a TWO-FOLD purpose interlocking tube section that are overlapped 6 inches for rigidity and an ideal staggered method for attaching guy wires to mast.
- All Parts Protected From Weather.

Priced at only—$32.25

MASTER OSCILLATOR MI-19427-B

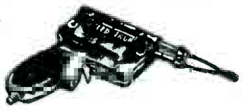


This unit was built for R.C.A. Add a final—becomes a complete transmitter with signal shifter. 2.20 mg—also FM—only a few cycles drift from cold start. Complete with regulated power supply and heavy duty deluxe rack. Power supply is electronically regulated 300 v. output — maximum current 400 mills—½ v. variation between no load and full load output — uses 10 tubes: 5—6Y6G; 2—5U4G; 2—VR150/30; 1—1852—Perfect for Television sweep circuits for field or station use or wherever 300 v. must be maintained under varying load conditions — COMPLETE (less tubes).......... **$225.00**

BAT HANDLE SWITCH

Mfgd. by Cutler-Hammer—10 amp. SPDT with neutral position — Perfect for rotary beam control—a positive steal at.................. **29c**

WELLER Soldering Gun



A must in the kit of every man who makes soldered electrical connections. Heats in five seconds; see where you work; gets into tight corners. Operating on the same principle as the resistance welder. 100 watts, 115 volts, 60 cycles AC.
—Your COST **$12.95**

Tip Fastening Stud	.10
Copper Tip	.05

ANTENNA LEAD IN BOWLS

Made of genuine Pyrex—3" in diameter; brass rod 5½" long—complete with hardware and waterproof rubber gaskets **Special—$1.49**

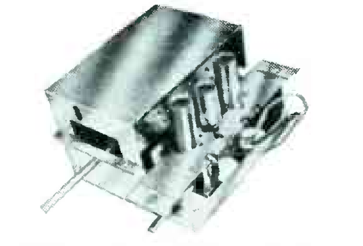
Mallory Vibrapack 12 v. input, 150 v. @ 85 mils output—Extra
Special at **$3.75**

75,000 ohm bleeder, 200 watts Ohmite—special **$1.65**

50,000 ohm bleeder, 100 watts, I.R.C. .... **.89**

VACUUM CONDENSER VC50

Capacity 55 mmfd—test voltage 20,000 v. peak. **WHILE THEY LAST $4.95**

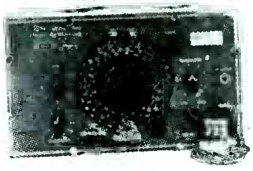


ALL CHANNEL R. F. UNIT

FOR USE IN BUILDING YOUR OWN CUSTOM-MADE TELEVISION RECEIVER—ANY SIZE or TYPE

This all-channel R.F. unit is factory pre-wired and tuned for 7 channels* (covers all channels in lower and higher bands in any single area operating presently or in the future). Average sensitivity 20 microvolts; has R.F. stage before oscillator; complete with 3 tubes: 1—6AK5, 1—6AK6, 1—6C4; input impedance 300 ohms, balanced to ground. Size 9½" deep, 4½" high, 6⅜" wide.
* NOTE: No single area is scheduled for more than 7 channels. However, 6 more channels can be added to this unit, if desired, at nominal factory cost. It is not expected that these additional 6 channels will be required for several years.................. **$31.95**

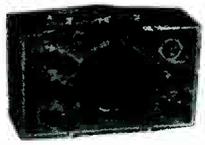
McMURDO SILVER AM-FM 906 SIGNAL GENERATOR



Available Now

What an instrument: 90 kc through 170 mc. on foundamentals . . . 8 airtrimmed bands . . . variable % 400—amplitude modulation . . . built-in variable electronic FM sweep . . . laboratory triply adjustable attenuator . . . metered microvolts . . . output ½ microvolt to over 1 volt . . . multiply shielded . . . strays lower than $500.00 laboratory generators! Yet all this costs you only **$99.50**

Model 904 Capacitance Resistance Bridge



Net Price $49.90

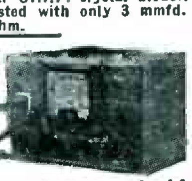
¼ mmfd./ohm thru 1,000 mfd/megohm: 0-50% power factor; 0-500 volt adjustable internal polarizing voltage; 0-10 and 0-100 ma. electron-ray leakage current meter; measures resistance, capacitance under actual operating voltages!

Model 905 COMBINATION "SPARX" DYNAMIC SIGNAL TRACER

Net Price $39.90

Frequency range from 20 cycles to over 200 megacycles. Contains isolating capacitor, resistor and one of the new radar U.H.F. crystal diodes. Loads a circuit being tested with only 3 mmfd. and higher than .5 megohm.

Model 'Vomax' Vacuum Tube Voltmeter



Net $59.85

51 ranges directly measure d.c., a.c., a.f., i.f. and r.f. volts up through hundreds of megacycles, six resistance ranges six direct current ranges measuring from microamperes through 12 amperes. Voltage ranges measure from .1 through 3000 volts d.c., .1 through 1200 volts a.c.

WRITE FOR FLYER 3 SL

All Prices f. o. b. N. Y. C.

NIAGARA RADIO SUPPLY CORP.

160 GREENWICH STREET, NEW YORK 6, N. Y.

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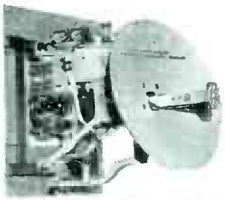
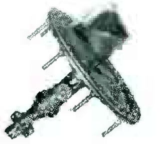


FINEST QUALITY "Communications" **LOWEST PRICES**

MICROWAVE ANTENNA EQUIPMENT

3 CM ANTENNA WITH DISH 14½". Cutler Feed horizontal and vertical scan with 28 V DC drive motor and drive mechanism. Complete. New as shown....................$65.00
Relay System Parabolic reflectors apprx. range 2000 to 6000 Mc. Dimensions 4½' x 3'. New....$85.00
Dipole for above............................$5.00
TDY "Jam" Radar rotating antenna, 10 cm. 30 deg. beam, 115 V AC drive. New..............$100.00
SO Surface Search Radar rotating antenna, 10 cm. 24" dish, complete with drive and selsyn motors. New $75.00
Used $45.00
10 Cm Horn. Rectangular-to square-to circular RF assembly ending in horn, radiating circularly polarized beam. Waveguide input. Complete with flange $35.00
Parabolic Peel. Radiation pattern approx. 25 deg. in horizontal, 33 deg. in vertical planes $20.00
Cone Antenna, AS 125 APR. 1000-3200 mc. Stub supported, with type "N" connector (as shown)....$4.50

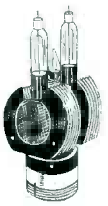


S.F. Radar Antenna. 10 cm. approx. 30" dish comp. with Selsyn and 150V drive motor $55
With motor driven turntable echo box $70

