Revolutionary Amplifier
The CRYSTAL TRIODE
We illustrate the units below for the information they bring to engineers of “What can be done.” A large part of UTC production, however, is on catalogued and special material of more standard nature. UTC quality has world-wide recognition on ALL types of transformer components.

FOR FILTERS

- **Broad Band Sharp Cutoff Filter**
- **Narrow Band Sharp Cutoff Filter**
- **Attenuates 10KC to 30 Megacycles**
- **Low Frequency — Low Pass Filter**

FOR TRANSFORMERS

- **This high gain transformer is used in a 60 cycle chopper circuit for measuring small DC voltages—primary inductance 10 Hys. Ratio 250:1 — 100 DB of shielding.**
- **This unit weighs but 1.3 oz. The rectifier in which it is employed delivers 2000 V DC with vibrator-battery input.**
- **This input transformer was the perfect answer for an amplifier with a difficult hum problem. The locking universal joint mounting permits orientation to point of minimum hum level.**
- **This pulse transformer has tight requirements. Frequency response is ±3 DB from 80 KC to 4 MC.**

Write for our Catalog PS-408
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This tiny capacitor for radio, television and other electronic applications combines compact design with proven performance. Molded in low-loss bakelite the CM 15 is famous for dependability. Impregnated against moisture, it delivers at maximum capacity under extreme conditions of temperature and climate.

**CM 15 FEATURES**
- 500 D.C. working voltage
- 2 to 420 mfd. capacity at 500v. DCA
- 2 to 525 mfd. capacity at 300v. DCA
- Temperature co-efficient 0 ± 50 parts per million per degree C. for most capacity values
- 6-dot color coded to Joint Army-Navy Standard Specifications JAN-C-5

**SPECIFY EL-MENCO for your product . . .**

from the Tom Thumb CM 15 to the CM 40, all El-Menco capacitors give you — and your product — dependable performance, endurance, and accuracy. Send for catalog — Specify El-Menco Capacitors.

**THE ELECTRO MOTIVE MFG. CO., Inc.**
**WILLIMANTIC, CONNECTICUT**

**MOLDED MICA CAPACITORS**

**EL-MENCO**

**MICA TRIMMER**

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September, 1948 — ELECTRONICS
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CLEVELAND • DETROIT • INDIANAPOLIS • MILWAUKEE • NEW BRUNSWICK, N.J. • NEW YORK • PHILADELPHIA • ROCHESTER • ST. LOUIS

September, 1948 — ELECTRONICS
YOU CAN CONTROL MULTI-TOWER ARRAYS THIS SIMPLE WAY

1. Use one Antenna Control Unit for two towers

The Western Electric 33C Antenna Control Unit includes a branching circuit and two phase shifters, and permits adjustment of the current ratio and phase relation between the element currents of two towers. This unit handles up to 10 kw.

2. Add a compact Phase Control Unit for each additional tower

Does your pattern call for an array of 4 or even 6 towers? Then merely order the necessary number of compact 34A Antenna Phase Control Units to be connected to taps on the branching transformer of the 33C. The 34A handles up to 10 kw.

TYPICAL CIRCUIT DIAGRAM SHOWING TWO 34A ANTENNA PHASE CONTROL UNITS CONNECTED TO BRANCHING TRANSFORMER OF 33C ANTENNA CONTROL UNIT FOR CONTROL OF 4-TOWER ARRAY. ADDITIONAL 34A'S MAY BE CONNECTED AS NEEDED FOR AS MANY AS 6 TOWERS.

You can use Western Electric Antenna Control Equipment to good advantage in controlling current ratios and phase relationships. The master 33C Antenna Control Unit is styled to harmonize with cabinet design of Western Electric AM Transmitters. The 34A Phase Control Unit measures only 2' high, 3'7" wide, 2' deep, and requires no front-of-panel line-up space.

QUALITY COUNTS

For complete information on Western Electric Antenna Control Equipment, send the coupon below.

Western Electric


ELECTRONICS — September, 1948

www.americanradiohistory.com
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Exclusive Manufacturers of Communications Network Components

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Wide band sharp cutoff band pass.
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Sub-miniature band pass.
Includes 3 coils and 4 condensers.
Volume—4½ cubic inches.

Cycles
The big three out of 30 types of toroidal coils we are supplying.
TC-1 any ind. up to 10 hys.
TC-2 any ind. up to 30 hys.
TC-3 any ind. up to 750 hys.

Crystal filter for narrow band pass applications too critical even for toroidal coils.

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Our new plant will be the last word in modern manufacturing quarters, equipped with the newest and most efficient machinery and facilities, including the most complete and up-to-date paint and finishing department, scientifically air conditioned and dustproof. These advancements will enable us to extend the scope of the precision service we render the leaders of the radio and electronics industry.

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Ask For Our Informative New Catalog

KARP METAL PRODUCTS CO., INC.
124 - 30th Street, Brooklyn 32, New York
Custom Craftsmen in Sheet Metal
POWERSTAT variable transformers are not limited to laboratory, test panel or low power applications. As single units or as ganged assemblies, POWERSTAT types 1156 and 1256 provide smooth, precise, continuously adjustable variable a-c voltage for heavy duty requirements.

Type 1156 operates from a 115 volt, single phase, 50/60 cycles source to deliver 0-135 volts, 45 amperes output. Type 1256 delivers a variable output of 0-270 volts, 28 amperes from a 230 volt, single phase, 50/60 cycles line.

To obtain higher single phase ratings, types 1156 and 1256 are series, parallel or parallel-series connected, in ganged assemblies of 2, 3, 4 and 6 — operating on a common shaft. POWERSTATS in this arrangement can be supplied in 115, 230 or 440 volt ratings with output currents as high as 270 amperes. Three phase units are available in the same ratings. As many as 18 individual POWERSTAT types 1156 or 1256 can be employed in a three phase assembly. Type 1256-18Y (18 POWERSTATS with a single control) delivers 0-515 volts, 168 amperes from a 440 volt, three phase 50/60 cycles source.

Motor drive is recommended for heavy duty POWERSTATS. It gives finger-tip operation from a conveniently located push-button station, with the same smooth control found in the smallest manually-operated unit.

Whether your variable voltage requirement is 1 or 150 KVA, there's a POWERSTAT variable transformer to do the job.

The Superior Electric Co., 409 Meadow St., Bristol, Conn.
### 3-Phase Regulation

<table>
<thead>
<tr>
<th>Model</th>
<th>Load Range Volt-Amperes</th>
<th>Regulation Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>3P15,000</td>
<td>1500-15,000</td>
<td>0.5%</td>
</tr>
<tr>
<td>3P30,000</td>
<td>3000-30,000</td>
<td>0.5%</td>
</tr>
<tr>
<td>3P45,000</td>
<td>4500-45,000</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

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

### Extra Heavy Loads

<table>
<thead>
<tr>
<th>Model</th>
<th>Load Range Volt-Amperes</th>
<th>Regulation Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000+</td>
<td>500-5,000</td>
<td>0.5%</td>
</tr>
<tr>
<td>10,000+</td>
<td>1000-10,000</td>
<td>0.5%</td>
</tr>
<tr>
<td>15,000+</td>
<td>1500-15,000</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

### 400-800 Cycle Line

**Inverter and Generator Regulators for Aircraft.**

<table>
<thead>
<tr>
<th>Model</th>
<th>Load Range Volt-Amperes</th>
<th>Regulation Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>D500</td>
<td>50-500</td>
<td>0.5%</td>
</tr>
<tr>
<td>D1200</td>
<td>120-1200</td>
<td>0.5%</td>
</tr>
<tr>
<td>3PD250</td>
<td>25-250</td>
<td>0.5%</td>
</tr>
<tr>
<td>3PD750</td>
<td>75-750</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Other capacities also available.

### The NOBATRON Line

- Output Voltage DC Amps.
  - 6 Volts: 15-40-100
  - 12 "  ": 15
  - 28 "  ": 15-30
  - 48 "  ": 15
  - 125 " ": 5-10

- Regulation Accuracy 0.35% from 1/4 to full load.

### General Application

<table>
<thead>
<tr>
<th>Load Range Volt-Amperes</th>
<th>Regulation Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>25-150</td>
</tr>
<tr>
<td>250</td>
<td>25-250</td>
</tr>
<tr>
<td>500</td>
<td>50-300</td>
</tr>
<tr>
<td>1000</td>
<td>100-1000</td>
</tr>
<tr>
<td>2000</td>
<td>200-2000</td>
</tr>
</tbody>
</table>

### General Specifications:

- Harmonic distortion max. 5% basic, 2% "S" models
- Input voltage range 95-125: 220-240 volts (1-2 models)
- Output adjustable bet. 110-120: 220-240 (1-2 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.

September, 1948 — ELECTRONICS
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.
742 Military Road Buffalo 17, N. Y.

HU-50 Perforating unit used in conjunction 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.
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Watch
Master

Frequency Standards

GUARANTEED ACCURACY
1 part in 100,000
(.001%)

Uses
Time bases, rate indicators, clock systems, chronographs, geo-physical prospecting, control devices and for running small synchronous motors.

Features
1. Bimetallic, temperature-compensated fork, no heating or heat-up time is required.
2. Fork is hermetically sealed, no barometric effects on frequency.
3. Precision type, non-ageing, low coefficient resistors used where advantageous.
4. Non-linear negative feedback for constant amplitude control.
5. No multi-vibrators used.
6. Synchronous clock simplifies checking with time signal.

Specifications
Accuracy—1 part in 100,000 (.001%).
Temperature coefficient—1 part in 1,000,000 per degree centigrade (or better).

Outputs—
1. 60 cycles, sine wave, 0-110 volts at 0 to 10 watts (adjustable).
2. 120 cycle pulses, 30 volts negative.
3. 240 cycle pulses, 30 volts positive and negative. Pulse duration, 100 micro-seconds.

product of

AMERICAN TIME PRODUCTS INC.
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Operating under patents of the Western Electric Company.

American Time Products, Inc.,
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Company: _________________________
Address: __________________________
City: ___________________ State: ______
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CLARE Relays were selected by RCA engineers as a protective device to prevent the high voltage from being connected with the electron tubes before the evacuation of the column is completed. This application called for use of a relay designed for a long and reliable operating life... a relay that could be "installed and forgotten"... no further maintenance or attention required.

Selection of CLARE Relays by RCA engineers for this exacting service is typical of the increasing reliance placed in the ability of CLARE engineers to provide a CLARE Relay to meet specific job requirements. CLARE sales engineers are located in principal cities for your convenience. Whatever your relay problem, you will find them capable, experienced, and anxious to be of service.

Look up the nearest CLARE sales engineer 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.

CLARE RELAYS
First in the Industrial Field...
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Beltone Hearing Aid Co. combines 45 parts, including capacitors and resistors, into a smaller, lighter chassis.

Standard Coil Products uses one "Filpec" to take the place of two capacitors and one resistor—save space and simplify production of I. F. Transformers.

Sentinel Radio Corp. uses "Filpec" and "Couplate" for production savings on small receiver circuits.
CRL's Coup/ate consists of a plate load resistor, grid resistor, plate by-pass capacitor and coupling capacitor. Write for Bulletin 943.

Centralab's Filpec is for use as a balanced diode load filter. It combines up to three major components into one tiny filter unit, lighter and smaller than one ordinary capacitor. Also available for other applications. Write for complete information about Filpec, as well as other Printed Electronic Circuits.

Centralab's revolutionary, new Slide Switch offers improved AM and FM performance! Flat, horizontal design saves valuable space, allows short leads, convenient location to coils, reduced lead inductances for increased efficiency in low and high frequencies. Rugged, efficient. Write for Bulletin 953.

High quality, long life, dependability—that's the reason more manufacturers are switching to CRL's Hi-Kap Ceramic Capacitors.

LOOK TO CENTRALAB IN 1948! First in component research that means lower costs for the electronic industry. If you're planning new equipment, let Centralab's sales and engineering service work with you. Get in touch with Centralab!

Centralab

DIVISION OF GLOBE-UNION INC., MILWAUKEE, WIS.
4 PROBLEMS 4 ANSWERS

You, as a Communications Engineer, will be interested in the four Aerocom products illustrated below. They are designed and built to solve your communications problem. They are the result of engineering knowledge and experience gained during 18 years of manufacturing communications equipment for more than 200 installations throughout the world.

WEATHERPROOF LOW FREQUENCY ANTENNA TUNER. Sturdily constructed; using heavy aluminum sheet and rustless hardware. Ample ventilation provided, yet insect and vermin proof. Suitable for 1-2 kw carrier, 200-415 kcs; coupling coil matches either coaxial or 2 wire line. Illustration shows cabinet with protective and weatherproof (no gaskets) covers removed. Locking facility provided.

AUTOMATIC KEYER provides continuous or interrupted identification signals for beacon or aerophare service. Small, compact (6-3/8" x 9" x 7") and fully enclosed, this keyer will give long trouble-free service. Two synchronized cams, which can be milled to your specifications, provide several keyer combinations. Motor -- 105/115 v-50/60 cy.

METEOROLOGICAL INSTRUMENTS -- Aerocom’s group assemblies; anemometer and wind direction indicator on mast for outside installation, and reading instruments in cabinet or standard rack panel, give constant and reliable weather information. Instruments available: wind direction, wind speed, Kollsman station barometer (altimeter), 24 hour clock, or any combination thereof. Mast assembly may be remotely located from instruments.

LINE MATCH INDICATOR: Made in two models (a) LMI-72 for coaxial lines and frequencies from 0.2 to 10 mcs; (b) LMI-500 for balanced pair lines and frequencies from 0.2 to 2 mcs., or 2 to 20 mcs. These instruments permit adjustment of load for optimum line match. Sturdy and rugged, engineered for field use.

FOR OVER EIGHTEEN YEARS CONSULTANTS, DESIGNERS, AND MANUFACTURERS OF STANDARD OR SPECIAL ELECTRONIC, METEOROLOGICAL AND COMMUNICATIONS EQUIPMENT.
Plastics where plastics belong for strength, light weight; wear resistance and anti-frictional qualities.

Most important of Synthane's advantages is its unusual combination of chemical, electrical and mechanical properties. Structural strength, moisture and corrosion resistance and light weight are only a few of these characteristics that fit Synthane for so many applications. An excellent electrical insulator, our type of laminated plastics is hard, dense, durable, quickly and economically machined . . . it's the set plastic, stable over wide variations in temperature.

Synthane's versatility is demonstrated by its use for seven different parts and purposes in this Second Operation Machine.

The High Speed Precision Second Operation Machine (above), plays an important role in the high speed finishing of automotive accessories, aircraft fittings and fine instrument parts. In the rotating members especially, Synthane's light weight means quicker starting and stopping and higher speeds with less friction.

If these few of Synthane's many properties suggest its use in your product, let us help you with design, materials or completely fabricated parts. Write today for complete Synthane plastics catalog. 6 River Road, Oaks, Pa.
you're safer with Synthane

A desirable property of Synthane Laminated Plastics is the ability to withstand comparatively high concentrations of many common corrosives over long periods of time. While not 100% corrosion proof, Synthane is used in hundreds of applications because it often retains its shape, size, and strength for a longer time, and has a longer life per dollar invested, than other materials.

Parts fabricated from Synthane resist the action of corrosive waters and atmospheres, chemical salts and solutions, gasoline and other petroleum products. In addition, Synthane is light in weight, mechanically strong, an excellent electrical insulator and easy to machine.