140-600mc Directional Antenna

140-310mc cone and 300-600mc cone, each consisting of 2 end fed half wave conical sections with enclosed matching stub for reactance changes with changing frequency.
New: complete with mast, guys, cables, carrying chest $49.50

MICROWAVE TUBES



3J31 (1 cm) $17.50
3J31 MAGNET 8.00
2J26 (10 cm)................ 15.00
2J32 (10 cm)................ 15.00
2J55 Packaged Magnetron 9345-9405 MC. 50 KW peak pwr. output, waveguide output.... 25.00
MAGNET for 2J32.......... 8.00
2J38 (10 cm) with magnet....25.00
WE 700 A (L band)........ 45.00
WE 720 BY (S Band) 1000 KW 25.00
2K25-723 AB Klystron...... 3.50
QK 59, QK 60, QK 62 Tunable packaged Magnetrons, 10 cm, ea. 45.00

RADAR SETS

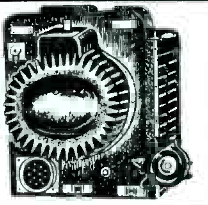
S09-10CM. SURFACE SEARCH 4, 20 and 80 mile ranges: Raytheon, 250 KW peak power input to 2J27 magnetron. Complete set including: spare parts, tubes, wave guides and fittings. Send for information.
S013-IDENTICAL TO S09. Complete set, used. Consists of transmitter and receiver, PPI scope modulator, motor alternator, rectifier, power unit and new rotating antenna..................$375.00
SN RADAR-GE, low power, 5 and 25 mile ranges. Uses GL464 as pulsed oscillator, 5" "A" scope, "S" band. Extremely compact; ideal for demonstration and laboratory work. 115V 60C operation. Used, excel. Cond..........................$600.00

MICROWAVE TEST EQUIPMENT

Wave guide experimental kit. Consists of: One direct-reading wavemeter, app 2600-3400 mc. (cavity type); One dummy load w/crystal probe. One line stretcher full wave; two wave guide to RG 18/U coax couplers; two 1' sections w/flanges. Complete $250.00
10 CM ECHO BOX, complete with micrometer adjust cavity & resonance indicator. Type TS 238/GP. With calibration chart..........$105.00
10 CM WAVEMETER. Model "SL". Micrometer adjust cavity with microammeter resonance indicator. Includes 115 VAC operation converter section. In grey metal carrying case, complete with cables & spares. Made by Western Electric.$135.00
W.E. 1138 A. Signal generator. 2700-2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram................$50.00

SPECIALS

10 CM. RF Package. Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator, 250 KW peak input. 707-B receiver-mixer..........$150.00
Modulator-motor-alternater unit for above... $75.00
Receiver rectifier power unit for above........ $25.00
Rotating antenna using dipole feed and parabolic reflector. New less hood.................. $75.00
Used $45.00
RT39APG15 Transmitter-receiver. Lighthouse tube oscillator. .5 KW. App. 2700 Mc. operation. With lighthouse and TR tubes............$100.00

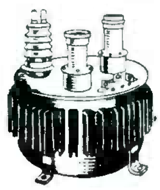


PULSE MODULATOR

W. E. No. D-151756. Contains multivibrator, amplifier, rectifier; air and oil sections. Designed for 400 cycle operation. Has following tubes: 1—3E29, 1—6AG7, 1—8016, 1—705A. Size: 18"Lx10"W x15"H $49.95

PULSE TRANSFORMERS

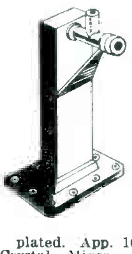
All Standard Name Items
Type K2450A. Will receive 13 KV. 4 micro-second pulse on pri., secondary delivers 14 KV Peak power out 100 KW GE..................$15.00
HI Volt. Magnetron Input transformer W.E. # D-166173 with cooling fins.....................$[illegible]
U 4298E—Pri. 4 KV, 1 microsecond Sec. 16 KV, 16 amps. Fil. pri. 115v. 400 Cycle Raytheon.$15.00
HI Volt input pulse Transformer W.E. #D169271 ....$9.95
Pulse. Input, line to magnetron K2748A......$12.00
Utah Pulse or Blocking Oscillator Transformer: Freq. limits 790-810 cy-3 windings turns ration 1:1:1 Dimensions 1 13/16 x 1⅛ x 19/32 ....$.75



GE # K 2731
Repetition Rate: 635 PPS. Pri. Imp: 50 Ohms. Sec. Imp: 450 Ohms, Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output 28 KV. PK. Peak Power Output: 800 KW Bifilar: 2.75 Amp...$19.50

MICROWAVE PLUMBING

10 Centimeter



10 Cm McNally cavity. Silver Plated. Type SG .....$3.00 Ea.
Sand Load (Dummy Antenna) wave guide section with cooling fins. app. 28" high.......$28.00
Rigid Coax Directional Coupler CU-90/UP 20 DB drop, has short right angle, about 8".$5.50
Coax Rotary Joint with mounting plate $8.00
Dipole Antenna in lucite ball, for use with parabolic $5.00
Flexible Coaxial Connector, rigid coax to rigid coax ⅞"diam.$2.50
10 CM Dipole and Reflector with type "N" Fitting.........$2.75
Waveguide to flexible coax coupler (RG 18 U), with flange. Gold plated. App. 10" high (As Shown).........$17.50
Crystal Mixer. "S" Band. Complete with Type "N" fitting and 1N22 crystal...............$3.85
Rigid coax slotted section CU-60/AP...........$5.00
Stub-supported rigid coax, gold plated. 5' lengths. Per 5' length............................ $5.00
10 Cm waveguide. 5'9" choke to cover.
Per section $12.00
Per set of 4 sections......................$45.00

3 Centimeter

Wave Guide Section 2.5' long, silver plated with choke flange $5.75
Wave Guide 90 deg. bend E Plane 18" long..$4.00
Wave Guide 90 deg. bend E Plane with 20DB directional coupler $4.75
Wave Guide 18" long "S" Curve..............$2.00
Rotary joint wave guide in/out choke to choke..$6.00
Rotary Coupler choke input; round guide output $5.25
S-Curve Wave Guide 8" long cover to choke....$2.50
Wave Guide 2.5' long, silver plate, 180 deg. bend choke to cover..............................$5.95
Duplexer Section using 1B24..................$10.00
Pick-up loop with adjustable tuning section, used in duplexer $1.50
3 CM Wavemeter Maguire 152 TFX-24GA $15.00
3 CM stabilizer cavity, tunable transmission type. Model 1551 (TFX 11 GA)..................$20.00
3 CM waveguide, 1¼" x ½". 15 Ft. lengths available. Per Ft.................................$1.50

1.25 Centimeter

Wave Guide Section 1" cover to cover..........$2 00
T Section choke to cover......................$4.50
Mitred Elbow cover to cover...................$3.00
Mitred Elbow and "S" sections choke to cover.$3.50
Flexible Section 1" long choke to choke.......$3.00
Tunable Cavity with Coax input and output...$6.00

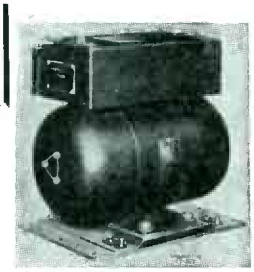
Connectors

UG 21/U, Type "N", Male.................. $.85
UG 86/U, Gold Plated..................... $.95

NETWORKS

W.E. #D-168184. Delay network. 4" L x 3¼" W x 1¼" D. $4.00
W.E. #D-165997. Delay network. 11½" x 2¼" x 1⅜" $7.50
W.E. #D-169421. Resonant network. 3⅝" L x 2¼" Diam. $6.50

DYNAMOTORS



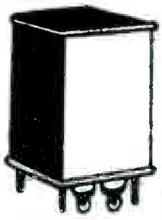
PE 73 CM, Power supply for BC 375 input; 28 V DC. Output: 1000 VDC @ 350 Ma. Starting relay, filter, etc. NEW $4.95

Mfrs: write for quantity, prices and discounts on above item.
BD 77KM, Power supply for BC 191. Input: 14V DC. Output 1000 VDC @ 350 Ma. New, with spare fuse links, etc.........................$5.95
PE 101C. Input: 13/26 VDC @ 12.6/6.3 A. Output: 400 VDC @ 135 Ma., 800 VDC @ 20 Ma. (9VAC @ 1.12 A.)..........................$3.40
PE 86 N. Input: 28 VDC. Output: 250 VDC @ 60 Ma. Westinghouse w/Filter................$1.95
Without Filter 1.60
PC 77. Input: 12 VDC. Output 275 VDC @ 110 Ma. 500 VDC @ 50 Ma....................$3.25
DAG 33 A. Input: 18 VDC @ 3.2 A. Output: 450 VDC @ 60 Ma..........................$2.45
DM 33 A. Input: 28 VDC @ 7 A. Output: 540 VDC @ 250 MA. Power supply for modulator for SCR 274 N..........................$3.95
Dyn. Model 23350. Input 27 VDC @ 1.75 A. Output: 285 VDC @ 75 Ma....................$1.75
DM-21: In 14VDC 3.3A Out 235VDC 90 ma with filter $2.59
DM-25: In 12VDC 2.3A Out 250DVC 50 ma..$2.49
DM-34: In 14VDC 2.8A Out 220VDC 80 ma..$2.49
DM-42: In 14VDC Out 515/1030 VDC 215/260 ma and 2/8VDC..........................$3.95
BD-77 input 14VDC output 1000V 350ma DC...$5.95

ROTARY INVERTER PE 206-A

Input: 27.5 v. @ 38 amp. Output: 80 v. @ 500 volt-amperes. 800 cps. Complete, with enclosed voltage regulator, filter, starting relay, spare fuses, etc. New $12.50

TRANSFORMERS



(Filament Transformers)
All Primary 117 V, 60 cycles
#5058: 6.3 VCT @ 2 A, 6.3 VCT @ 2 A, 6.3 VCT @ 2 A $2.25
#5126: 5 VCT @ 3A, 5 VCT @ 3 A, 5 VCT @ 6 A..$2.25
#5100: 6.3 VCT @ 1.2 A, 5000 V test............$1.35
#5085: 6.3 V NCT @ .6 A, 6.3 V NCT @ 1.5 A....$1.40
#5056: 6.3 VCT @ 9 A, 6.3 VCT @ 2.2 A, 6.3 VCT @ 2.2 A $2.50
#5057: 6.3 VCT @ 1 A, 5 VCT @ 3 A, 5 VCT @ 3 A $2.50
UX 6899: 5 V @ 5.5 A, 5V @ 5.5 A. 29,000 Volts Test $24.50

Fil. Xfmr. to supply filament current to surplus equipment using 12 Volt tubes. Pri: 117 V 60 cy. Sec: A wide range of voltages up to 26 V @ 2 A..$1.50

LINE VOLTAGE REG 2 KW Saturable reactor type Pri 95-130 v 60 cy Sec 115 v 60 cy. 17.4 A 2 KW 100% P.F...........................$160.00
LINE VOLTAGE REG Pri 92-138v 57/63 cy. 1ph 15 A Sec 115v 7.15A 82 Kv 96% PF......$135.00
Self-Contained Unit in Grey Cabinet.

POWER CHOKES

6 Hy @ 150 Ma..................................$1.50
6 Hy. @ 300 Ma $3.25
1 Hy @ 800 Ma. 7.5 Ohms........................$8.95
Dual Choke: 2-2 HY @ 100 Ma....................$.90
Dual Choke: 7 Hy @ 75 Ma 11 Hy @ 60 Ma...$1.50
8.5 h @ 125 ma.................................$1.50
25 h @ 65 ma...................................$1.10

OIL CONDENSERS

.25 mf @ 20000 VDC Aerovox, $17.50
1.5 mf @ 6000 VDC Aerovox $12.50
1 mf @ 25000 VDC........$60.00
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MICA

.08 mf @ 1500 VDC, Sprague MX60 ....$11.50
.03 mf @ 2000 VDC, CD 551A-50 ....$12.75
.045 mf @ 2000 VDC, Sangamo, G1 ....$12.75
.00015 mf @ 20 KV, Aerovox 1970-404 ....$25.00
.0001 mf @ 20 KV, Sangamo G3 ....$25.00
.0051 mf @ 15 KV, Sangamo G4............$25.00
.006 mf @ 10 KV, Sangamo G3.............$17.50
.002 mf @ 15 KV, Sangamo $20.00
Isolating Capacitor, Cornell-Dubilier PL 1417, 106-110 mmf @ 10 KV AC (peak) Each....$3.50
MFRS: Send your requirements for bathtubs, Micas, Hardware, resistors, & connectors.

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D-163392 Button

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WIRE RECORDING MAGAZINES
Magazine for KS 1200 9 recorder, made by W.E. Comes with wire for ½-hour recording. Has elapsed time indicator, recording and erase features. Size: 14¾" L x 7" W x 5¾" H. Less Drive Motor $32.50

SURPLUS BARGAINS!

PORTABLE A.C. AMMETER
WESTON #528

Double range ammeter. 0—3 Amps and 0—15 Amps. Two of the very useful ranges for your Lab. or shop. Complete in genuine leather case with test leads.

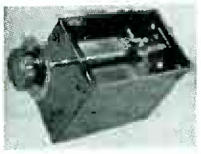
Your Price $12.25

L. & N. A. C. Res. Boxes #4750

L&N 6 Decade resistance box for precise measurements with AC bridges (for low capacitance and inductance changes). Shielded in aluminum can. 6 dials. Total res: 11,111-1 ohms. Decade steps 10. (0.01+0.1+1+10+1000) Limited Quantity.

Your Price $75.00

TRANSTATS—3 K. V. A.