If these properties suggest new uses for Synthane let us help you before you design; we may be able to save you time, trouble and money. Send for your free copy of the Synthane Plastics Catalog. Use the handy coupon.

SYNTHANE CORPORATION, 6 River Road, Oaks, Pa.

Gentlemen:

Please send me without obligation a complete catalog of SYNTHANE technical plastics.

Name ____________________________
Company __________________________
Address __________________________
City ____________________________ State __________________________

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PLAN YOUR PRESENT AND FUTURE WITH SYNTHANE TECHNICAL PLASTICS. SHEETS, RODS, TUBES, FABRICATED PARTS, MOLDED-LAMINATED, MOLDED-MACERATED

www.americanradiohistory.com
STANDBYS OF RELIABILITY AND PERFORMANCE

After more than a decade of proven service these Eimac triodes are still the workhorses of electronic equipment... from communication to industrial applications.

Recently improved by post-war developments, these tubes provide a big plus in performance, dependability and life expectancy.

As future replacements in the hundreds of thousands of applications in which they now function and as components in new equipment yet to be developed Eimac triodes are the wise buy. Remember when you specify an Eimac tube... you don't gamble... their performance is proven and guaranteed, and future procurement is assured... they're carried by better dealers everywhere.

Eitel-McCullough, Inc.
202 San Mateo Ave., San Bruno, California

EXPORT AGENTS: Fraser & Hansen—301 Clay St.—San Francisco, Calif.

ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Tube</th>
<th>35TG</th>
<th>100TH</th>
<th>250TH</th>
<th>450TH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filament</td>
<td>Thoriated Tungsten</td>
<td>5.0 volts</td>
<td>5.0 volts</td>
<td>5.0 volts</td>
</tr>
<tr>
<td>Current</td>
<td>4.0 amperes</td>
<td>4.2 amperes</td>
<td>10.5 amperes</td>
<td>12.0 amperes</td>
</tr>
<tr>
<td>Amplification Factor (Average)</td>
<td>39</td>
<td>40</td>
<td>37</td>
<td>38</td>
</tr>
<tr>
<td>MAXIMUM RATINGS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plate Dissipation</td>
<td>50 watts</td>
<td>100 watts</td>
<td>250 watts</td>
<td>450 watts</td>
</tr>
<tr>
<td>D-C Plate Voltage</td>
<td>2000 volts</td>
<td>3000 volts</td>
<td>4000 volts</td>
<td>6000 volts</td>
</tr>
<tr>
<td>D-C Plate Current</td>
<td>150 ma.</td>
<td>325 ma.</td>
<td>350 ma.</td>
<td>600 ma.</td>
</tr>
<tr>
<td>Grid Dissipation</td>
<td>15 watts</td>
<td>20 watts</td>
<td>40 watts</td>
<td>80 watts</td>
</tr>
</tbody>
</table>

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C, Telegraphy (Key down conditions)

<table>
<thead>
<tr>
<th>Tube</th>
<th>35TG</th>
<th>100TH</th>
<th>250TH</th>
<th>450TH</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-C Plate Voltage</td>
<td>1500 volts</td>
<td>2000 volts</td>
<td>3000 volts</td>
<td>4000 volts</td>
</tr>
<tr>
<td>D-C Plate Current</td>
<td>125 ma.</td>
<td>165 ma.</td>
<td>333 ma.</td>
<td>450 ma.</td>
</tr>
<tr>
<td>D-C Grid Current</td>
<td>40 ma.</td>
<td>59 ma.</td>
<td>90 ma.</td>
<td>85 ma.</td>
</tr>
<tr>
<td>D-C Grid Voltage</td>
<td>-120 volts</td>
<td>-80 volts</td>
<td>-150 volts</td>
<td>-200 volts</td>
</tr>
<tr>
<td>Plate Power Output</td>
<td>141 watts</td>
<td>235 watts</td>
<td>750 watts</td>
<td>1350 watts</td>
</tr>
<tr>
<td>Plate Input</td>
<td>188 watts</td>
<td>335 watts</td>
<td>1000 watts</td>
<td>1800 watts</td>
</tr>
<tr>
<td>Plate Dissipation</td>
<td>47 watts</td>
<td>100 watts</td>
<td>250 watts</td>
<td>450 watts</td>
</tr>
<tr>
<td>Peak R.F. Grid Input Voltage, (approx.)</td>
<td>250 volts</td>
<td>230 volts</td>
<td>395 volts</td>
<td>410 volts</td>
</tr>
<tr>
<td>Driving Power, (approx.)</td>
<td>9 watts</td>
<td>8 watts</td>
<td>32 watts</td>
<td>35 watts</td>
</tr>
</tbody>
</table>

NOW WITH... Pyrovac Plates • Processed Grids

ELECTRONICS — September, 1948
The Star Performer—
in assemblies that must stand the gaff...day-in-and-day-out...for months and years to come:

DURANITE
THE SUPERIOR CAPACITOR

- Component-breakdown insurance. That's precisely why assemblies that must stand up—regardless of humidity, heat, cold, mechanical or electrical abuse—are featuring Duranite capacitors.

Duranite means different. Not just another plastic tubular. Not just an improvement over previous paper tubulars. Duranite stands for an entirely new concept of the capacitor art—new impregnant, Aerolene, doing the work of both wax and oil; new casing material, Duranite, providing rock-hard, non-varying, impervious sealing throughout; new processing methods insuring quality with economy. You will never know how dependable radio-electronic components can be until you have tried Duranite capacitors.

- Write on your business letterhead for samples. Detailed literature on request. Let us quote on your requirements.

FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

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

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

Cable: "ARLAB" • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.
AS NEW AS THE FUTURE!
... the only transformer line of its kind

Advanced, practical engineering gives you

**THESE OUTSTANDING FEATURES**

1. **SEALED IN STEEL CONSTRUCTION**
Chicago Transformer's drawn steel cases provide convenient, compact mountings; seamless steel-wall protection against atmospheric moisture and corrosion; unsurpassed strength and rigidity to withstand shock and vibration; clean, streamlined appearance that adds eye-appeal to any equipment.

2. **CHOICE OF CONNECTORS**
Solder lugs or wire leads. Most units are available with identical ratings in two base styles to fit your price and/or wiring preference.

3. **CHARACTERISTICS KEYED TO MODERN TUBES**
Voltage, current, and output ratings have been designed for one purpose only—to fill the requirements of the receiving, transmitting, and industrial electronic tubes currently most in demand. No listings wasted on obsolete circuit needs. Result—a condensed, yet comprehensive, line that's right in step with today's new circuit designs.

4. **EXACT MATCHING OF REACTORS**
with power transformers. Current ratings of plate and filament supply transformers and of the high voltage plate transformers are matched by choke capacities specially designed for the purpose. Mountings match, as well, for uniform, "tailored" good looks.

5. **TRUE HIGH FIDELITY THROUGHOUT 3 RANGES**
Frequency response within ±1/2 db; distortion exceedingly low, even at low frequencies. These are the characteristics of the input and output transformers. Driver and modulation transformers provide response within ±1 db. All audio units are designed for frequency ranges that fit three classes of up-to-date audio application. Full Frequency Range: 30-15,000 cycles (good up to 20,000 cycles, where required). Public Address Range: 50-10,000 cycles. Communications Range (voice): 200-3,500 cycles.

Have Complete Details On Hand For Your New Equipment Planning
WRITE TODAY FOR CATALOG

CHICAGO TRANSFORMERS
Division, Essex Wire Corporation
3501 Addison Street, Chicago 18, Illinois

ELECTRONICS — September, 1948
WHAT MAKES A GOOD RECORDING BLANK GOOD?

CENTER-HOLE SCIENCE

Thanks to progress in standardization of disc recording equipment, it is seldom necessary to ream out the center hole of a disc, nor, on the other hand, to tolerate an unduly sloppy fit. Most recording and playback machine manufacturers provide either NAB standard turntable pins or slightly smaller ones. Soundcraft, therefore, makes the disc center-hole to the NAB standard and holds such a tolerance that clearance on a standard pin is less than .001".

Although so close a fit helps assure consistently better recordings, it calls for special equipment. Flow-coated Soundcraft discs, unlike dip-coated blanks, are lacquer covered over the center. Holes must, therefore, be punched after coating and initial inspection. The design of the Soundcraft punch-and-die sets for this work is complicated by the fact that they must punch cleanly through both plastic-lacquer and aluminum without distorting and without throwing even one chip that could imbed between discs. In addition they must permit punching of otherwise finished discs without scratching the high-gloss Soundcraft surface.

Drive-pin holes are punched simultaneously with center holes and are also NAB standard specification—three drive-holes for convenience on instantaneous Soundcraft types, one drive-hole for better processing of Soundcraft ‘Maestros’.

Soundcraft discs fit any machine, are tailor made for broadcasting and the record pressing industry.

When the utmost in recording quality is needed, ask for the ‘Broadcaster’, a master-disc selection in instantaneous sizes at an “extra-fare” price.

For work-a-day broadcast-quality recordings, the Soundcraft ‘Playback’ offers superior cutting properties in competition with other “best-grade” blanks.

Soundcraft discs are sold by over 250 radio parts distributors in principle U. S. cities. Foreign sales by Reeves International, Inc., 10 East 52nd St., New York 22, N. Y. Cable REEVINTER.
THE NEW -hp- 400C VACUUM TUBE VOLTMETER

Increased sensitivity. Wider range. Easy-to-read linear scale. Space-saving, time-saving versatility!
Those are but a few of the many advantages of the new -hp- 400C Vacuum Tube Voltmeter.

30 times more sensitive than the -hp- 400A voltmeter, the new -hp- 400C accurately determines voltages from .1 mv to 300 v. Its measuring range is broad and new—3,000,000 to 1. And with it you can make split-hair measurements all the way from 20 cps to 2 mc!

The big, clearly-calibrated linear scale reads directly in RMS volts or db based on 1 mw into 600 ohms. Generous overlap makes possible more readings at mid or maximum scale, where accuracy is highest. A new output terminal lets you use the -hp- 400C as a wide-band stabilized amplifier, for increasing gain of oscilloscopes, recorders and measuring devices. As a voltmeter, the new instrument has still wider applicability—for direct hum or noise readings, transmitter and receiver voltages, audio, carrier or supersonic voltages, power gain or network response.

Naturally the new -hp- 400C includes the familiar advantages of the -hp- 400A voltmeter. Range switch is calibrated in 10 db intervals providing direct readings from —70 dbm to +52 dbm. Overall accuracy is ±3% full scale to 100 kc. High input impedance of 1 megohm means circuits under test are not disturbed. And the rugged meter movement is built to safely withstand occasional overloads 100 times normal.

In every respect, the convenient, durable -hp- 400C is the ideal new voltmeter for precision work in laboratory, plant or repair shop. Complete details are available at no obligation. Write today!

Hewlett-Packard Company
1556 E Page Mill Road • Palo Alto, Calif.

VOLTAGE RANGE:
3,000,000 to 1

READINGS:
.1 mv to 300 v

FREQUENCIES:
20 cps to 2 mc

CHECK THESE SPECIFICATIONS

VOLTAGE RANGES:
-12 ranges. Full-scale readings.
.001 v .100 v 10.0 v
.003 v .300 v 30.0 v
.010 v 1.00 v 100. v
.030 v 3.00 v 300. v

FREQUENCY RANGE: 20 cps to 2 mc

ACCURACY:
±3% full scale 20 cps to 100 kc
±5% full scale 100 kc to 2 mc

INPUT IMPEDANCE:
10 megohms shunted by 15 uufd on .100 v to 300 v ranges
25 uufd on the .001 v to .300 v ranges.

METER SCALE:
3" linear. Voltage ranges related by 10 db steps.
Db calibrated —12 to —2 db. Zero level 1
mw into 600 ohms.

OUTPUT CIRCUIT:
Maximum 0.5 v full scale. Internal impedance
1000 ohms.

POWER SUPPLY:
115 v, 50/60 cps, 45 watts.

CABINET SIZE:
8½” high, 7½” wide, 9½” deep.

Power Supplies Frequency Standards Amplifiers Electronic Tachometers Frequency Meters
UHF Signal Generators Square Wave Generators Audio Frequency Oscillators Attenuators
Audio Signal Generators Noise and Distortion Analyzers Wave Analyzers Vacuum Tube Voltmeters
The makers of Duncan Electric Meters required an insulation able to withstand soldering temperatures up to 400° F. Read what they say:

"We selected Ben-Har Special Treated Fiberglas Tubing for the heater leads in our thermal demand meters because it withstands soldering on the lead wire without discoloration. Temperatures encountered in the soldering operation are 300 to 400 degrees F. The results are completely satisfactory."

"The smooth, attractive appearance of Ben-Har and the fact that it does not unravel at the ends give extra value in our product."

See for yourself how Ben-Har speeds assembly because it cuts without fraying; prevents insulation breakdown because it combines toughness and flexibility. Knot it, twist it, pound it with a rawhide mallet—there's no loss of dielectric strength. If you require an insulation with these extra advantages, get a sample of Ben-Har without delay.
CENTRALAB ANNOUNCES A NEW AND REVOLUTIONARY ROTARY SWITCH WITH A MINIMUM LIFE TEST OF 150,000 CYCLES

New Coil Spring Design Means Smoother Action, More Positive Indexing, Longer Life

YOU ASKED for it — and here it is! Centralab's new Rotary Coil and Cam Index Switch sets an all-time record for ruggedness, long life, flexibility, installation and maintenance convenience. Check these design and operation features, and you'll see why this new switch is one of the important switch developments of the year! (1) 30° index with 11 indexing combinations permit handling up to three sections. (2) New, tested stop-strength of 48 inch pounds. (Standard RMA stop-strength — only 24 inch pounds.) (3) Guaranteed minimum life — 150,000 cycles. (RMA Standard — 10,000 cycles.) (4) Only ¼" spacing between front plate and first section gives you decreased depth behind panel. (5) Removable spring can be replaced without removing switch from chassis. Write today for complete information on this great new switch. Order Bulletin 995.

Four Positions Give You Wide Choice of Switching Combinations

PI — Positive Index
SR — Spring Return

1 Two position positive index.
2 Two position spring return from counter-clockwise.
3 Two position spring return from clockwise.
4 Three position positive index.
5 Three position spring return from both sides to center.
6 Three position index — two positive spring return from counter-clockwise.
7 Three position index — two positive spring return from clockwise.
8 Four position, three positive, spring return from counter-clockwise.
9 Four position, three positive, spring return from clockwise.
10 Four position, two positive, spring return from clockwise and counter-clockwise. Also five positions in this same combination.

LOOK TO Centralab DIVISION OF GLOBE-UNION INC., MILWAUKEE

ELECTRONICS — September, 1948
These general-purpose panel instruments are particularly suitable for use in radio equipment and industrial applications where accuracy and quality are required and space is at a premium. Many of the instruments have been newly styled for better readability and for the smooth, modern appearance that will help give your panels a well-engineered look.

Thermocouple-type instruments, for measurements of high-frequency alternating current in radio or other electronic circuits, are available. There is also a complete line of rectifier types (a-c, for measuring alternating current or voltage at high frequencies or where the source is not sufficient to operate conventional a-c instruments. Typical applications include television transmitters, radar wave meters, testing equipment for electronic circuits. For a full story of G-E instruments, send for Bulletin GEC-227.