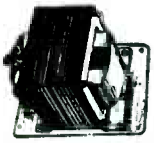
Type RH. Input: 115 V 10%. Output: 115 V. Max. Amps: 26 A. Made as a line voltage corrector 10% of input voltage, or can be connected to give plus 20% or minus 20% of input. Can also be reconnected to be used as an isolated type stepdown with variable secondary. Input: 115 V. Output: 0-36 Volts at 30 Amps.

A Real Buy at . . . $18.00

(same type, but .25 KVA. Input: 103-126 V.; Output: 115 V.-2.17 A.)

Price $6.50

STEPDOWN TRANSFORMER



Made by General Electric. Heavy duty stepdown transformer, with considerable overdesign. Ideal for rectifier applications, low voltage heating, general laboratory use, etc. Open frame type.

Input: 115 Volts—60 Cycles
Output: 15 Volts (at full load)
Capacity: 180 V.A.
Size: 3½" x 3½" x 4".

Your Cost $3.75

Quantity prices available

HEAVY DUTY STEPDOWN TRANSFORMERS

Input: 115 V. (with 8 taps in primary).
Output: from 16 to 10.5 V. (in 8 steps).
Capacity: 1.25 KVA—Sec. Amps: 100.
Size: 13"x10"x5". Approx. Weight: 30 Lbs.
Open Frame Construction.

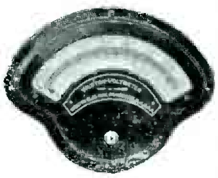
Your Cost $12.50
10 for. $100.00

SELENIUM RECTIFIERS
Full Wave Bridge

Approximate Rating

Federal Type #	*Input Max.*	*Output Max.*	*Amps.*	*PRICE*
10B1CV1	18 V.	14 V.	.5	.98
10B2CV1	36 V.	28 V.	.5	1.50
4B3CV2	48 V.	36 V.	.5	2.75
5B2AV1	36 V.	28 V.	1.6	4.25
5B2AV5	36 V.	28 V.	8	11.75
11BA6AM1	120 V.	100 V.	1.6	11.95
9DO612R	150 V.	115 V.	1.6	14.50

WESTON MODEL 271
Large Fan Shaped Microammeter



Another of the famous Weston fan shaped line. Very large scale 5.8" long. These meters were made by Weston to General Radio specifications, with special mirrored scale and knife edge pointer. Accuracy 1%.
0—600 Microamps
170 M.V.
Coil Res: 250 Ohms

Your Price $12.50
10 for $100.00

D. C. MICROAMPS
0-100 Microamps, res. 100 Ohms 3" Rd. Westinghouse NX/35
$7.95

0-150 Microamps—2" rd. G.E.—DW51 or Whse NX33. Res: 500 Ohms.
Your Cost $3.75

D. C. AMPS & MILLS

0-1 Ma 2" G.E. DW41 . . . . $3.75
(special scale)
0-1 Ma 2" Weston 506 . . . . 3.75
0-2 Ma 2" Sun 1AP525-5 . . . . 2.25
0-2 Ma 3" Weston 301 . . . . 4.95
0-3 Ma 2" Weston 506 with metal case . . . 1.85
0-5 Ma 2" Dejur S-210 . . . . 1.95
0-25 Ma 2" G.E. DW41 . . . . 2.95
0-30 Ma 2" G.E. DW41 . . . . 2.95
0-100 Ma 2" sq. Simpson 127 . . . . 2.95
0-100 Ma 3" Weston 301 . . . . 4.95
0-500 Ma 2" G.E. DB41 . . . . 3.25
0-1 Ma 3" sq. Westhe RX-35
(Scale: 1.5 KV) 4.25
0-1 Ma G.E. DO-41-Black Scale 3" (Scale: 3 KV) 3.85
0-1 Ma G.E. DO53-3" 4.75
0-15 Ma 3" Westhse NX-35
(scale: 15/150/300) 2.95
0-30 Ma 3" Weston 301 (Metal) 3.75
0-1 A. 3" sq. Weston 301 . . . . 5.50
0-10 A 3" sq. Triplett 2.50
0-10 A. 3" Simpson #25 . . . . 4.50
30-0-30 A. 3" Simpson #25 . . . . 4.50
0-30/120/600 Ma Weston Portable-Model 280—Precision Type 5.95
0-300 A. 3" Roller-Smith 4.95
(fl. bake. Type TD-50 MV)
(with ext. shunt)
0-300 A. same as above 2.25
(without shunt)
0-300 A. 4" Weston 633 . . . . 8.50
(fl. metal—black scale—ext. Shunt)
0-300 A. 4" same as above 5.50
(without shunt)

D. C. VOLTS

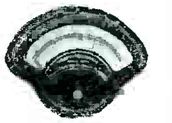
0-15 V. 2" Westhse BX-33 . . . . 2.75
(Black scale)
0-15 V. 2" Simpson #125 . . . . 2.95
0-20 V. 2" Weston 506 . . . . 2.95
(1000 Ohms per Volt)
0-15 V. 3" Westhse NX-35 . . . . 3.95
0-40 V. 2" Weston 506 . . . . 2.95
0-150 V. Weston 301 . . . . 4.50
(Black scale-metal case)
0-150 V. 3" G.E. DO-G1 . . . . 4.75
0-50 V. 4" Westhse NX-37 . . . . 6.00
0-150 V. 4" Weston 643 . . . . 6.75
(Blak scale—flush—metal)

A. C. VOLTS

0-10 V. 2" G.E. AW-42 . . . . $2.95
0-10 V. 3" G.E. AO-41 . . . . 3.75
0-150 V. 2" Simpson 155 . . . . 2.95
(metal case)
0-150 3" G.E. AO-41 . . . . 4.50
0-150 V. 3" Simpson 55 . . . . 5.95
0-75 V. 4" Weston 642 . . . . 6.75
(Surface Metal Case)
0-300 V. 4" sq. Triplett 3.25
(431A 300/600 V. scale)

All meters are white scale flush brakelite case unless otherwise specified.

WESTON MODEL 269 FAN SHAPED METER



One of the Weston popular fan shaped line. Exceptionally long scale for size of instrument. Accuracy — within 1%. Scale length—4". Spade pointer. Here is a good movement for special purpose instruments. Comes with blank scale with arc drawn in. Ready for plotting calibration points. Can be used to make up any range of volts, amps, MA., etc. Full scale deflection—5 M.A.—40 M.V.

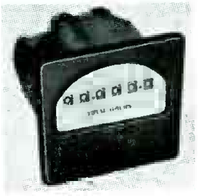
List $29.83
Your Cost $8.95
10 for $75.00

OHMMETER

Weston — 689 1-F.
Convenient pocket size with sturdy leather case, for low resistance readings. Double Scale.
0-10 Ohms Full scale.
0-1000 Ohms Full scale.
Size: 5"x2⅞"x1⅞".

Your Cost $14.75
(with case & batteries)

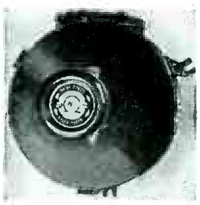
TOTAL HOUR METER



Westinghouse elapsed time meter. Type RH-35; 120 Volts, 60 Cycles. Six counter units, the sixth counter indicates 1/10th hour steps.

Your Cost . . . $4.95

HEAVY DUTY RHEOSTAT
WARD LEONARD



10 ohms — 9.2 Amps —9.2 Amps (Not tapered). 14" Dia. Complete with handle and legs for rear of panel mounting.

Your cost $5.95

RECTIFIER TUBES

6 Amp. (Tungar type) for battery chargers, rectifiers, etc.

Your Cost $1.50
(minimum order of 10 tubes)

SPECIAL METERS

Westinghouse RA-37—4" square.
0-300/600 V. Scale $7.85
Same meter with Potential Transformer for 600 V. Range 9.95
Westinghouse RA-37—4" square.
0-5 Amps 7.00
Frequency Meter—350/450 CPS Aircraft type 4" Weston Model 637 . . . 4.95
Resistance Thermometer—30 Deg. F. to 0-230° F. Complete with res. bulb. Aircraft type. 2" Weston 727 . . . . 4.75
Weston Thermometer 221-D—4" rd. 50° F. to 300° F. 2½" stem 4.95

A. C. AMPS

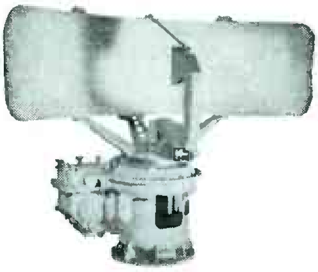
0-1.5 A. 2" Weston 507 (RF) $3.50
0-2 A. 3" Westhse RT-35 (RF) 3.95
0-3 A 3" Westhse NA-35 . . . . 3.95
K (scale: 120 A.)
0-30 A. 3" Triplett (metal) 2.95
0-5 A. 4" Weston 642 (surf.) 7.95
(surface-metal)
0-5 A. 4" sq. Triplett 431A 2.95
(scale: 150/300)

All meters are white scale flush bakelite case unless otherwise specified.

POWERTRON Electrical Equipment Co.

119 LAFAYETTE STREET *Phone:* **WOrth 4-8610** **NEW YORK 13, N. Y.**

RADAR EQUIPMENT



SO-1 Antenna Assembly Comprises:

- A drive mechanism including a drive motor and gear train.
- A synchro 400 cycle generator with gear train and mechanical differential.
- A rotating radiator system including a right angle radiator nozzle, a reflector in the form of a paraboloidal section, R.F. fittings for coupling the rotating system to a stationary waveguide.
- A supporting pedestal and base plate.

Brand new packed in export cases.

These antenna assemblies have many uses as replacements on vessels now using SO-1 equipment, experimental radar and microwave work, amateur beam rotators, etc.

PRICE $90.00

SO-8 Antenna assemblies also available, brand new and export packed.

PRICE $120.00

IN STOCK

S.G. Radar complete sets of yard spares.
S.O.3 Radar complete sets of tender spares.

HIGH PRECISION 100 Kc. CRYSTALS

(Photo slightly less than actual size.)

Exceptional Frequency Stability ± 15 cycles from —50° to +80°c. (.0015) 10G Vibration Test. Calibrated at 30°c Brand New, Mounted in Sealed Cases as Shown.

Price $3.95 each

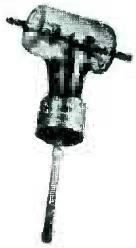
(No C.O.D.'s. Please include 25c for postage and handling.)

VACUUM CONTACT RELAYS

For application in all types of high speed switching devices. Long service life, high operating speeds, large current and voltage handling capacity, uniform and constant operating characteristics under adverse atmospheric conditions. Hermetically-sealed mercury-wetted contacts in gas-filled glass envelope. Free from moisture, dirt, corrosion and atmospheric pressure.

W. E. D-168479 Relay

Price $9.75 each

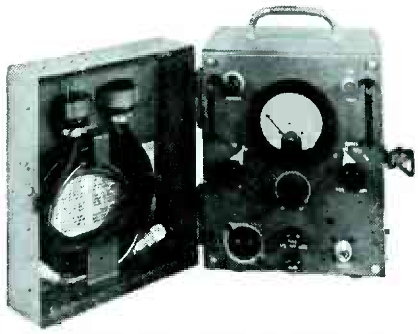


This switch has many applications such as switching or interrupting high voltages, antenna circuit switching at high altitudes, power supply switching for high voltage vacuum tubes and high-speed keying operations at any voltage up to 10,000, or current up to 5 amperes, frequency up to 30 Mc.

Sperti Vacuum Switch

Price $2.95 ea.

PEAK-TO-PEAK V.T.V.M.



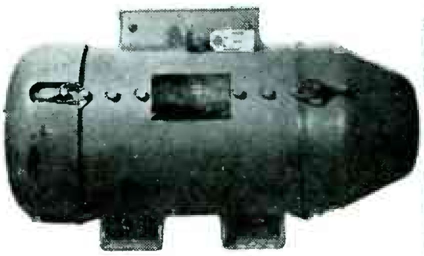
A small, lightweight, portable instrument designed to measure peak-to-peak voltages of recurrent waves, particularly of the type normally found in radar video circuits. It is especially intended for use in setting the levels of video and synchronizing voltages in radar equipment where the relationships between these voltages are important to the operation of associated equipment.

Designed by Radiation Labs. M.I.T. for the U. S. Navy.

Type TS-487U

Price $49.50 each

MOTOR GENERATORS



Brand new. Built by Allis Chalmers to rigid specifications of the U. S. Navy.

K.V.A. output 1,250 R.P.M. 3600
K.W. output 1. Cont. Duty PH. Single
P.F. 80. Cycles 60
Volts input 115 D.C. Volts output 120 A.C.
Amps. input 14 Amps. output 10.4
Length 26"; width 12⅞"; height 13". Compound accumulative A.C. and D.C. fields. Centrifugal starter. Splashproof covered. Frequency adjustable to load, plus or minus five cycles.

Price $87.50

Identical Machine, but 230 volts D. C. input, $125.00

Set of Replacement Spare Parts for Either Machine $29.50

PAN-OSCILLO-RECEIVER

Ideal for laboratory, television and general service work

PERFORMS WORK OF FOUR UNITS:

1. Panoramic Adaptor: For use with any receiver with I.F. frequency of 405-505 kcs. 4.75 to 5.75 mcs., and 29-31 mcs.
2. Oscilloscope: Visually checks received signals, monitors transmitter, output-percentage modulation, carrier waveshape, etc.
3. Synchroscope: External inputs provide synchroscope action.
4. Receiver: Three inputs provide facilities for use with convertors to cover wide range of frequencies to 10,000 mcs.