GENERAL ELECTRIC
Digest

Cased for Protection

Suitable for wall or panel mounting, these cage-type, enameled resistor units employ a strong, high-heat-resisting silicate compound body which withstands sudden and extreme temperature changes without weakening or in any way being injured. The resistance wire has a low temperature coefficient so that the resistance remains nearly constant as the temperature increases. Ample protection to the units is provided by the perforated metal case. Each unit is rated at 85 watts and is available in resistance values from 0.5 to 100,000 ohms; one to four units in a cage. For more complete information please contact your G-E representative.

Need a "Low VA" Voltage Stabilizer?

General Electric's latest additions to its line of automatic voltage stabilizers are three 115-volt, 60-cycle designs in 15-, 25-, and 50-va ratings. Check the low prices—you may now be able to utilize the advantages of an automatic voltage control for your application. The price consideration plus the low case height and small size will make these units especially applicable to radio chassis and other shallow-depth installations. Other features include totally insulated design, which is necessary where isolation is required between primary and secondary circuits, and universal lead construction which makes these units adaptable to various wiring and mounting arrangements. If you have an application problem, contact your G-E representative, or check bulletin GEA-3634B.

Simplified Circuit Control Devices

Simplify your circuit designs by replacing complicated and costly components with simple, economical G-E Thermistors. These electronic semiconductors are unique in that the resistance changes rapidly with slight variations in temperature—electrical resistance decreases as temperature rises, and increases as temperature falls. G-E Thermistors give you these five advantages: flexible in application, small in size, available in various shapes, indefinitely stable, and they are economical. These new circuit devices are especially adaptable as sensitive elements in flow meters, liquid-level gages, time-delay relays, vacuum gages, switching devices, and modulating thermostatic circuits. Check coupon for technical report CDM-9.

Hermetic Seal Eliminates Moisture Problems

The new cast-glass bushings with their sealed-in metal hardware can be readily welded, soldered, or brazed directly to the apparatus, thus eliminating gaskets and providing a better seal than ever before. The small, compact structure of the bushings makes it possible to reduce the overall size and weight of the electric apparatus. Bushings are practically unaffected by weathering, microorganisms, and thermal shock. Their great mechanical strength makes them well suited for use in airplanes, etc., where they are subject to continual vibration. Available in ratings up to 8.6 kv and for currents to 1200 amperes. Check bulletin GEA-5093.

More Soldering with Less Power

G.E.'s midget soldering iron can do a big job for you with only one-fourth the wattage usually used. This handy 6-volt, 25-watt iron is only 8 inches long (with 3/8" or 1/4" tips) and weighs but 1/4 ounces. It was especially designed for close-quarter, pin-point precision soldering. The "midget" offers you all these advantages: low-cost soldering; "fingertip" operation; quick, continuous heat; easy renewal; long life; low maintenance. The iron is a real aid in manufacturing radios, instruments, meters, electric appliances, and many other products requiring precision soldering. Irons and specially designed 115/6-volt transformers are available from stock. Check bulletin GES-3488.

Timely Highlights on G-E Components

General Electric Company, Section A642-18
Apparatus Department, Schenectady, N. Y.

Please send me the following bulletins:

- GEC-227 Instruments
- GEA-5093 Cast-Glass Bushings
- GES-3488 Midget Soldering Iron
- GEA-3634B Voltage Stabilizer
- CDM-9 Thermistors

Name

Company

Address

City

State

25

www.americanradiohistory.com
NEW INDIANA PERMANENT MAGNET MANUAL

Not a catalog. Not a reprint. It’s an up-to-date DESIGNER’S HANDBOOK!

Here’s a new reference book that you’ll want within arm’s reach. From front to back, it contains helpful information about permanent magnets—what they are and how they’re used. Air gaps and their functions...new magnet materials...energy curves and formulae...design procedure and construction data. All in simplified form for easy use.

This new 32-page manual, complete with 92 illustrations and graphs, reflects the design experience of more than 25,000 different permanent magnet applications. Prepared for you by the research and design staffs here at INDIANA—world’s largest exclusive permanent magnet manufacturer. A request on your company letterhead will bring a copy to your desk. Write today—ask for free book No. 4-E-9.

THE INDIANA STEEL PRODUCTS COMPANY
PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE - CHICAGO 2, ILL.

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910
PLANTS: VALPARAISO, INDIANA; CHAUNCEY, WESTCHESTER COUNTY, N. Y.
HI-Q TEMPERATURE COMPENSATING CAPACITORS

HI-Q temperature compensating capacitors are available in three types. CN & SI types with capacities from .25 mmf to 1830 mmf and CI types from .25 mmf to 595 mmf with a temperature coefficient range from P 100 to N 1400. All of these HI-Q styles are of tubular ceramic construction with pure silver electrodes precision coated. Style SI is insulated with a synthetic coating of Durez, style CN is of Styrene and CI is Steatite covered.

HI-Q GENERAL PURPOSE CERAMIC CAPACITORS

HI-Q General Purpose Ceramic Capacitors readily replace mica and paper condensers of corresponding values. HI-Q General Purpose Ceramic Capacitors should not be confused with the HI-Q line of close tolerance temperature compensating units. HI-Q General Purpose Ceramic Capacitors are available in capacity ratings from 5 mmf to 33,000 mmf.

HI-Q STAND-OFF CAPACITORS

HI-Q "stand-off" capacitors are basically tubular with a screw fixture for mounting to the chassis or common ground. Close coupling and their unique construction make them an excellent choice for bypassing RF in the high frequencies. Standard capacity tolerances are ± 10% and ± 20% for "stand-off" capacitors and ± 20% and ± 30% for multiple tap units. Closer tolerances available wherever economical manufacturing permits. All units flash tested for 1000 volts DC with power factor under 3% maximum and insulation resistance is above 10,000 megohms. All units stamped for capacity.

HI-Q FEED-THRU CAPACITORS

HI-Q "feed-thru" capacitors provide perfect transmission through the chassis or ground, as well as by-passing to ground. The high quality construction of HI-Q "feed-thru" capacitors, is extremely rugged and will withstand severe vibration, making them ideal for use in mobile and aircraft applications.

HI-Q HIGH VOLTAGE CAPACITORS

HI-Q HV Capacitors are a sturdy unit, capable of withstanding high voltages, operating at extreme humidity and raised temperatures. They are a natural television component. The basic dielectric is body 20, encased in a low loss, mineral filled bakelite. Available in capacities 50 mmf to 1,000 mmf. Specify desired capacity after type HV when ordering.

HI-Q DISC CAPACITORS

HI-Q Disc Capacitors are high dielectric by-pass, blocking or coupling capacitors. Designed for application where its physical shape is more adaptable than tubular units. The placement of leads is such that close connections are easily made, thus reducing inductance to a minimum, a much desired feature in high frequency designs, such as television and FM. Available in three types: BPD-5: .005 MFD guar. min., BPD-10: .01 MFD guar. min. and BPD-1.5: .0015 MFD guar. min.

WRITE FOR FREE CATALOG

Electrical Reactance Corp.
FRANKLINVILLE, N.Y.

Plants: FRANKLINVILLE, N.Y.—JESSUP, PA.
Sales Offices: NEW YORK, PHILADELPHIA, DETROIT, CHICAGO, LOS ANGELES
Introducing the New DU MONT CATHODE-RAY OSCILLOGRAPH

Type 250

FEATUREING...

✓ a-c and d-c amplifiers
✓ Built-in voltage-calibrator
✓ Three horizontal and three vertical input choices
✓ Recurrent or driven sweep
✓ Z-axis modulation
✓ Provision for photography
✓ Brilliant traces
✓ Automatic beam blanking
✓ High-sensitivity amplifiers
✓ High-impedance input probe

TYPICAL APPLICATIONS REQUIRING TYPE 250...

Application No. 1: If a machine component is to be studied for its reaction under shock-load conditions, what characteristics must the oscillograph have?

Characteristics required:

1. Single sweep, variable in duration. The single sweep of the Type 250 is continuously variable from 1 second to 20 microseconds.

2. Adequate light output. The Type 5CP-A Cathode-ray Tube in the Type 250 operates at 3000 volts accelerating potential for brilliant traces.

3. High-sensitivity amplifier. Type 250 provides either d-c to 200 kc at 1 d-c volt/in. sensitivity, or 5 cps to 200 kc at .02 rms volt/in. sensitivity.

4. Automatic beam blanking, so that the fluorescent screen is excited only when signal is present on driven sweeps. This too is a feature of the new Type 250.

Application No. 2: Quantitative measurements and permanent records are to be made of the waveforms at various points in an electronic circuit.

Additional characteristics required:

1. Built-in voltage-calibrator that can be switched in before attenuator and gain control of Y-axis amplifier – a feature of the Type 250.

2. Provision for photography. Du Mont Types 271-A and 314 Oscillograph-record Cameras are designed to fit the Type 250.

3. d-c levels, a-c signals, or both, can be recorded with the new Type 250.

Other possible applications of the new Type 250...

Since the Type 250 was designed as a versatile general-purpose oscillograph of laboratory quality, it therefore has a wide range of applications in such fields as medicine, biology, welding, mechanics, and many other fields where a high-quality instrument for medium and low-frequency work is required.

Why not consult us now about the possibility of applying the new Type 250 to your particular problem? Detailed specifications on request.

PRICE: $635.00 with Type 5CP1-A tube. Cat. No. 1303-E.

© Allen B. Du Mont Laboratories, Inc.

DU MONT for Oscillography

Allen B. Du Mont Laboratories, Inc., Passaic, N. J.
Cable Address: Albeedu, New York, N. Y., U. S. A.

September, 1948 — Electronics
MAKE THINGS

GO!

with

alliance motors

Reliable, high-speed mass production of motors at low cost—that's the big job at Alliance! Makers of mass consumer products need Alliance motors for their small load tasks. Noted for long life, they are compact and light weight. Many weigh less than a pound! Power ratings range from less than 1/400th h.p. to 1/20th h.p. Some are uni-directional—others are reversible and can be made for continuous or intermittent duty.

Practical uses for Alliance motors are to power automatic controls, switches, valves, motion displays, movie projectors, vending and business machines, toys, record players, and radio tuning devices. The newer Alliance Model A and Model B motors are especially built for driving fan blades in air circulators, room heaters, hair dryers, coolers, and air conditioning appliances. Model B is also an excellent power source for sound recorders.

Alliance Motors pack more motion and automatic action into new products!

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.

ELECTRONICS — September, 1948
IRON CORES

From horizontal deflection and flyback transformer cores to i.f. and other types, Stackpole offers a complete line.

Type 10034—For use with tubes of any size in horizontal deflection circuits. Assures uniform results, saves materially on assembly costs.

Type 10748—A smaller horizontal deflection or flyback transformer design for tubes up to 10" diameter.

O.T. Types... and dozens of standard and special types to match any circuit requirement.

VARIABLE RESISTORS—CONTROLS

Stackpole controls, single or dual, are available in numerous types and with wattage ratings and other characteristics adequate for modern television applications. Samples on request to quantity users.
UCTS for TELEVISION

MOLDED COIL FORMS
for choke and peaking coils

The advantages of Stackpole Molded Coil Forms as inexpensive mechanical supports for windings include: reduced space factor; easier assembly; point-to-point wiring with one-third fewer soldered connections; extreme flexibility of application and absolute minimum cost. Types include units with coaxial leads, single hairpin leads, single hairpin lead at one end with double hairpin lead at other end, and double hairpin leads at each end. Iron core sections can be incorporated in most types.

Note: These values apply to type D8 coil forms only

<table>
<thead>
<tr>
<th>Di-electric Constant</th>
<th>600 Kilocycles</th>
<th>1000 Kilocycles</th>
<th>2.3 Megacycles</th>
<th>20 Megacycles</th>
<th>48 Megacycles</th>
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<tbody>
<tr>
<td></td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>36</td>
<td>45</td>
<td>118</td>
<td>90</td>
</tr>
</tbody>
</table>

INEXPENSIVE SNAP SLIDE OR ROTARY ACTION SWITCHES

These popular Stackpole switches add greatly to the sales appeal and convenience of almost any electrical product. Standard, low cost types are available for practically any switching arrangement or type of operation.

FIXED RESISTORS

The result of more than 15 years specialized manufacturing experience, Stackpole Resistors meet modern television specifications —whether from a moisture-protection, insulation or overload standpoint, or satisfactory high frequency characteristic. Standard ranges are from 10 ohms to 20 megohms in the customary ± tolerances of 5%, 10% or 20%.

Write FOR THIS NEW STACKPOLE ELECTRONIC COMPONENTS CATALOG

Fixed and variable resistors, switches, iron cores, molded coil forms, GA miniature capacitors and Polytite cores for high capacity stability under conditions of humidity and vibration in high frequency circuits when properly supported and insulated.

CARBON CO. • ST. MARYS, PA.
SOME TIME AGO, a large automotive manufacturer was attempting to learn whether gas tanks could be strengthened.

They first used a mechanical shaker on a test tank in an attempt to discover possible trouble—but days went by without signs of failure. However, when an MB Exciter was attached, the tank was vibrated to destruction in a matter of minutes! A repeat test produced a similar failure. Based on the visual evidence, which eliminated the need for any dynamic computations, the tank was redesigned, and it was made not only stronger, but materially lighter—cutting costs as well as saving steel.

In another case, where one manufacturer's headlight bulbs were failing in great numbers, an MB Exciter fixed the blame at once—on the filament supporting arm, which was resonating at a frequency within the operating range of the car.

These cases illustrate a technique of testing that you'll find increasingly valuable as experience shows you new applications for this product improver. MB vibration exciters are now being used by many of the country's largest companies—for fatigue testing, for location of noise sources, for determining the vibratory response of products—and the corrective measures.

Would you like to know more about how to use this shaker in your own work? An MB engineer will be glad to give you the benefits of our specialized vibration experience.

If your product has any vibration at all—this MB VIBRATION PICKUP will detect it!

There's no practical lower limit on the amplitude of vibration you can detect with the MB Vibration Pickup—it's that sensitive! And there's no engine it can't be used on—it's that durable under high-powered pulsations! It is a velocity-type pickup, electrically damped, with a range of 5 to 1000 c.p.s. and usable in any position. When the pickup's electrical output is fed to standard voltage measuring equipment, it can be used to check products for operating smoothness and for quality-control.

WRITE FOR FREE BULLETINS
Ask for bulletin "Vibration Testing Technique" which describes how MB Exciters are used. And Bulletin 124A will give you more details on Pickup. Write Dept. D5.

THE
MANUFACTURING COMPANY, INC.
1060 State Street
New Haven 11, Conn.
VIBRATION ISOLATOR UNITS • VIBRATION TEST EQUIPMENT

VIBRATION DIVISION

32 September, 1948 — ELECTRONICS
HOW MANY OF THESE PRODUCTION PROBLEMS ARE YOURS?

RADIO INSULATION

Looking for high insulation resistance, low radio-frequency losses, high mechanical strength, resistance to extremes of temperature or humidity? Note the following properties of Taylor Grade XXXP-1.

- 24 hour water absorption - 1/16" thickness: 0.35%
- Loss Factor: 10^6 cycles — after 24 hours in water: 0.12
- Dielectric Strength - 1/16" thickness (V.P.M.):
  - Short time test: 690
  - Step by step test: 640
- Insulation Resistance: 4 days at 90% R.H., 96 F. (megohms): 500,000

ARC RESISTANCE

Have you experienced equipment breakdowns due to tracking or arcing? Taylor Vulcanized Fibre, Melamine Laminates, and combinations of Taylor Vulcanized Fibre and Phenol Fibre Grades XP-2 and C-2 have proved very satisfactory for many applications. Where high temperatures prevail, Taylor Glass Base Melamine Laminates, Grades G-5 and G-6, are particularly recommended.