Transformer built in for 110 V. 60 cycle operation.

Price $97.50

(Mail $1.00 for 80 page Technical manual and instruction book)

KOLLSMAN MAGNETIC COMPASSES (New Condition)

Type B-16 Price $9.95 each

Approach Indicators—I.D.—24/ARN-9 Price $4.95 ea.

Inverters—Pioneer Bendix type 12123-1-A Price $49.50

Instrument Lamps—Mazda #323 Price $22.00 per C

SYNCHROS (Selsyns, Antosyns, etc.)

G.E. types 2J5FB1, 2J5S1 Ford Inst. types 5SDG Bendix types 1-1, 11-2, X, CAL 18300 Electrolux type XXI Diehl type 1V, 78414 Navy ordnance types 5F, 5G, 5CT, 5DG, 1G, 1CT, and many other types in stock.

All prices quoted are F. O. B. Tuckahoe, N. Y. (About 20 miles north of New York City). All merchandise guaranteed. Immediate delivery subject to prior sale.

ELECTRONICRAFT, INC.

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Telephone Tuckahoe 3-0044

Finest of surplus at a fraction of cost

PEAK ELECTRONICS CO.

Industrials Schools - Labs

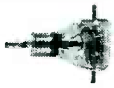
AMERTRAN TRANSTAT

110/220 volts 60 cycle input. Output variable plus or minus 10% of 115 volts at 8.5 amps. Also can be connected to give different voltage combinations. Brand new ......only $22.50

AMERTRAN VOLTAGE REGULATOR

130/230 volts 50/60 cycles input. Output variable from 0—260 volts. 1.3 KVA, single phase. Like new $29.50

SPERTI RF VACUUM SWITCH



9200 volts peak. 8 amps. Used as antenna switch in Collins ART 13. Brand new $1.95

FEDERAL SELENIUM RECTIFIER

Full wave. 36 volts input. 28 volts output at 6.1 amps. Brand new $7.95

OIL CONDENSERS—CD, GE, Aerovox, etc.

2mfd 600 vdc....$ .39
4mfd 600 vdc.... .59
3/3 mfd 600 vdc.. .79
4/4/4 mfd 600 vdc .95
14 mfd 600 vdc.. 1.35
20 mfd 600 vdc.. 1.85
2 mfd 1000 vdc.. .79
4 mfd 1000 vdc.. .95
2 mfd 1500 vdc.. 1.25
1 mfd 2000 vdc.. 1.15
3 mfd 3000 vdc..$3.95
1 mfd 4000 vdc.. 3.75
1 mfd 5000 vdc.. 4.50
.1 mfd 7500 vdc.. 1.95
.1/.1 mfd 7500 vdc 2.45
.01/.01 12 KV dc 5.75
.005/.01 12KV dc 5.50
.65 mfd 12500 vdc 12.95
.75/.35 mfd (dual) 8/16 KV dc.....14.95

WHERE SPACE IS LIMITED

This tiny GE meter only 1½ inches square. Basic movement 0—1 ma. Ideal as "S" meter for BC348, etc. Only.......$3.95 ea.

METERS (brand new)

2" GE 0—15ma (amp scale)................ $1.95
2" GE 0—1.2 ma (0—100 scale)............ 2.49
2" GE 0—1 amp R.F. (internal thermo).... 3.49
2" Weston 150-0-150 microamps., Model 506 (Sperry scale)..................... 3.49
2" McClintoch 0-50 microamps. (square).... 7.50
3" W.E. 500-0-500 microamps. (Blank scale) 3.95
3" Westinghouse 0-50 amps. A.C........... 4.95
3" Westinghouse 0-2 ma D.C............... 3.95
3" Westinghouse 0-20 ma D.C.............. 3.95
3" G.E. 0-15 ma D.C. (square)............ 3.95
3" Westinghouse 0-150 volts A.C.......... 3.95
4" G.E. 1-0-1 ma D.C. (Blank scale)...... 3.95

ELECTROLYTIC CONDENSER BARGAINS

(Cornell Dubilier, Aerovox, W. E. only)
25 mfd 25 w.v. tubular C.D............... $ .25
50 mfd 50 w.v. tubular Aerovox........... .29
4 mfd 150 w.v. tubular C.D............... .18
8 mfd 450 w.v. tubular C.D............... .37
12 mfd 450 w.v. tubular C.D.............. .44
500 mfd 15 w.v. tubular C.D.............. .49
10 mfd 450 w.v. can C.D.................. .49
16 mfd 450 w.v. can C.D.................. .69
20x20 mfd 450 w.v. can Aerovox........... 1.05
80 mfd 200 w.v. can W.E.................. .69
200 mfd 200 w.v. can W.E................. .98
1000 mfd 25 w.v. can Aerovox............. .95

I.R.C. WIRE WOUND RESISTORS

5 watt type AA, 20-25-50-200-470-2500-4000 ohms .... .09 ea.
10 watt type AB, 25-40-84-400-470-1325-1900-2000-4000 ohms .... .15 ea.
20 watt type DG, 50-70-100-150-300-750-1000-1500-2500-2700-5000-7500-10000-16000-20000-30000 ohms .... .20 ea.
30 watt type DJ, 100-150-2500-3000-4500-5300-7500-18000-40000 ohms .... .24 ea.

1% PRECISION RESISTORS—I.R.C.., Mepco, etc.

2000-2500-5000-8500-10000 ohms .... .39 ea.
50000-95000 ohms .... .49 ea.
100000-750000-1 meg .... .89 ea.

AMERTRAN STEPDOWN TRANSFORMER

7½ KVA. 50 cycles. 3 phase. Primary 208 volts. Delta secondary 106-144 volts in 3½ volt steps. 10¼x18¾x10 5/16. Brand new $59.50

U.H.F. COAX. CONNECTORS

UG12U—831R—831J—UG21U—831AP—831SP .39 ea.
Large stocks of Coax. and A/N connectors.

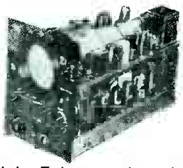
MEGOHM METER

Industrial Instruments Model L2AU 110/220 volts 60 cycle input. Direct reading from 0-100000 megohms on 4" meter. Can be extended to 500000 megohms with external supply. Sloping hardwood cabinet 15"x8"x10". Brand new with tubes plus running spare parts including extra tubes. Great value only $69.95

G.E. 2" SCOPE

This compact unit only 4½" x4"x6¾". Ideal for modulation indicator, etc. Has focus, intensity and reticle brilliance controls. Uses 2AP1 C.R.T. and 9006 rectifier. We supply instructions with each scope. Rectifier built in. Need only 500-600 volts A.C. plus 6.3 volts. Changes very simple. With cable and 9006 but less 2AP1 .... $4.95
2AP1 C.R.T. 2.50

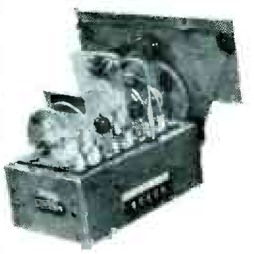
APN4, 5" SCOPE INDICATOR (25 tubes)



Makes an ideal basis for 5" scope. Also can be converted into Panadaptor with marker pips at 100-KC - 20KC - 2KC., for measuring drift and width of F.M. Has electronic switch for observing 2 frequencies simultaneously. Unit contains an accurate 100KC crystal. Tube complement: (1) 5CP1 (3) 6SL7 (14) 6SN7 (6) 6H6 (1) 6SJ7. Complete with tubes and 100KC crystal. Marvelous buy at $24.95

INNOVATION

An F.M. front end of exceptional stability featuring resonant tuned lines. Eliminates variables and slugs. 88-108 MC. Manufactured by Approved Electronics Inst. Corp.