HIGH STRENGTH PLUS HEAT RESISTANCE

Taylor Grade AAA asbestos mat laminate is offered for applications requiring high heat resistance plus high mechanical strength, at a low cost. Note these properties of Grade AAA:

- Tensile Strength — Lengthwise: 20,000 p.s.i.
  - Crosswise: 13,000 p.s.i.
- Flexural Strength — Lengthwise: 25,000 p.s.i.
  - Crosswise: 19,000 p.s.i.
- Compressive Strength — Flatwise: 50,000 p.s.i.
- Heat Resistance — Continuous: 300°F — Intermittent: 350°F.

CORROSION RESISTANCE

For applications requiring high resistance to the chemical action of acids and alkalies, plus high mechanical strength ... such as barrels for plating solutions ... Taylor Grades C-5 and L-5 (fabric base Melamine Laminates) are outstanding. For moderate concentrations of acids or weak alkalies, Taylor Grades C-4 and L-1 (fabric base Phenol Laminates) are equally effective and cost less.

INSULATION OF ARMATURE SLOTS, FIELD COILS

High in dielectric strength, Taylor Insulation (Fish-paper) withstands severe bending without cracking, resists abrasion from contact with rough spots in machined slots. Available in sheets, continuous rolls, and ribbon rolls.

FORMING TO INTRICATE SHAPES

Taylor Phenolic Fibre, Grade C-7, adapts easily to compound curves, and other intricate shaping operations ... yet retains all the desirable physical properties of Taylor Grade C. Among these properties: high tensile, flexural, and impact strength; good resistance to wear; dimensional stability.

Regardless of the problem ... if Laminated Plastics can help solve it, Taylor Fibre engineers are at your service. Please make your inquiry as specific as possible.

TAYLOR FIBRE COMPANY

LAMINATED PLASTICS: PHENOL FIBRE • VULCANIZED FIBRE • Sheets, Rods, Tubes, and Fabricated Parts

NORRISTOWN, PENNA.  Offices in Principal Cities  Pacific Coast Plant: LA VERNE, CAL.

ELECTRONICS — September, 1948

www.americanradiohistory.com
Age-Resistant Wire Keeps Your Products Young ... and Keeps Your Customers SOLD!

Let's suppose you make a television set, a range, a waffle iron or some other electrical product ... and Mrs. Jones buys one.

Her friends like its smooth modern design, dependable operation ... and enthuse over its novel features.

But after awhile wire-trouble rears its ugly head, performance goes haywire, again ... and again.

Then Mrs. and Mr. Jones tell all their friends, and you can say goodbye to a customer ... and a lot of prospects.


Tough Break?
Maybe ... but it could have been prevented with wire designed for years of dependable operation under even the most severe conditions. For many products that means permanently insulated Rockbestos wires, cables and cords.

Rockbestos wires, cables and cords—insulated with impregnated felted asbestos and other enduring materials—are the best insurance you can buy against wire-failure caused by heat, flame, fumes, grease, oil ... and age.

WRITE TODAY — for your copy of the new No. 10-F Catalog, sectioned for easy reference to Appliance, Aircraft, Electronic, Fixture, Lighting and Magnet Wires; Apparatus Wires and Cables; Power and Control Cables.

ROCKBESTOS PRODUCTS CORP.
463 NICOLL ST., NEW HAVEN 4, CONN.

New York Pittsburgh
Chicago Cleveland St. Louis Detroit
Los Angeles

ROCKBESTOS
THE WIRE WITH PERMANENT INSULATION

September, 1948 — ELECTRONICS
Solar’s new Type DY-TV series of dry electrolytic capacitors assures dependable operation under the severest conditions found in television receivers.

An especially developed Solar processing technique makes possible small yet sturdy capacitors designed for high temperature operation with no sacrifice in long life or electrical characteristics.

Because of the remarkable film stability of Solar’s DY-TV series of electrolytics, there is but an extremely small change in power factor and leakage current from room temperature to 85°C.

Type DY-TV capacitors, with their special film formation, do not “run away” when voltage is applied after idling under no-voltage conditions at 85°C. These characteristics are retained even after extended shelf life.

Investigate this remarkable achievement in capacitor design today! Write today for catalog.

SOLAR MANUFACTURING CORPORATION
NORTH BERGEN, NEW JERSEY
Add hot-dip galvanizing to Blaw-Knox construction, and you've got the utmost in tower performance with maintenance costs close to zero. Illustrated is a new Blaw-Knox Type N-16 insulated, self-supporting tower with "lifet ime" protection of a heavy zinc coating on all members as well as on inside climbing ladder and Electroforged Grating platforms. Painting to conform with CAA regulations is all that is required.

Hot-dip galvanizing is available on Blaw-Knox Antenna Towers of any height . . . We invite discussion on your plans for future station improvement.

BLAW-KNOX DIVISION
of Blaw-Knox Company
2077 Farmers Bank Building • Pittsburgh 22, Pa.
For Quality and Performance Use **FREED**

**INSTRUMENTS and COMPONENTS**

"**Q**" INDICATOR

**NO. 1030 by FREED**

Frequency range from 20 cycles to 50 kilocycles. "**Q**" range from .5 to 500.

"**Q**" of inductors can be measured with up to 50 volts across the coil.

Indispensable instrument for measurement of "**Q**" and inductance of coils, "**Q**" and capacitance of capacitors, dielectric losses, and power factor of insulating materials.

**Filters**

Narrow band pass filters for remote control and telemetering applications. High pass, low pass, band pass and band elimination filters for communication and carrier systems.

**Discriminators**

For telemetering and remote control applications using audio and supersonic frequency subcarriers.

<table>
<thead>
<tr>
<th>Low Frequency</th>
<th><strong>HI &quot;Q&quot; COILS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>#1900</td>
<td>100 HY</td>
</tr>
<tr>
<td>#1901</td>
<td>75 HY</td>
</tr>
<tr>
<td>#1902</td>
<td>50 HY</td>
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<tr>
<td>#1903</td>
<td>25 HY</td>
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<tr>
<td>#1904</td>
<td>10 HY</td>
</tr>
<tr>
<td>#1905</td>
<td>5 HY</td>
</tr>
<tr>
<td>#1906</td>
<td>1 HY</td>
</tr>
</tbody>
</table>

Available from stock in the indicated inductance values.

**FREED TRANSFORMER CO., INC.**

**DEP'T SE**

**72 SPRING ST.**

**NEW YORK 12, N. Y.**
REVERE PHOSPHOR BRONZES OFFER MANY ADVANTAGES

Strength — Resilience — Fatigue Resistance — Corrosion Resistance — Low Coefficient of Friction — Easy Workability — are outstanding advantages of Revere Phosphor Bronzes, now available in several different alloys.

In many cases it is the ability of Phosphor Bronze to resist repeated reversals of stress that is its most valuable property. Hence its wide employment for springs, diaphragms, bellows and similar parts. In addition, its corrosion resistance in combination with high tensile properties render it invaluable in chemical, sewage disposal, refrigeration, mining, electrical and similar applications. In the form of welding rod, Phosphor Bronze has many advantages in the welding of copper, brass, steel, iron and the repair of worn or broken machine parts. Revere suggests you investigate the advantages of Revere Phosphor Bronzes in your plant or product.
announces
a new thin 3½”
panel instrument

better readability
improved performance

New Styling For Better Readability

The New DO-71 Panel Instruments are easy to read—correctly—because they have been designed specifically for that purpose. This new design has also resulted in a smooth, modern, appearance. Take a look at these features to see how these instruments will improve the appearance of your panels and at the same time assure you of easier more accurate readings:

- Lance type pointer for rapid, precise reading.
- Absence of arc lines make scale divisions stand out by themselves.
- Simplified scale layout for improved readability.
- Numerals shaped and sized for greater legibility.

New Engineering For Improved Performance

A new high in performance and readability has been achieved by the engineering advances in the DO-71 Panel Instruments. Depth behind the panel has been reduced to less than 1 inch. The use of high-strength Alnico magnets results in high torque, good damping, and quick response. This allows the use of larger radius pivots, giving the instrument a greater sturdiness. The large clearance between stationary and moving parts helps assure years of trouble-free performance. And, all main components are rugged integral units which mean fewer repairs and less servicing.

Now is the time to improve the quality and appearance of your products by the incorporation of these new panel instruments. And, you can do it right now, because the DO-71 line is in full production for quick delivery. Contact your nearest G-E Sales Office, or Apparatus Dept., General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

ELECTRONICS — September, 1948
for mobile two-way radio

ALLIED'S NEW CO-AXIAL RELAY

The new Allied "RA" relay transfers 52 ohm antenna transmission line (type RG-8U Cable) from receiving to transmitting position. It is now used in police car radios and is highly recommended for both mobile and stationary applications.

This new relay is equipped with two Co-Axial cable fittings and one insulated transmitter line terminal. Co-Axial fittings for antenna and receiver connection are die cast as part of the metal housing. They will accommodate Signal Corps cable connector PL-259. Auxiliary double-pole, double-throw contacts can be supplied when specified.

NEW RELAY GUIDE
This new folder shows 24 small, compact Allied Relays with a carefully detailed table of characteristics and specifications. Write for YOUR free copy today.

ENGINEERING FEATURES OF THE
ALLIED TYPE "RA" RELAY

Contact Rating: Antenna transfer contacts will handle a maximum of 75 watts of radio frequency up to 150 megacycles when inserted in a properly terminated 52 ohm line. Auxiliary contacts have a non-inductive rating of 1 ampere at 24 volts D.C. or 115 volts A.C.

Coil Rating: Up to 110 volts D.C. and 115 volts A.C. 60 cycles.

<table>
<thead>
<tr>
<th>No.</th>
<th>Volts</th>
<th>D.C. Current</th>
<th>D.C. Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>6.</td>
<td>.46</td>
<td>13</td>
</tr>
<tr>
<td>34</td>
<td>12.</td>
<td>.22</td>
<td>54</td>
</tr>
<tr>
<td>38</td>
<td>26.5</td>
<td>.083</td>
<td>320</td>
</tr>
<tr>
<td>40</td>
<td>48.</td>
<td>.060</td>
<td>800</td>
</tr>
<tr>
<td>43</td>
<td>110.</td>
<td>.026</td>
<td>4100</td>
</tr>
</tbody>
</table>

(This table is based on average power rating of 2.5 watts. Minimum operating voltages are 80% of voltages shown above.)

Dimensions: 2"x2 3/8"x1 1/4". Weight: 4 oz.
In his search for the fountain of perpetual youth, Ponce de Leon would have found a perfect analogy in the improved Turbo Varnished Sleeving in which there is inherent, in its flexibility constituted insulating varnish, the antidote to hardening of the arteries.

Besides this great step of advance in the varnishing process of cotton sleeving, there are insured in this Turbo Varnish Impregnant topmost electrical insulating requisites—stabilized increased dielectric values, greater resistance to elevated temperatures, practical resistance to the effects of soldering-iron operations, acids, oils, alkalies, and electro-chemical influences.

Non-cracking, non-chipping, non-peeling regardless of angle of bend or twist. A knock-out to commonly encountered insulation failures accruing from embrittlement resulting due to the effects of aging.
The **H-2-P**

A New Purifying Jet Oil Diffusion Pump,

for electronic tubes and general laboratory use.

The blank-off pressure of this all-metal pump, untrapped, is $2 \times 10^{-7}$ mm of Hg, measured on an ionization gauge.

The speed and forepressure characteristics of the pump are remarkable. Speeds at three significant points follow—

- 50 litres per second at $10^{-5}$ mm Hg.
- 60 litres per second at $10^{-4}$ mm Hg.
- 35 litres per second at $2 \times 10^{-3}$ mm Hg.

High Vacuum of $2 \times 10^{-7}$ mm Hg. is maintained when the forepressure is increased to 0.34 mm Hg.

This pump is designed for unlimited continuous service. The jet tube is so constructed that it may be completely disassembled in a few moments with an Allen wrench. This makes every part of the pump freely accessible for cleaning. The heater is buttoned to the bottom of the pump and can be replaced easily. The permanent maintenance of this pump in condition to achieve the pressures and speeds listed above is assured by its construction. Recommended particularly for the requirements of Cathode Ray Tube production. Special models for exhaust equipment will be made to customer's specifications. For further details, please write—Vacuum Engineering Division, National Research Corp., Cambridge 42, Mass.
MIRAGLAS IS THE NAME for the 4 GRADES OF VARNISHED TUBINGS that provide positive protection for electrical apparatus...

1. **STANDARD GRADE** for maximum flexibility, has little varnish and is recommended for high temperatures where dielectric strength is not a factor.

2. **DOUBLE SATURATED** has all qualities of the STANDARD GRADE but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

3. **TRIPLE STRENGTH** is built up with coats of especially flexible insulation varnish for dielectric ratings up to 2500 volts and is particularly suited where assembly operations include the possibility of rough handling.

4. **IMPREGNATED** is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 7000 volts and is unequalled for Long Life Under Most Severe Conditions. Write for Samples.

**FOR USERS OF COTTON YARN VARNISHED TUBINGS** The Mitchell-Rand MIRAC and HYGRADE Varnished Tubings of long staple fiber yarn are comparable to Fiberglas Tubings in dielectric ratings, tensile strength, flexibility and long life. Write For Samples.

**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 TAPS, WEBBINGS AND SLEEVINGS • IMPREGNATED VARNISH TUBING • INSULATED VARNISHES OF ALL TYPES • EXTRUDED PLASTIC TUBING

Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drills, etc.

September, 1948 — ELECTRONICS
Shaft, cover, faceplate, and other ferrous parts are made of stainless steel.

The TYPE J BRADLEYOMETER

... an adjustable resistor of superior quality for jobs that demand superlative performance

FIXED RESISTORS

Bradley unit resistors are small in size but "tops" in load and life tests. Under continuous 100% load for 1000 hours, resistance change is less than 5%.

The leads are differentially tempered to prevent sharp bends near the resistor.

Available in 1/2-watt and 2-watt sizes in standard R.M.A. values from 10 ohms to 22 megohms.

One-watt units are available from 2.7 ohms to 22 megohms.

When you have a circuit which requires a top-quality adjustable resistor ... rated at 2 watts with a big safety factor ... with a solid-molded resistor element not affected by heat, cold, moisture, and age ... then specify the Allen-Bradley Type J Bradleyometer.

The resistor element is molded as a single unit to provide any resistance-rotation curve. Insulation, terminals, faceplate, and threaded bushing are molded in one piece. There are no rivets, welded, or soldered connections.

Type J Bradleyometers are available in single-, dual-, and triple-unit constructions. Built-in line switch can also be furnished.

Send for dimension sheet and performance curves.

Allen-Bradley Co., 110 West Greenfield Avenue, Milwaukee 4, Wisconsin

Allen-Bradley fixed and adjustable radio resistors are sold exclusively to manufacturers of radio and electronic equipment.
GET COSTS DOWN
"Out of the Air"
and put a fresh breeze behind sales...

... the way Air Conditioners do it
with AMERICAN PHILLIPS SCREWS

DEFLATE COSTS ... like one of the largest refrigerator and air conditioner manufacturers ... who says: "Our present high production would not have been possible without American Phillips Screws ... which permitted the efficient use of power drivers." And which did not permit any more driver slips, spoiled work, dropped screws, burred screw heads, slashed hands. Now, labor costs keep in line, as do material costs. And time savings run as much as 50%.

INFLATE SALES with the modern, inviting look of American Phillips Screws. The clean-edged, tapered recess flashes the message of quality instantly to the buyer's eye. And remember, too, that in any motorized merchandise, the special vibration-resistance of American Phillips Screws has a lot to do with keeping customers sold. Let American engineers translate these Phillips advantages in specific terms of your own product. Write.

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)

September, 1948 — ELECTRONICS
**On the Job Proof of Instrument Performance!**

where Westinghouse reliability and readability

**REALY COUNT!**

Westinghouse instrument specialists are available in the field for consultation on your instrument problems. Call your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

Send for Booklet B-2209-A, Communication Instrument Booklet B-3283, or Switchboard Instrument Booklet B-3363.

Radio stations can take no chances on "outages"—time off the air is costly. For split-second timing, efficiency, and continuity, all vital operating information must be readily available to the control engineer at a glance.

For these reasons, instruments of unfailing performance and quick readability are a must. The Westinghouse instruments at KMOX solved these problems. They also provide co-ordinated styling and smart appearance.

**What are YOUR electrical measuring problems?**

Would they include—reliable performance...styling...size...readability or different types of service...portable...switchboard...panel...recording?

The vast lines of Westinghouse electrical measuring instruments provide you with the answers to all of these problems. Every Westinghouse instrument is backed up by more than 60 years of skill, "know-how" and experience in every field of industry.

**Westinghouse Instruments Also Provide You With**

- Dials that stay white under all conditions
- Magnets that stay permanent
- Springs that remain constant for life
- Pivots with high shock capacity and low friction
- Quick delivery of more different ratings and types
- Complete Nationwide Service

**YOU CAN BE SURE... IF IT'S**

**Westinghouse**

PLANTS IN 25 CITIES... OFFICES EVERYWHERE

**Electrical Measuring Instruments for ANY Job**

New 50,000-watt transmitter at station KMOX, St. Louis. This station is one of the important links in the Nation's vital educational, news, and entertainment industry.
A handful of vhf Power

Over 1 kW output at 120 Mc/s from a valve only 5 1/2" long! The 3J/16OE incorporates a theriated tungsten filament requiring low filament power and is air blast cooled, facilitating the design of simpler and smaller radio equipment.

For complete data write to: Department 3707

Standard Telephones and Cables Limited
OAKLEIGH ROAD, NEW SOUTHGATE, LONDON, N.11, ENGLAND
You gain these advantages in **ALSIMAG**

**CUSTOM MADE TECHNICAL CERAMICS**

These are the reasons for the consistent growth of American Lava Corporation:

**RESEARCH.** American Lava stands pre-eminent in its field in research. Here you are most apt to find the answer to any question involving technical ceramics.

**ENGINEERING SERVICE.** American Lava is long on engineering service. You will find one or more graduates of many leading engineering schools on our staff. Their specialized experience is freely available to you on selection and design of technical ceramics for your specific requirement.

**EXCLUSIVE PROPERTIES.** Constant development of special purpose ceramics has led to the production of many Alsimag compositions with advantages not found in any other material.

**DEPENDABLE QUALITY.** Our customers know that Alsimag components are always well within the physical characteristics specified. That is assured by alert Quality Control Supervisors and rigid final inspections.

**ACCURACY.** Already supreme in the field of accuracy, the many new precision machines installed in the past year achieve normal tolerances without additional cost penalty. Alsimag can be held to almost any tolerance required at commensurate cost.

**ADVANTAGEOUS DELIVERIES.** Deliveries are not as good as we would like to have them—but, during the past year 84% of our deliveries were on time and a good percentage of the remainder followed rather closely. Factory expediting practices are being constantly improved and we pledge further improvements toward increasing the already favorable percentage of deliveries on time.

**PROPERTY CHART.** The more frequently used Alsimag compositions are shown in a Property Chart, sent free on request.

**AN INVITATION.** If you have a problem which might be solved by technical ceramics, submit details and let our engineers make recommendations without cost or obligation.

[Address and Contact Information]
You would find it hard to set a requirement on Arnold magnets that is not already exceeded in our regular production procedure.

All Arnold products are made on a basis of 100% quality-control at every step of manufacture. These rigidly maintained standards cover all physical, magnetic and metallurgical characteristics... you can place complete confidence in the uniformity and dependability of Arnold Permanent Magnets, and their resultant performance in your assemblies.

Remember, too, that Arnold's service covers all types of permanent magnet materials, any size or shape of unit, and any field of application. Our engineers are at your command—write us direct or ask any Allegheny Ludlum representative.
a LORD VIBRATION CONTROL SYSTEM

Protects Delicate Mechanism
Lowers Servicing Costs
Reduces Worker Fatigue

Various Bulletins available on Vibration Control Mountings, Flexible Couplings and Bonded Rubber Products. For applications providing vibration isolation regardless of direction of disturbing forces, Bulletin No. 106; for applications isolating vibration but not subject to intense shock, Bulletin No. 104; for applications involving transient shock loads in addition to vibration, Bulletin No. 103; Flexible Couplings, Bulletin No. 200-C.

In this New IBM CALCULATING PUNCH

A marvel of inventive ingenuity that multiplies two ten-figure numbers and gives you the twenty-figure product in less time than it takes to tell it; that adds, subtracts, and divides with the same ease—that's the new IBM Calculating Punch.

The mechanism is supported and protected by four standard Lord Tube Form Mountings. They serve to isolate the vertical vibration caused by the punching mechanism and other moving parts. The life of the machine is prolonged; service calls are reduced to a minimum; and operators and neighboring workers are spared the nervous fatigue caused by uncontrolled vibration.

Whether your product is designed for precise recordings, high speed production, or heavy duty service, its performance can be improved, its output increased, its life extended, through a built-in Lord Engineered Vibration Control System.

MAKE GOOD PRODUCTS BETTER with Vibration Control

LORD MANUFACTURING CO. • ERIE, PA.

Field Offices: Detroit • Chicago • New York • Washington, D.C. • Providence, R.I.

www.americanradiohistory.com
Faster, easier relay installations

All wiring confined to backs of panels

Wiring can be completed before relays are installed

Relays can quickly be removed or changed without disturbing wiring

Practically any Struthers-Dunn Relay having an insulated base can be supplied—At No EXTRA Cost—with eyelet terminals for quick, easy mounting on studs extending through the panel. Wiring is confined to the rear of the panel and the studs form the electrical connection to the relays, permitting fast installation, removal or change.

In installations where the relays are small and where no vibration exists, compression-type plugs may be used instead of studs and nuts. Then the relays are simply pushed into place on the plugs.

**STRUTHERS-DUNN**

5,348 RELAY TYPES

STRUTHERS-DUNN, INC., 150 N. 13TH STREET, PHILADELPHIA 7, PA.
MIDGET THYRATRONS MEAN ECONOMY

... of space ... of first cost ... of power to operate

THEY'RE DOING "BIG-TIME" WORK THROUGHOUT INDUSTRY

Lots of performance in a tiny tube envelope, so you can design for extreme compactness ... that's the GL-5663 glass thyratron, only 1 1/4 inches in seated height! For circuits requiring a larger tube current capacity, General Electric offers the self-shielding metal GL-502-A, 2 3/16 inches high when seated. This space-saving type will replace the twice-as-large 2050.

Applications of General Electric's capable midget thyatrons? ... Too many to specify here; however, these uses are frequent:
- Photoelectric-relay work ... either to actuate a mechanical relay, or to drive a larger thyratron for that purpose.
- Timing and time-delay relay operation.
- Control of small aviation and other fractional-hp d-c motors.

- Use in welder-control panels.
- Temperature-control work—in electric thermostats, and in the chemical and other industries where vats, retorts, and furnaces need automatic regulation. Note the wide ambient-temperature range of both tubes!

Much of the popularity of G-E midget thyatrons stems from General Electric's policy of continuously improving design. For instance, the GL-5663 is a better tube than the GL-546 it supersedes, in that the new type will hold for life its initially low control-grid and shield-grid currents. This especially fits the GL-5663 for timing-circuit work, where a rise in grid current caused by electrical leakage would mean inaccuracy.

Now—while your new electronic-control circuit is in the planning stage—is the time to consider the saving in space, the economy of first cost, the low power requirements of G-E midget thyatrons! For full particulars phone your nearby G-E electronics office, or address General Electric Company, Electronics Department, Schenectady 5, New York.

GENERAL ELECTRIC
FIRST AND GREATEST NAME IN ELECTRONICS

CHARACTERISTICS

GL-502-A GL-5663
Max over-all height 2 3/16 inches 1 1/2 inches
Max over-all diameter 1 15/16 inches 3/4 inch
No. of electrodes 4 4
Cathode voltage 6.3 v 6.3 v
current, approx. 0.6 amp 0.15 amp
heating time, typical 10 seconds 10 seconds
Peak voltage drop, typical 11 v 11 v
Average anode to control-grid capacitance 0.2 mmfd 0.1 mmfd
Ambient temperature limits -55 to +90 C -55 to +90 C

MAXIMUM RATINGS

Peak anode voltage, inverse forward 1,300 v 500 v
Anode current, instantaneous 650 v 500 v
average 1 amp 60 ma
Time of averaging anode current 100 ma 20 ma
30 seconds 15 seconds

ELECTRONICS — September, 1948
What's your problem?

Fine Wire? Tungsten? Molybdenum?

Problem 1

MR. N. AMMELLING needed 339,000 feet of .001 enamelled copper wire. He called North American Philips and in good time received a one-pound package...his 64 miles of wire enamelled to his specifications.

Problem 2

The firm of ALLOY & ALUMINUM were in urgent need of fine aluminum and aluminum alloy wire for a delicate production job. Fine Wire Headquarters assured them that it was no problem at all. The order was placed, the Fine Wire delivered, and it performed to the complete satisfaction of all concerned.

Problem 3

MR. MUST B. PLATED, who required metal-clad wire for a specific application, phoned Fine Wire Headquarters. We supplied the base material to provide the physical characteristics desired, and plated it to meet his exacting specifications for special surface qualities.

the answer

WHY not call Fine Wire Headquarters when you have a question about fine wire? We can’t do the impossible, but we can do lots of things that can bring you the right fine wire for the job.

So—when you have a problem on Fine Wire, Tungsten or Molybdenum—wire, phone or write to North American Philips, makers of NORELCO Fine Wires, and ELMET Tungsten and Molybdenum products.

NORTH AMERICAN PHILIPS COMPANY, INC.

Dept. XT-9, 100 East 42nd Street, New York 17, N.Y.

Export Representative • Philips Export Corporation • 100 East 42nd Street, New York 17, N.Y.
More and more, electrical appliance customers are asking—"Will it cause radio interference?" And in the answer to that question lies the secret for many more sales of your products.

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It is unbelievable that so small a resistor can carry 35,000 watts! But it actually happens, repeatedly, in the case of Ward Leonard Non-Inductive Plaque Resistors wound with Nichrome V wire — used in telephone carrier circuits operating through rural power lines.

This is the story: Circuit breakers are installed in the power lines to protect them against "shorts" due to falling wires, etc. But the telephone carrier currents are blocked by the high impedance of the breaker solenoids. A low-impedance resistor is therefore used as a by-pass at each solenoid.

When a "short" occurs, the resistor must be momentarily able to carry amperage far in excess of its normal rating, because mechanical lag prevents the circuit breaker from opening instantly. The same applies when lightning, or accumulated static charges, discharge to the ground.

Tremendous strain is imposed upon the winding of the resistor during the instant of high current impact, yet it must stand up.

To assure maximum performance and dependability, Ward Leonard uses windings of Nichrome V. This superlative Driver-Harris alloy sustains tremendous voltage surges without loss of characteristics, retains its superb stability in spite of severe thermal shock, stays on the job even though "jolted" again and again . . . when a breaker makes several attempts to restore an open circuit.

Whatever your electrical resistance problems — conventional, unusual, or seemingly impossible of solution — send your specifications to us. We manufacture and draw the most complete line of electrical resistance alloys in the world.
Announcing A NEW LINE OF SPRAGUE ELECTROLYTIC CAPACITORS

Designed for Television Use
(for operation up to 450 volts at 85° C.)

With some 7 times as many components in a television receiver as in the average radio, the possibility of service calls is greatly increased. The new SPRAGUE ELECTROLYTIC line offers the first practical solution to this problem.

Designed for dependable operation up to 450 volts at 85° C., these new units are ideally suited for television's severest electrolytic assignments. Every care has been taken to make these new capacitors the finest electrolytics available today. Stable operation is assured even after extended shelf life, because of a new processing technique developed by Sprague research and development engineers, and involving new and substantially increased manufacturing facilities. More than ever before your judgment is confirmed when you SPECIFY SPRAGUE ELECTROLYTICS FOR TELEVISION AND ALL OTHER EXACTING ELECTROLYTIC APPLICATIONS! Sprague Electric Company invites your inquiry concerning these new units.

SPRAGUE ELECTRIC COMPANY • NORTH ADAMS, MASS.

SPRAGUE Capacitors • Koolohm Resistors

PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS

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Viewed from any angle this molded case for Wilcolator* was a real challenge. Using standard finishing techniques, 34 machining operations would have been needed to produce the intricate pattern of holes, recesses, slots and lettering appearing on the topside alone! Not less than a dozen additional operations could have provided the fillets, bosses and stepped-planes of the inside contour. Yet by careful engineering, this part was precision molded as it appears above without recourse to a single after-molding operation. To meet the demands of the application for a heat-resistant material, we used a compound, custom-formulated in our own plant. And for speed and economy in production the cases were molded eight-at-a-time in an enclosed type semi-automatic mold.

In baseball parlance, facing this "tough line-up" Consolidated came up with a perfect triple play ... from Custom-Mold to Custom-Material to Custom-Processing ... scoring complete customer satisfaction. We will be glad to meet the challenge of your next plastics application with an equal display of brilliant teamwork. Inquiries invited!
From this package come the finest recordings in the world

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Presto Brown Label discs. They’re one-side perfect...with a flaw on the other side you probably couldn’t find. Perfect for one-side recordings, reference recordings and tests, and at greatly reduced cost.

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Presto RECORDING CORPORATION
Paramus, New Jersey

September, 1948 — ELECTRONICS
FOR panel-rack or other sectionalized circuits, Lapp offers a variety of plug-and-receptacle units, some of which are shown above. Any number of contacts can be provided (in multiples of twelve). Male and female contacts are full-floating for easy alignment and positive contact. Contacts are silver-plated, terminals tinned for soldering. Polarizing guide pins are provided where desired. Insulation is Steatite, the low-loss ceramic which is non-carbonizing even under leakage flashover resulting from contamination, moisture or humidity. Write for complete electrical and mechanical specifications of available units or engineering recommendations for an efficient component for your product.
Lead makes an excellent sheath for telephone cables—sixty years and thousands of miles in service have well proven that. But lead is useful in other ways—storage batteries and paint, to name only two. So the telephone industry shares the limited available supply with other claimants.

Before the war when there was no lead shortage, Bell Laboratories engineers sought to develop better and cheaper cable sheaths. An ideal sheath is strong, flexible, moisture-proof, durable and must meet specific electrical requirements. No single material had all those virtues, so thoughts turned to a composite sheath, each element of which should make a specific contribution to the whole.

Various materials and combinations were studied. Desirable combinations that satisfactorily met the laboratory tests were made up in experimental lengths, and spent the war years hung on pole lines and buried in the ground. After the war, with an unparalleled demand for cable and with lead in short supply, selection was made of a strong composite sheath of Alumimum and Polyethylene. Now Western Electric is meeting a part of the Bell System's needs with "ALPETH" sheathed cable.