★ Lines and contacts have heavy silver overlay.
★ Non microphonic.
★ Feeds into 10.7 MC. I.F.
★ Floating Chassis.
★ Slide Rule Dial—16:1 Ratio.
★ Negligible Drift.
★ 6AK5 RF., 6J6 osc.—mixer, 6U5 indicator.

Chassis 8"x5"x3". Beautifully constructed. Wired and complete with tubes and instruction book $18.95 Complete tuners available. Detailed literature on request.

POWER PLANT (PE 197)

4 cylinder Hercules Gas driven engine. Output 110 volts 60 cycles. voltage regulated. 5KW-6.3KVA at 80% Pwr. Ftr. Single phase, complete with running spare parts, meter panel, battery, tools, remote cable, etc.

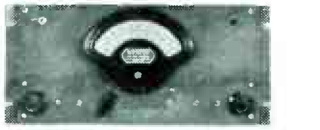
Weight 1200 lbs. Export Packed. Excellent for emergency power. Brand new............ $575.00

MISCELLANEOUS SPECIALS

2-11 mmf. Butterfly with ball bearings.....$ .59
G.E. S.P.D.T. Relay 10000 ohm coil........ .59
Heineman Circuit Breaker 5 amp. 110V. A.C. .89
G.E. Solenoid W/Microswitches 24 V. D.C... .69
Ohmite 25 ohm 25 watt Rheostat............ .39
Microswitch 10 amp. (interlock)........... .59
C.H. Bat Handle Switch—D.P.S.T. ½ H.P. .95
Bendix Synchro Motor 115V. A.C. 400 cycle 1.95
Weston 663 Analyzer 19.50
Weston 665 Analyzer 29.50
Veeder Root Counter .... .95
Single Plate to P.P. input 3:1 ratio trans... .49

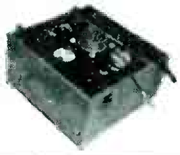
Tremendous stocks on hand. Please send requests for quotes. Special quantity discounts. Prices f.o.b. N. Y. 20% with order unless rated, balance COD. Minimum order $3.00.

DAVEN AUDIO FREQUENCY METER Model 837E



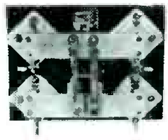
Direct reading from 0-30 KC in 4 separate ranges on 6" Weston Model 271 Fan Meter. Built-in voltage regulated power supply operates from 115 volts 60 cycles. Has high input impedence. With pick-up can be used to determine frequency in vibration tester. With suitable mixer can check deviation of R.F. carrier from standard. Mounts on 8¾"x19" rack panel. Complete with tubes. Slightly used but perfect. Only $59.50

S.C. TEST SET—I-114



In portable wood case 6" x 6" x 10" (including cover not shown). Has Weston 0-150 volt A.C. meter 60 cycle, 2 switching circuits. Complete with line and test cables. A bargain at only $3.95.

HIGH WATTAGE ANTENNA RELAY



110/220 volt 60 cycle coil. D.P.D.T.-rated at 5000 volts. Heavy duty paralleled contacts. Sturdy construction. Isolantite insulation. Base 8" x 10½". Brand new..$7.95

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C.T.C. 1.5 henry 250 ma. 72 ohms.......... .69
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2500 volts 2 ma. hermetic sealed $5.95
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770 V.C.T. 100 ma.. 6.3 volts—2.5 amp. 5 volts—2 amps.—3½" x 4" x 4½"........ $2.75

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Hammarlund APC 100-100 mmf............ .39
Hammarlund APC 50-50 mmf.............. .29
Hammarlund HFD30X-Dual 30 mmf. D.S... 1.10
Bud MC 913 Dual 35 mmf. D.S........... 1.25

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Cardwell XD160 XD. Split stator. 160 mmf./section .125 spacing................... $7.95
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C.D. (6H) .0013 5000V. D.C.................. 1.00
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Full Wave Bridge Type

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up to 18v A.C.	up to 12v D.C.	15 Amp.	9.95
up to 18v A.C.	up to 12v D.C.	30 Amp.	14.95
up to 36v A.C.	up to 28v D.C.	1 Amp.	3.45
up to 36v A.C.	up to 28v D.C.	5 Amp.	7.45
up to 36v A.C.	up to 28v D.C.	10 Amp.	12.45
up to 36v A.C.	up to 28v D.C.	15 Amp.	18.95
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150 Watt—CW and Phone
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Sec.: 115 volts @ 1.74 amps.
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6SH7	.59	957	.75
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1700v @ 4 ma.; 6.3v @ .6A; 2½v @ 1.75A	8.50
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400-315-0-100-315v @ 200 ma.; 2.5v @ 2A; 6.3v @ 1A; 5v @ 3A; 6.3v @ 9A	7.50
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325-0-325v @ 120 ma.; 10v @ 5A; 5v @ 7A	3.49
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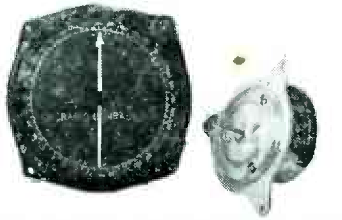
Remote Position Indicator System



5 inch indicator with 360 degree dial. Pioneer Type I-82A. 2320 transmitting Autosyn with heavy duty brushes. Operates on 6-12 V. 60 cy. Stock #S-115. Price $9.95 per system.

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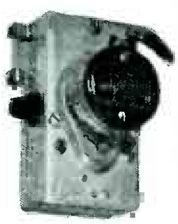

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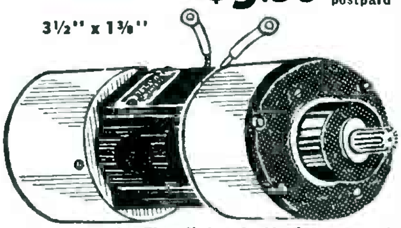

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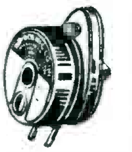

to operate switches, etc. can be had either 1 Rev. per hour or 1 Rev. per minute at this SPECIAL PRICE **$3.85**

Many other speeds available at $4.95

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RT-7/APN-1 Altimeter—New, complete with tubes & dynamotor less plugs and controls...... **$11.95 ea.**

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154-186 MC; part of Radio Equipment RC-148C.