Meeting emergencies—whether they be storm, flood or shortage of materials—is a Bell System job in which the Laboratories are proud to take part.
MICROWAVE MEASUREMENT COMPONENTS
Now Available...

**TYPE 351-A — REACTION TYPE FREQUENCY METER**
(1" x 1/2" waveguide)
High Q cavity; Precise and permanent calibration; Extraneous mode suppression

- These non-sealed frequency meters will soon be augmented by a new line of thermetically sealed, temperature compensated units covering the frequency range from 500 to 40,000 megacycles per second. Also available: frequency standardized signal sources.

**TYPE 401 — DIRECTIONAL COUPLER**
(1 1/4" x 3/8" waveguide)
High directivity; Minimum frequency sensitivity; Broadband operation

- This unit is representative of a group of mono-directional broadband couplers covering in four waveguide sizes the frequency range from 4000 to 10,000 megacycles per second.

**TYPE 211 — PRECISION WAVEGUIDE SLOTTED SECTION**
(0.420" x 0.170" I.D.)
Broadband operation; Crystal and bolometer detection; Ball bearing carriages support

- Similar Slotted Sections and Probes in standard rectangular waveguide and coaxial line sizes make possible precise impedance measurements over the microwave spectrum from 1000 to 40,000 megacycles per second.

**TYPE 309 — SLIDE SCREW TUNER**
(1 1/4" x 3/8" waveguide)
Wide range impedance matching; Simplified rapid adjustment; Broadband operation

- Also available: similar units in standard waveguide sizes, fixed and tunable crystal and bolometer mounts, dielectric tuning devices for coaxial lines.

**TYPE 169 — CALIBRATED VARIABLE ATTENUATOR**
(2" x 1" waveguide)
Metallized glass attenuating element; Precise and permanent calibration; Negligible insertion loss

- A full complement of fixed and variable attenuators and broadband terminations in standard waveguide sizes provides coverage for the frequency range from 2600 to 40,000 megacycles per second. Fixed pads and terminations are available for standard coaxial transmission lines.

The items presented above are representative of the complete PRD line of precision microwave measurement and test equipment. These units embody basically new design principles calculated to provide the microwave research engineer with the ultimate in accuracy and reliability. A skilled staff of engineers and physicists is constantly pioneering the advance to the higher frequency regions of the microwave spectrum and stands ready to assist in the solution of your microwave problems. An illustrated catalog may be obtained by writing on company letterhead to Dept. E-6.

Polytechnic RESEARCH & DEVELOPMENT COMPANY, Inc.
66 COURT ST., BROOKLYN 2, N.Y.

ELECTRONICS — September, 1948
BUSINESS BRIEFS

By W. W. MacDONALD

Buttons, badges and keep-out signs are more in evidence in electronic equipment plants turning out military gear than at any time since the war.

Heater-Type subminiature tubes are not far away; at least one manufacturer is known to have them pretty well along in the design stage. Available with 6.3-volt indirectly heated cathodes, such tubes should be useful for voltage amplification in equipment which must be compact, particularly in multistage devices.

Mail-Order Houses miss few bets. They are already advertising, in direct-mail flyers, dual-speed turntables operating at both 33⅓ and 78 rpm, hoping to cash in if and when Columbia’s new Microgroove transcriptions for the home (see p 86) become popular.

Business Failures among radio equipment manufacturers in the fiscal year 1947–1948 totalled 29, according to RMA, approximately half having been in business 5 years or less. Of the 29, 10 made radio sets, 5 communications equipment, 3 test equipment, 2 television receivers, 2 recorders, 2 radio parts, 2 phonographs, 1 sound equipment, 1 motors, and 1 projection equipment.

Causes contributing to failure included extensive inventories, excessive plant facilities, inadequate distribution, poor merchandise and inadequate production experience.

Immense Investment required for production of television receivers will change the character of the radio manufacturing industry, according to Zenith’s H. C. Bonfig. The trend, he thinks, is toward a smaller number of larger manufacturers.

Stratovision demonstration out in Ohio brought one fact forcefully to our attention: there are hundreds of people in the hinterlands, away from reliable service, with their antennas hanging out in the hope that they will some night pick up a good stray picture. While the program was in progress we heard several telephone calls come in reporting reception and asking when the Westinghouse-Martin B-29 would be up again. And since then we have seen many similar letters.

Klieg Lights needed by movie people more than by television men were responsible for excessive heat generated in Philadelphia at the recent political conventions and reported by many newspaper commentators. Most television pickup cameras used image or studio orthicons, and these tubes do a pretty good job even by the light of a kerosene lamp.

Acrylic Magnifiers (plastic shells filled with a mineral oil like Nujol) are being manufactured for television in substantial quantities, according to Hiram McCann of Modern Plastics, but the average price at the fabrication shop has gone from $30 to $12, with some production reported at $8.

Sailboat Men are rarely surprised about anything the powerboat boys do, but we are forced to take note of the fact that out on Long Island Sound a few fairly elaborate palaces are being installed floating palaces are fitting for well-off colossus mounted on cabin tops amid other chromium-plated gizmos. Just this last weekend we spotted two seagoing hotels sporting television arrays.

Definition: Radio is television without the pictures.

Britain’s Exports are up; twice in the first quarter of this year radio equipment shipments exceeded the £1,000,000 monthly objective. High on the list of reasons is the fact that models are designed with particular overseas markets in mind; bandspread on shortwaves, high sensitivity, free-
dom from drift and tropicalization are contributing factors.

Australia had 1,737,152 licensed radio receivers on April 30, 1948, an increase of 607,366 since 1939. The ratio of licenses to population was 23.38 percent. More than 125,000 listeners had licenses for more than one set.

College Courses in engineering fully accredited by the Engineers Council for Professional Development in that organization’s fifteenth annual report dated September 30, 1947 and released July 1, 1948, total 509, broken down as follows:

- Elect. and Comm. 109
- Civil 108
- Mechanical 102
- Chemical 41
- Mining 24
- Metallurgical 27
- Industrial 21
- Aeronautical 14
- Architectural 11
- Petroleum 12
- Ceramic 9
- General 8
- Sanitary 5
- Agricultural 5
- Naval 4
- Electrochemical 2

More men are still trying to break into our field than any other.

Fiscal Year Reports: Zenith, $70,406,138 worth of business in the period ending April 30, 1948, up 38 percent over the previous 12 months.

Magnavox, $27,434,019 for the period ending February 29, 1948, as against $24,013,812 in the preceding fiscal year.

Judging a contest for Hytron, we note with interest that a large number of radio servicemen have designed their own trick tube-pullers. Manufacturers, it seems, have mastered the technique of designing tubes that will stay in sockets. Someday they may find it desirable to equip them with wings, or lugs, or handlebars that permit the repairmen to get the things out.

Rose Buss Korsgren, formerly with Hallicrafters and now with Alaska Radio Supply, writing from Anchorage, says it seems to her that nearly everyone she's met is either a radio man or connected with the airlines in some way. That would be natural in a territory in which both communications and transportation involve unusual terrain difficulties.

There are 458 amateurs to 80,000 people in Alaska. In the States there are about 6 hams to that many.

It's A Long Way back, but people around New York are still talking about how perfectly f-m performed when local electrical storms blotted out regular broadcasting the night of the Louis-Walcott fight. This sort of experience does more to sell the new service than any amount of industry propaganda.

Coming Attractions: As promised, we're presenting quite a few articles about computers in the feature pages of ELECTRONICS this year. The latest appears on page 110 of this issue.

Transistors are also considered of sufficient importance to keep the editorial heat on. See page 85.

There will be more.

The ultimate importance of superregeneration is a matter of speculation, but it is about time somebody separated fact from fiction. Two articles in this issue, on pages 96 and 99, do it.

Speaking of hard, cold facts, we hope to have some in print soon concerning Stratovision.

Wondering what goes on at G-E's ambitiously named "Electronics Park"? Read about it next month in these columns and you'll know more about the setup than many of the people who work in Syracuse.

Story Of The Month: It’s late for this one, but only now can it be told.

During the war, a friend of ours who silk-screens panels received an order for a few and started to turn them out on AAAI priority. Then he learned they were part of a classified item and that a 24-hour guard would be required at the plant.

Several months went by, with production hanging fire, while our friend explained that the cost of the guard would exceed the price of the panels. Finally, the go-ahead was given when government officials reluctantly agreed there was scarcely need for security measures in connection with a panel lettered, simply . . . Power On-Off.

Electronics — September, 1948
Mallory Presents the First

ALL NEW Variable Resistor in Years!

The Revolutionary
Mallory
Midgetrol

When we call this \( \frac{15}{16}'' \) Mallory Midgetrol new, we mean entirely new inside and out—with new design and new features achieved by new production methods. It's the first really new control to appear in years.

EXTREMELY LOW NOISE LEVEL—STAYS QUIET, TOO

Both mechanically and electrically, you'll find the new Mallory Midgetrol the quietest, smoothest control you ever handled—with greater uniformity and balanced contact pressure. The new carbon element, contact and 2-point, wobble-free shaft suspension combine to make it so. Better still, it stays quiet! Our tests and customers' laboratory tests prove that after tens of thousands of cycles, the Midgetrol still has an amazingly low noise level.

Behind the new Mallory Midgetrol are many years of Mallory experience and widely diversified manufacturing facilities in metallurgy and electronics. You can specify the Midgetrol with the utmost confidence. Write today for Technical Information Bulletin and Specification Sheets.

OTHER ALL NEW FEATURES . . .

- Higher standardization—faster delivery schedules— thanks to the Midgetrol's new design.
- You can bend or twist the terminals without breaking them.
- Terminals are farther away from the mounting surface . . . eliminates need for extra insulation.
- Has voltage characteristics that make it especially adaptable for television receivers as well as radio sets.
- Saves precious space—can be specified where a \( \frac{1}{4}'' \) diameter control ordinarily would be required.
- Lightness makes it ideal for portable radio applications.
- Flat shaft for standardization and uniformity in production—for adaptation to fit any type knob now in use.
- Specially designed switch for long, trouble-free life.
OBIT . . . The death of Harry Diamond, at the height of his career, is a severe loss to the profession and to the Bureau of Standards, where he headed the Electronics Division. His work on radio range beacons, the instrument landing system, the radiosonde and the proximity fuze, are outstanding contributions to aviation and military science. They are matched by an equal contribution to the training of young radio scientists, many of whom received their first inspiration from Mr. Diamond. He saw electronics clear and he saw it whole. One of his last speeches contained a breakdown of the field of electronics:

This was his business; he served it well:

(1) Radio communication and broadcasting, including television and facsimile.

(2) Electronic ordnance, including radar fire control, electronic controls for guided missiles, proximity fuze, and electronic controls for underwater torpedoes.

(3) Radio navigational aids, including radar, loran, and other sea and air navigational aids.

(4) Electronic power conversion, including dielectric and inductive heating.

(5) Electronic instrumentation and controls, including special instruments for physical, chemical, medical and biological research and practice, and the general concept of the servomechanism.

(6) Electronic devices for mathematical computation.

TELE-QRN . . . For years the fight against man-made interference has been conducted by the men of radio against the great outside world, the non-radio domain of electric shavers, telephone dials, ignition systems, and similar impulsive characters. More lately, the battle has assumed the character of a civil war.

In television engineering, at least, the arms of brothers are raised in conflict. A television set lives on impulses, at high level in the scanning and video-amplifier circuits, and these pulses, uncontrolled, raise lots of hob with other radio and television sets in the vicinity. An RMA Committee has given wide circulation to this fact, and urged that adequate shielding be employed to cure the interference. But most sets employing magnetic scanning (the majority at present) are still very noisy out to 10 or 20 feet, much more than the thickness of the wall between apartments. This nuisance, if unabated, threatens to unsell a lot of equipment. Like the oscillator radiation problem, it remains a solvable problem on which not enough money and manpower have yet been spent.

A related miscellany is a letter from the city fathers of Garden City, N. Y., sent to all residents, asking them kindly to refrain from erecting television antennas on the roofs of that as-yet-unspoiled village. Seems they have gone so far as to ask experts, who tell them that the flat terrain of Long Island, close to New York, with no high buildings in the vicinity, is ideal for aerials inside attics.

SEMICONS . . . From audion to orthicon (not forgetting pilotron, kenotron, thyatron, and ignitron) it has been customary to coin names for the vacuum-tube family ending in "on". Now comes another family, practitioners of the art without benefit of vacuum. These are the solid-state cousins, the crystal brethren, the germanium, silicon, copper oxide, selenium boys. For years these crystals have rectified, detected, responded to light and to heat. Now, with the coming of the transistor (described in this issue), they amplify. Seems like the country cousins ought to have a name.

Since these crystals are electronic by occupation, if not by constitution, we beg leave to suggest a name in the vacuum-tube tradition. To wit, semicon: a device employing a semiconducting material in the solid state, through which flows a current capable of being varied by external physical influences. The crystal detector current varies with the direction of the applied potential; it rectifies. The barrier-layer photocell current responds to light, the thermistor current to heat. The transistor current responds to the magnitude of an applied voltage; it amplifies. Respectable brethren, these semicons, and welcome.
The TRANSISTOR—A Crystal Triode

Germanium crystal with two cat-whisker contacts has characteristics of grounded-grid triode amplifier, provides 20 db gain, 25 milliwatts output at frequencies up to 10 megacycles. It will replace vacuum tubes in many applications and open new fields for electronics.

A NEW DEVICE, operating on an entirely new principle and capable of many functions of the electronic vacuum tube, but having neither an evacuated envelope nor a hot cathode, was announced early in July by scientists of the Bell Telephone Laboratories. Known as a TRANSISTOR (TRANSfer resISTOR), the device is essentially a triode form of the well known germanium crystal diode.

In its present experimental form the Transistor is a metal cylinder \(\frac{3}{16}\) inch in diameter and \(\frac{3}{8}\) inch long, as shown in Fig. 1. Inside the cylinder, Fig. 2A, is a block of germanium soldered to a metal disc to which it makes low resistance contact and that grounds it to the cylinder. Two 2-mil tungsten wires make contact with the upper face of the germanium at points about 0.002 inch apart.

An input signal, Fig. 2B, in series with a small positive bias voltage, is applied between the grounded face and the input cat whisker (emitter). A large negative bias voltage is applied between ground and the output (collector) point contact. The output signal appears across a load resistor in series with the negative bias. In this manner a power gain of 100 (20 db) is obtained between input and output of a Transistor. The terminal characteristics of an experimental Transistor are shown in Fig. 2C (see the Phys. Rev. p 230, July 15, 1948.)

This is an early unit having a gain of about 15 db. The characteristics are typical of later units having an average gain of 20 db.

Because of its unique properties, the Transistor is destined to have far-reaching effects on the technology of electronics and will undoubtedly replace conventional electron tubes in a wide range of applications. The Transistor requires no heater or filament power and uses the power supplied by its bias sources with high efficiency. Under typical operating conditions it draws only 0.1 watt from the bias sources (about a tenth the power consumed by a flashlight bulb) and delivers 25 milliwatts of useful output, thus having an overall efficiency.
of 25 percent.

The Transistor is smaller than a subminiature vacuum tube. It seems likely to have a useful life of many thousands of hours because of its simple, sturdy construction. Where portability and low battery drain are essential, as in hearing aids and personalized radios, the Transistor appears ideal. In equipment using large numbers of amplifiers, large-scale computers being an extreme example, the absence of a heater makes it possible to place many Transistors in confined space without creating difficulties in heat dissipation.

Although cost factors have not been thoroughly explored, Transistors should be no more costly to manufacture at present than the 1N34 (high back-voltage) germanium diode, which lists for replacement at $1.20 and is obtainable in large lots by equipment manufacturers at $0.53 apiece. These prices are slightly higher than the prices of a corresponding vacuum tube (6H6). However, present costs of crystal diodes are not representative of inherent costs. The industry has spent about 40 years mechanizing production of vacuum tubes and has written off engineering and plant costs over that time. If crystal devices (diodes and Transistors) prove as successful in practice as they now appear to be, they too will be put into mechanized production and their cost reduced. Ultimately they should be cheaper than comparable vacuum tubes because of their simplicity and because they do not require evacuation, which is the most difficult step in producing vacuum tubes.

There are limitations to the use of Transistors in their present state of development. The power output is restricted to about 25 milliwatts per unit, or 50 mw from a push-pull stage. A Transistor capable of developing several watts output does not seem feasible at present. Parallel operation of two or more units is possible, however, and could be used to increase the power to a load several fold. The upper frequency of operation is limited to about 10 megacycles by transit time within the germanium. Thus the Transistor is at present useful at audio, video, and the lower radio frequencies, but is unsuited to vhf and uhf applications. Furthermore, the noise generated within a Transistor is appreciably greater than that produced in vacuum triodes.

If the requirements of an application for which the properties of Transistors are suitable justify their cost when they first become commercially available, there remains a temporary obstacle to their immediate use, namely engineering this new device into the circuit. One of the principle problems requiring development is matching the input and output impedances of the Transistor to the circuit. The input impedance of the Transistor is low because the bias in the input circuit causes current to flow in the forward direction through the point contact of the emitter. On the other hand, the output impedance of the Transistor is about a hundred times higher than the input impedance because its bias causes current to flow in the reverse direction through the point contact of the collector. These impedance levels are the opposite of those for vacuum tubes and require a new approach to the coupling circuits between amplifier stages. Intensive work on this problem is underway. The Transistor thus opens new fields for clever design and inventive talent.

Illustrative Applications

In announcing the Transistor, BTL scientists demonstrated several typical electronic devices in which it was used. A booster amplifier for telephony illustrated its application to voice-frequency amplification. A similar video amplifier was also demonstrated. Its low power-supply drain makes it suitable for telephone and television repeater service. In fact, it requires no more power than that usually available at a subscriber's set from the central office batteries that are connected to the line. Use of a Transistor as an oscillator showed the versatility of the unit. Use in a radio receiver for the standard broadcast band illustrated its practicality.

The radio receiver contained no tubes. It consisted of a broad-band r-f amplifier, a tuned r-f stage, local oscillator, mixer, three stages of i-f, second detector, and four stages of a-f amplification, the last being push-pull. A total of 11 Transistors were used in the amplifier stages, with 2 germanium diodes for the mixer and detector stages, and 2 selenium rectifiers for the power supply. The receiver brought in local stations, delivering 25 mw of audio power to its loudspeaker.

At low power levels crystal diodes and triodes, in conjunction with printed circuits, make possible the extension of electronic techniques. Existing equipment can be made more compact. Transistors, having no filament, are operative the instant power is applied.

Research Background

Research work in semiconductor materials began at least 24 years ago. Germanium and other semi-
conductors have been used as rectifiers because of their unilateral conductivity. These employ a single point contact; the input and output circuits are not separated. The two-contact arrangement is the practical outcome of a long program of scientific research on semiconductors.

Although investigation of semiconductors at BTL dates back a number of years, with the end of the war a concentrated basic research program was undertaken. Groups in the Physics Department were reorganized. Additional personnel were taken on, particularly theoretical specialists. The groups consisted of paper-work men and laboratory experimentalists who could pass problems from office desk to lab bench and back as the program unfolded. The fact that pure research paid off relatively quickly, in so spectacular a way, is testimony to the ability of the men who carried out the program and to the facilities with which they worked.

The group on semiconductors, led by William Shockley, one of this country's leading solid-state physicists, was seeking answers to three basic questions: (1) physically, what is a semiconductor, (2) how does its physical nature produce its observed properties, and (3) how does the fabrication and processing of the material affect its physical nature? Among the semiconductors studied were silicon, copper oxide, and germanium.

A great deal of empirical information had been amassed on these substances during their use, particularly as detectors in microwave equipment ("Crystal Rectifiers," H. C. Torrey and C. A. Whitmer, McGraw-Hill, 1948). In particular it was known that their resistivities were determined chiefly by impurities, and furthermore that their resistivities could be varied over wide ranges by applying various external influences (light in the case of photocells, electric potential in the case of rectifiers and detectors, or temperature in the case of Thermistors).

Theory of Conduction

Modern physics has developed a detailed concept of the construction of matter and consequently an understanding of the mechanism of conduction. In metals there is approximately one free electron that can be used for carrying current for every atom; in insulators there are practically no free electrons. By free electrons is meant electrons so loosely associated with their atoms that they can easily be induced to move to adjacent atoms.

In semiconductors there is only about one current-carrying electron for every millions atoms, but this number of carriers can be varied 1,000-fold by changing the physical environment of the material. Such a change in the number of carriers is effectively a change in the resistance of the material. For example, light falling on a barrier layer changes its resistance. Alternating voltage applied to a selenium rectifier or a germanium diode changes its resistance so that current flows predominantly in one direction. Likewise, a high potential applied externally (without making contact) to a semiconductor should change its resistivity. Using a sheet of germanium as one plate of a capacitor, Shockley and his colleagues measured the change in resistance produced by changing the voltage across the capacitor. The change in resistance was much smaller than anticipated in the light of prevailing theory. Conclusion: something wrong with theory. So John Bardeen, a theoretical physicist in the group, devised a theory of surface states that would account for the measured change as well for older known effects unexplained by previous theories.

To review the old theory for a moment, it was known that conduction in semiconductors could take place by two mechanisms, operating either separately or simultaneously. In some types of semiconductors the electrons, as usual, moved under the influence of applied voltages and thus provided a current flow. Such semiconductors are called N-type because conduction is by negative (electron) charges. In other types of semiconductors, in which there is a deficiency of electrons, the current flow consists of the movement of virtual positive charges (images of electrons) that are actually empty places from which electrons have been removed. Such semiconductors are called P-type because conduction appears to be by positive charges, are shown in Fig. 3.

The two types of conduction had been identified with impurities. For example, as shown in Fig. 3B, silicon alloyed with a minute percentage of phosphorus is an N-type (electronic) conductor. Physically, the effect is explained by the fact that phosphorus has five valence electrons. Four of these form bonds with the four valence electrons in a silicon atom (thus binding the atoms together), leaving one electron free for carrying current.

If the impurity is boron (Fig. 3C), which has only three valence electrons, there is one incomplete bond between each boron and its neighboring silicon atom, leaving a hole in the structure. Because the percentage of boron impurity is very low, not many silicon atoms are so bound. Hence the hole in the bond of one silicon atom with a boron atom can be filled with an electron from an adjacent silicon atom under the influence of an external electric field. However, this action leaves a hole from which the electron came. This hole is free to be passed from atom to atom and hence to carry current. Whereas a negative electron will migrate from a negative region toward a positive region when voltage is applied, a hole will migrate from a positive region to a negative one. (In P-type—hole—conductors the electrons would have no place to go if it were not for the hole, so, although the electrons do move when current flows, it is the presence of the hole that makes their motion possible. Thus, to physicists, conduction is by (owing to the presence of) holes. Such action takes place in germanium.

The new theory suggested new experiments, which, when performed, called for refinements in the theory. While W. H. Brattain and John Bardeen were following up the consequences of the refined theory of surface states they invented the Transistor. With it they discovered a surface layer having peculiar characteristics.

To account for these characteristics, they postulated and later showed by experiment that there is a thin layer of electrons at the
surface of germanium. This surface layer would prevent the penetration into the body of the semiconductor of an externally applied field and thus account for the smallness of the changes in resistance observed in the capacitor experiment. The field created by these surface electrons causes the formation of holes in the adjacent material, and these holes conduct current. The conducting layer may be caused by an excess of impurities near the surface such as boron that accept electrons into bonds and thus create holes, or by a space-charge barrier layer. Between this P-type layer and the N-interior is a rectifying barrier.

When a single point contact is made, the surface layer determines the conductivity for reverse currents or small forward currents. For large forward currents there is an increase in the concentration of carriers (electrons and holes). In either case (forward or reverse current) a large part of the current is carried by the surface conducting layer within an area of interaction very close to the point. Within this area the conductivity, which is mainly by holes, is much greater than elsewhere in the semiconductor. The second point contact for the Transistor is added within this area of interaction.

Transistor Characteristics

In a Transistor, the positive point contact causes the release of holes in the surface layer of the germanium, which is prepared in a similar manner to a high back-voltage rectifier. These holes spread away from the point, flowing in all directions along the surface (but not into the body of the semiconductor). The holes reach the other contact point 0.005 cm away, in less than a ten-millionth of a second. This is the transit time that limits present performance to frequencies below about ten megacycles. From this observation, it is estimated that the holes travel at the order of 100,000 centimeters per second. Higher applied potentials and smaller spacings, as used in vacuum tubes to increase high-frequency performance, may reduce this transit time. That there are holes capable of moving from 10 to 100 times this speed is known from estimates of their thermal velocities.

The negative bias applied to the collector causes a very small current to flow from the germanium in the absence of hole conduction produced by the emitter. When the positive bias is applied to the input, however, holes are attracted to the output point contact, which is biased negatively, and these are absorbed, thus increasing the current in the output circuit. Variations in the input current change the number of holes released toward the collector and thus vary the output current proportionately. The Transistor circuit thus closely resembles a grounded-grid triode circuit.

In a grounded-grid vacuum triode the current from the cathode is controlled chiefly by the potential between it and this grid (ground); the plate potential has little effect. In the Transistor the positive bias (about 1.1 volts) of the emitter (cathode) causes a small current to flow into the semiconductor. The negative bias (up to 50 volts) of the collector (anode) is made large enough so that it withdraws about the same current (a few milliamperes) from the semiconductor. While the collector is a poor emitter of electrons, it is a good collector of holes. A variation of the number of holes in the surface around the two point contacts is produced by changes in the input voltage of the emitter. This variation changes the current (carried by holes) to the collector by a factor of from one to two times the change in emitter current, depending on the operating bias. Furthermore, this change in current flows in the high impedance of the output circuit, of the order of 10,000 to 100,000 ohms. The voltage change produced in this high-impedance circuit by the change in current is thus proportionally large, of the same order of magnitude relative to the signal voltage input as the ratio of reverse to forward impedance of the point contact. There is a corresponding power amplification of the signal.

Because the output circuit can influence the input circuit only by electronic conduction, for which the surface resistance is high, there is little coupling from output to input, and the circuits, one of low impedance (low power) and one of high impedance (high power), are properly isolated for use in unilateral amplification.

The d-c characteristics of a typical experimental Transistor, Fig. 2C, show the interrelation of the four variables, the two currents and the two voltages. If two are specified the other two are determined. The effect depicted by these characteristics shows that, in addition to the forward amplifying action, the collector current lowers the potential of the surface in the vicinity of the emitter in proportion to the collector current times a constant internal resistance, and thus increases the effective bias on the emitter. This describes the nature of the back coupling that exists. Under certain operating conditions this coupling, which represents positive feedback, can cause instability. Thus, although the principle of operation is vastly different, the Transistor has the properties of vacuum tube amplifiers in many respects.—D.G.F. and F.H.R.
JTAC

Its Purpose and Program

The Joint Technical Advisory Committee, eight engineers appointed by RMA and IRE, has the important job of advising government bodies and industry groups on the wise use and regulation of the radio spectrum.

The central problem of the radio industry is the fact that its domain, the radio spectrum, must be administered and policed by agencies subjected to commercial and political pressures, while the by-laws governing the domain are based on technicalities which cannot be changed by commercial or political argument. In each of the major forms of broadcasting for example, this fundamental conflict has led to an improper use of the spectrum, or to faulty administration of it.

Standard broadcasting, put on an orderly basis first in 1925, has suffered ever since from a channel separation too narrow to permit high-fidelity transmission, and the multiple assignment of frequencies (to approximately 2,000 stations at present) has so congested the spectrum that serious interference is the rule in all but urban areas. Television, ready to start in 1939 on standards not radically different from those now used, was stopped dead in its tracks in 1940 by an intra-industry fight which the FCC was unwilling to referee. Frequency modulation was first assigned a band from 44 to 50 mc, and later moved wholesale to 88–108 mc, to the consternation of broadcasters and set owners alike. Whatever the
merits of the arguments in each case, the fact remains the public has suffered from an inadequate understanding of the radio spectrum and its standards of use, on the part of regulating bodies and their advisers.

One of the first attempts to rectify this situation was the formation in 1940 of the National Television System Committee, to advise the FCC on television standards. The success of this effort led to an extension to cover additional classes of radio service. This was the Radio Technical Planning Board, which presented evidence to the FCC on the post-war allocation of frequencies. Other groups, notably the Radio Technical Commission for Aeronautics and similar groups for marine (RTCM) and land-mobile (RTCLM) services have been formed to study the problems of particular services and to recommend standards and allocations for them.

On July 1st, 1948, the RTPB was dissolved, and its panels were absorbed in the committee structures of the RMA and the IRE. This action was based on the realization that the administration of the spectrum could no longer be guided solely by groups devoted to particular services, as were the RTPB.
panels. The competition for additional ether space had reached fever pitch and the FCC despaired of refereeing between panels recommending opposed allocations based on conflicting technical evidence. What was needed was an impartial committee to act as a buffer between the regulating body and the proponents of individual services.

**Formation of JTAC**

The signal for the formation of such a group came soon after the appointment of Wayne Coy to the chairmanship of the FCC. At the IRE annual convention in March 1948, Mr. Coy pointed to the FCC's need for assistance in arriving at an adequate national allocation of television facilities, and mentioned the needs of other services, notably the land-mobile service, as conflicting factors.

At that time the IRE was considering the formation of a technical committee on spectrum utilization, which would gather evidence on the characteristics of different portions of the spectrum and correlate them with the needs of particular classes of service. This committee was the brainchild of the incoming IRE president, B. E. Shackelford. Acting on Mr. McCoy's request, Shackelford met with W. R. G. Baker, outgoing IRE president and Director of the RMA Engineering Department. Together these men roughed out the plan for a joint IRE-RMA committee to consider problems of spectrum utilization and to assist the FCC as required. The idea was presented to the Boards of Directors of the IRE and RMA, and received their blessing.

Two men were appointed to the committee initially, Philip F. Siling, representing IRE, to serve as the first chairman, and Donald G. Fink, representing RMA, to serve as vice chairman. These men met with a group of interested engineers on May 12th to develop the basic philosophy of the new committee. Based on this discussion a charter was drawn up, amended and finally approved by IRE and RMA June 20th.

The charter, the full text of which is appended here, establishes a committee of eight members, each to serve for two years. While JTAC will find that, most of its actions relate to FCC activities, it will assist other government bodies, such as the Interdepartment Radio Advisory Committee, and the Civil Aeronautics Authority, on request, and is also available to industry groups, such as railroad, aviation and marine interests. If the load gets too heavy, JTAC has the power to decide on its own motion what problems it will tackle first.