Transmitter: designed for pulse operation with a peak power output of 1 KW.

Receiver: is a super het with 2 stages of RF using 6AK5 tubes, 5 stages of IF amplifier in its present form has a band width of 4MC, can be peaked to 11MC.

The power supply is the RA-105-A which supplies all operating voltages for the transmitter and receiver. It is supplied complete with tubes for 110 Volt AC. Operation less cables. Included is a sturdy carrying chest in which the units are packed. Brand new. Shipping weight approx. 500 lbs. Your cost............ **$22.50**

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Microwave Generator TS 13/AP for Xa band, power meter for internal and external metering, calibrated attenuator.

Fluxmeter TS-15/AP, 1000 to 10,000 gauss, for .6" and 1.3" to 1.5" gaps, new, $60.00

Radar Test Set TS278, synchronized, delayed pulse generator, 400-430 mc, 115 v 60 cps, complete with cables, new $75.00

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Radar Transmitter Converter, 3 cm, 115 v 400 cps, used, complete with magnetron & klystron $100.00

Radar Transmitter BC 947 A, 10 cm, 115 v 60 cps, less HV supply, wt 380 pounds $40.00

Complete Marine Radar, Navy SD 3, 220 megacycles, 115 v 60 cps, new, export packed.

Complete 10 cm Radar Sets, SL & SF-1, new export packed.

Crystal Mixer Assembly, 10 cm...... $3.00
Tunable Mixer Assembly, 10 cm...... $5.00
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Mixer Butterfly, 80-300 mc........... $3.00
Attenuator TPS-51PB-20, fixed 20 db, $3.50
Attenuator CN-50/APN, 30-100 db, calibrated $15.00

Type N Connectors, UG 12, 21, 24, 25, 27, 30, 58, 83, 86, 245 U and UHF Connectors SO239, PL259, M359, UG266U, immediate delivery.

RG 9/U and RG-8/U cable with UG21/U connectors at ends, 4.5' long...... $2.00

GENERAL RADIO PRECISION WAVEMETER, Type 724A, range 16 kilocycles to 50 megacycles, V.T.V.M. resonance indicator, complete with accessories and carrying case, new $200.00

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Radio Compass Receiver, Bendix MN26-A, 150—1500 kc, 12 v, new.......... $40.00

Transformers, 115 v 60 cps primaries:

1. 7500 v 35 ma ungrounded, Thordarsen suitable for doubler........... $15.00
2. 6250 v 80 ma ungrounded, G.E.. $12.00
3. 2 secondaries at 500 volts 5 amps each $50.00
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Pulse input transformer, permalloy core, 50 to 4000 kc, impedance ratio 120 to 2350 ohms $2.80

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500 to 2500 ft.	$30.00
3000 to 5000 ft.	27.50
5500 to 10,000 ft.	22.50
Over 10,000 ft.	20.00

No charge for reels.

RADAR TRANSMITTER-BC-1072-A: Operates on 115 volt, 60 cyc., freq. range 150 to 200 mcs.

CONTAINS:

Blower—115 V., 60 cyc., 28 watts, 1525 R.P.M.
Variac—Gen. radio type, 200 B, 100 watts
4 Transformers—
117 V Pri; Sec. 3500 V
117 V Pri; Sec. 6.3 V@2.1 A, 312 V Center tap each side, 5 V@3 A
117 V. Pri; Sec. 4 V @ 16 A, 2.5V @ 1.75 A
117 V. Pri; Sec. 6.3 V@1.2 A, 700 V either side of center, 5 V@3 A
2 Chokes—2 relays
11 Tubes, including 6J15, 2X2, 6SN7, etc.
Meter—G.E. 3½", 0-5 Kilovolt and 0-10 M.A., D.C.
Circuit Breaker—115 volt, 15 amp.
5 Condensers—(1) .1 mfd, 7000 V. (2) 2 mfd., 1000 V, (2) 4 mfd, 600 V

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2 mfd	4,000	V.D.C.	4.65
4 mfd	3,000	V.D.C.	3.25
1 mfd	3,000	V.D.C.	1.70
4 mfd	2,500	V.D.C.	2.65
.2 mfd	750	V.A.C. (2200VDC)	.40
4 mfd	2,000	V.D.C.	2.00
.1 mfd	2,000	V.D.C.	.75
4 mfd	1,000	V.D.C.	1.00
3 mfd	1,000	V.D.C.	.90
14 mfd	600	V.D.C.	1.70
10 mfd	600	V.D.C. (Solar)	1.35
4. mfd	600	V.D.C.	.70
1 mfd	600	V.D.C.	.29
1.75 mfd	330	V.A.C.	.39

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.01 mfd	300 V	.002 mfd	500 V
.0047 mfd	500 V	.0012 mfd	400 V
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.000022 mfd 500 V

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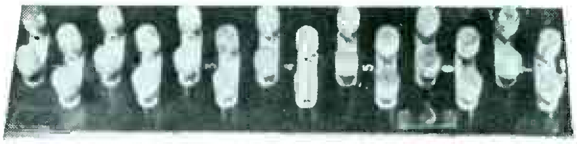

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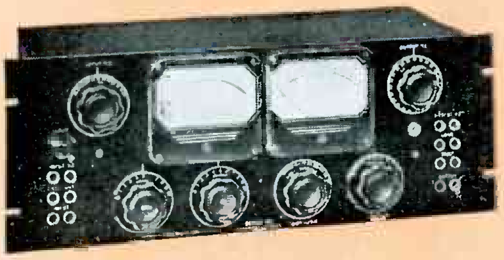

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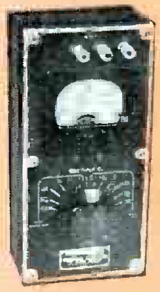

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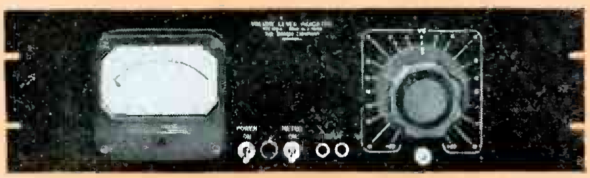

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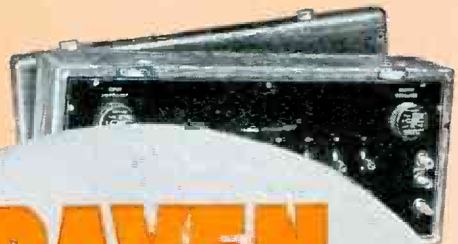

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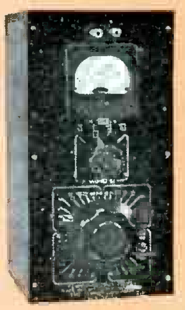

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