Established IRE and RMA technical committees will be called on to supply information and make detailed studies for JTAC, and special ad hoc committees may be appointed to do so. Other groups or individuals who may have information will be encouraged to pass it to the JTAC. To this end, notices of problems under consideration will be published regularly in the technical press. JTAC's findings will be available to all who request them.

The basic information collected by JTAC will thus come from informed sources, including recognized specialists in particular fields. JTAC's overriding responsibility will be to sift the information for internal inconsistencies or conflicts, to separate facts from opinions, and to remove commercial bias. To assist in this job, it has the power to appoint technical consultants. Moreover, the JTAC members are chosen as individuals of high professional standing, and are expected to conduct themselves completely outside the sphere of company politics and commercial interest. In fact, it is only by so operating that the JTAC can earn the reputation for complete objectivity, impartiality and accuracy which its charter sets up as a goal.

**Television Hearing**

The need for the JTAC is underlined by the fact that before its charter was approved and the membership assembled, an urgent request for assistance was presented by the FCC. Early in May, the FCC announced that it would hold a hearing beginning September 20th on the question of utilizing the television frequencies in the region from 475 to 890 mc. These frequencies are currently available for experimentation in improved systems of television, and are reserved for future commercial use when such an improved system is ready for public. But pressure for additional television channels, plus the demands of other services for space, had forced the FCC to step up its schedule and to inquire, at once, how this space might be used.

Accordingly, the FCC requested the JTAC to provide authoritative information on the ways in which these uhf channels might be employed. Questions relating to available equipment and propagation characteristics, were prepared by Commission engineers and were circulated through the JTAC secretariat to the television system committees of the RMA and IRE for detailed study. Reports from these committees, and from other interested groups, were available in mid-August for the critical scrutiny of the JTAC members and their consultants in time for presentation at the hearing in September.

**JTAC Charter**

The text of the JTAC charter, excepting the preamble and portions relating to administrative procedure, is as follows:

**Objective.** The JTAC shall obtain and evaluate information of a technical or engineering nature relating to the radio art for the purpose of advising Government bodies and other professional and industrial groups. In obtaining and evaluating such information, the JTAC shall maintain an objective point of view. It is recognized that the advice given may involve judgment on many interrelated factors, including economic forces and public policy.

**Duties.** The duties of the JTAC shall be as follows:

(a) To consult with Government bodies and with other professional and industrial groups to determine what technical information is required to ensure the wise use and regulation of radio facilities.

(b) To establish a program of activity and determine priority among the problems selected by it or presented to it in view of the needs of the profession and the public.

(c) To establish a program of activity and determine priority among the problems selected by it or presented to it in view of the needs of the profession and the public.

(d) To sift and evaluate information thus obtained so as to resolve conflicts
of fact, to separate matters of fact from matters of opinion, and to relate the detailed findings to the broad problems presented to it.

(e) To present its findings in a clear and understandable manner to the agencies originally requesting the assistance of the Committee.

(f) To make its findings available to the profession and the public.

(g) To appear as necessary before Government or other parties to interpret the findings of the Committee in the light of other information presented.

Membership. The JTAC shall consist of eight (8) members.

The members shall be chosen on the basis of professional standing, integrity, and competence to deal with the problems to be considered by the Committee. The members shall be chosen from among all qualified engineers irrespective of the organizations to which they belong or the companies by whom they are employed and shall operate without instruction. Half of the members shall be nominated by IRE and half by RMA, and the appointment of all members shall be confirmed by both bodies. None of the members shall receive any regular compensation for services from the National or any State Government.

There shall be no alternate members.

Members shall serve for a term of two (2) years, commencing July 1 and terminating June 30. To assist in maintaining the continuity of action of the Committee, half the initial roster of members of the Committee shall be appointed to serve two consecutive terms.

Offices. The officers of the Committee shall be a Chairman, a Vice-Chairman, and a Secretary. The Chairman and Vice-Chairman shall be appointed from among the eight members of the JTAC by the Boards of Directors of the IRE and of the RMA on alternate years and will serve for a term of one year, except as may be otherwise determined by the Boards.

The Secretary shall be a qualified individual appointed by the members of the JTAC and shall serve for a term of one year. The Secretary shall not be a member of the Committee.

Committees and Consultants. The JTAC shall make use of existing committees in the IRE and RMA organizations wherever possible. Where a qualified group does not exist, the JTAC shall appoint ad hoc committees to study and report on particular subjects. Such ad hoc committees shall be disbanded upon completion of their assignments. The Committee shall also make use of qualified sources of information outside the IRE and RMA organizations, including the engineering staffs of Government bodies as well as professional, educational, and industrial groups qualified to assist in its program. Technical consultants may be invited to assist upon occasion, by the Committee as a whole.

JTAC's First Assignment

The FCC hearing scheduled for September 20th, 1948, has the following objectives:

(A) To obtain full information concerning interference to the reception of television stations operating on channels 2 through 13 resulting from adjacent-channel operation of other services, from harmonic radiations, and from man-made noise.

(B) To receive such additional data as may be available since the close of previous hearings (Dockets 6651 and 7896) concerning the propagation characteristics of the band 475 to 890 mc.

(C) To obtain full information concerning the state of development of transmitting and receiving equipment for either monochrome or color television broadcasting, or both, capable of operating in the band 475 to 890 mc.

(D) To obtain full information concerning any proposals for the utilization of the band 475 to 890 mc, or any part thereof, for television broadcasting and the standards to be proposed therefor.

At the request of JTAC, members of the Commission staff prepared the following list of detailed questions:

1. What is the present state of development of equipment in the band 475 to 890 mc, in regard to (a) transmitters, tubes and components, (b) receivers and components, (c) antennas, transmission lines and related equipment for transmission and reception?

2. How much experimental work has been undertaken in television systems in this band, with respect to field operation (transmitter hours operated, number and distribution of receivers, and propagation tests) and laboratory work (development of receivers, transmitters and tubes)?

3. What consideration has been given to the costs of television systems for this band, particularly to the reduction of receiver costs, and the transfer of cost burdens to the transmitter?

4. What areas of service might be expected in this band, based on the following assumptions: (a) a particular system, using one of the following typical bandwidths: 6 mc, 13 mc, 20 mc; (b) radiated power, available now and expected to be available, say, 10 years in the future, (c) receiver sensitivity, and (d) of each of the following typical frequencies: 475, 600 and 890 mc?

5. What co-channel and adjacent-channel separations would be appropriate under the assumptions made in item 4, above?

6. How many channels would be available in the band 475-890 mc, on the assumptions of item 4, above, and how might they be allocated among the 140 metropolitan districts of the United States?

JTAC has transmitted these questions to RMA and IRE committees as well as many other groups, such as NAB and TBA, who may contribute to the store of knowledge. Any reader of Electronics who has information on these matters is urged to communicate it at once to the JTAC Secretary, L. G. Cumming, care of the Institute of Radio Engineers, 1 East 79th Street, New York 21, N. Y.

—THE EDITORS.
Television receiver front-end design is one of the most difficult problems engineers face today. The quality and cost of receivers depends to a large extent upon its solution.

Front ends must have sufficient bandwidth for acceptance of both picture and sound on each of the twelve available channels; almost everything else is optional and at the discretion of the designer.

R-F and Converter

There is, first, the question of gain; this is at present achieved by the inclusion of a stage of r-f amplification.

A triode used in the r-f stage gives a better signal-to-noise ratio than a pentode but provides less isolation; there is a possibility of more oscillator voltage passing through the tube and appearing across the antenna terminals. There is, therefore, a trend toward the use of pentodes. The 6BH6 provides adequate gain on the seven highest-frequency channels and also reduces circuit loading.

Theoretically, the greater the number of tuned circuits the better the performance. However, multiple-tuned circuits cannot always be used due to mechanical design considerations and cost, so either grid or plate-circuit tuning is currently employed. Where grid tuning is used, separate antenna coils must be provided for each channel, with the disadvantage that more switch points are needed. Where plate tuning is used the transmission line must be fed into the grid and cathode of the r-f tube, inasmuch as an input circuit balanced for both signal and noise is essential.

A gain of 6 db is considered satisfactory at the present time for the r-f stage of a television receiver designed for use in the average location. An image-rejection ratio of 40 db can readily be maintained on all channels.

Conversion can be achieved with a triode, pentode, diode, or even a crystal. The 6AG5 pentode performs well as a converter. The oscillator circuit must be chosen carefully; a plate circuit grounded with respect to r-f, with a floating cathode and tuned grid, is probably the easiest to use as there is only one switch point involved.

Some sort of vernier appears to be essential, unless automatic frequency control is incorporated into the design. This is not too difficult to add if a dual triode such as the 12AT7 is used. One half of the tube functions as the oscillator and the other half is used as a reactance.
Franklin rotary-switch assembly with die-stamped transmission lines

Possibly the greatest drawback today in making accurate measurements is mismatch due to the feeding of a signal from an unbalanced signal generator or sweeper into the balanced input circuit of a receiver.

Measurements

To observe and adjust r-f gain, bandwidth, and coupling, the author feeds a suitable sweeper into the antenna terminals through a correct match for 300 ohms. The output is taken at the converter grid or, better still, at its screen, and connected to an oscilloscope. If the inductances are correct for the different channels a curve can be observed on the oscilloscope screen and frequency markers inserted. Coupling can be adjusted while observing the curve on the oscilloscope.

Drift measurements on a front-end unit should never be made in the open. The unit should be installed on the chassis with which it is to be used and in the cabinet in which the chassis is to be placed. The proper temperature-coefficient capacitors can then be incorporated into the design to counteract the effects of heating.

In designing a tuner the most unexpected conditions are encountered at frequencies between 50 and 250 megacycles. All sorts of resonances can be expected. These frequently manifest themselves as absorption circuits, cutting gain or actually blotting a frequency out entirely. An oscillator may refuse to operate entirely at certain frequencies. Probably the worst offenders in this respect are heater chokes which, with their by-pass capacitors, often resonate in the television band. Switch shafts and plates, frameworks, wiring, and other innocent-looking items also give trouble.

Tuning Methods

There are several methods of tuning television receiver head ends, and sometimes they are used in combination. Typical methods are enumerated in the following paragraphs.

Rotary Switch. The rotary switch has met the needs of radio design engineers for nearly twenty years. It has successfully been applied to
television, sometimes using conventional inductances and sometimes resonant transmission lines.

On the plus side of the ledger, rotary-switch advantages include low cost, sturdy construction, and noise-free operation. The spacing between the contacts is small, lending itself to high-frequency operation. Switches of this variety are compact and therefore keep the overall size of a unit to a minimum. But this is the very feature that sometimes causes trouble. Because of its compact construction, the average rotary switch is not too accessible in production. Also, the concentration of conventional inductances in a small enclosed area in which there are warm resistors and hot tubes contributes to the drift problem. Use of printed or stamped inductances as shown in the upper photograph on the preceding page eliminates most of this trouble.

Rotary Tulret. Theoretically, the rotary turret represents excellent television head-end design. By rotating coils, lead lengths can be kept constant for all channels, providing a good LC ratio. But this system, too, has disadvantages. Contacts are difficult to design and, if satisfactory, are generally very expensive. Also, size easily gets out of bounds if all twelve channels are provided. Some manufacturers circumvent this by providing eight channels, leaving it to distributor or retailer to make a station selection satisfactory to the consumer.

Sliding Turret. The sliding turret is essentially a rotary turret that has been flattened out so that it can be moved sideways over or under a set of stationary contacts.

Among turrets, it is probably a good type as contacts are not too difficult to design. However, it has still greater size and more complex mechanical structure.

Permeability Tuning. Permeability tuners have been used successfully for years in radio receivers, and there is no reason why they cannot be adapted for television if the designer is willing to take the disadvantages along with the advantages.

To begin with, in order to cover the entire television band, the tuning spectrum has to be divided into at least two bands, with some method of switchover provided. Such a system could be used in two different versions, the first as a continuous-tuning device and the second with a detent and individual channels. The first system has the advantage of smooth operation but it will also tune through all kinds of interferences. Placing a detent in the system eliminates this trouble but complicates the problem of resetting. Inasmuch as permeability tuning in most cases depends on very small inductance changes, the problem of bringing slugs back to exactly the same position for given
channels is very difficult indeed.

**Inductive Tuning.** Inductive tuning has the advantage of smooth operation. On the other hand, it is mechanically complex and expensive. The idea ordinarily involves use of a rotating cylinder upon which wire is wound in grooves. A small contact wheel engages the first turn when the coil form rotates, and travels over its entire length as the cylinder is turned.

**Variable Capacitance.** The old reliable workhorse of radio, the variable capacitor, has not been forgotten. Although most designers have not employed such devices because of the wide frequency range that must be covered in a television head end, one has actually been developed. The unit referred to requires a high-low bandswitch.

**Pushbutton.** Two different pushbutton tuners have been developed. The first uses a conventional pushbutton switch and the three associated tubes are mounted on the main television receiver chassis rather than in the head-end unit. To overcome the normal high inductance of the contacts, a series capacitor is placed in the transmission line and a small variable capacitor at each pushbutton position to ground. The capacitors act as padders. For 12 channels, 36 trimmers are thus used.

The second pushbutton switch referred to comprises a framework designed to accommodate tubes and wiring. Space is provided near the converter tube for the first i-f coil or trap, while more space is available for broadcast or f-m components. Contacts are large and heavy and their inductance at the frequencies used is low. The moving contacts are welded to the pushrods and are self-aligning. Incorporated in this unit, and an important part of its design, are die-stamped circuits.

**Pushbutton Tuner Details**

In the Franklin Airloop Corporation pushbutton tuner referred to above only four adjustments are necessary. Three coils have an inductive-tuning arrangement consisting of a 4/32 brass screw with a \( \frac{1}{2} \) head. Moving the head of the screw closer to or farther away from the die-stamped coil provides necessary frequency adjustment. A similar device in the oscillator circuit tunes the low-frequency channels.

The oscillator has a vernier capacitance adjustable through the front of the tuner. In cases where automatic frequency control is used the vernier becomes an internal adjustment to compensate for different tube capacitances when and if the oscillator tube is replaced.

A 6BH6 tube is incorporated in the r-f stage. The antenna input is between grid and cathode terminals and is balanced and matched for a 300-ohm line. The grid of the tube may be used with automatic gain control. The plate is tuned and overcoupled to the grid of the converter, which is a 6AG5. The grid of the converter is tuned and the two circuits are coupled with fixed capacitors before channel 13 and at channel 7. Injection voltage at the grid averages 3 volts.

The oscillator is a conventional 6C4 with plate grounded with respect to r-f and a choke in the cathode circuit. The grid of the oscillator is tuned.

The heavy framework of the tuner readily dissipates heat, while the stamped inductances are comparatively far away from the heat sources. Oscillator drift is readily compensated for by means of temperature-coefficient capacitors when the tuner is used in different chassis and cabinets. Should a situation arise in which spurious signals are received in particular locations a trap for the offending signal, or an additional tuned circuit to bring up the wanted signal, or both, can be readily added. Threaded holes are provided on the rear of the switch for this purpose. However, no spurious responses have been found so far.

**Future Trends**

Present-day tuners serve their purpose well, considering the economics of the market, but already new and better front ends are on the drawing boards for 1949 and 1950. It will take time to complete design, field test and tool up.

The trend is toward more gain, greater stability and, particularly, greater freedom from interfering signals. Multiple stages of r-f are possibly in the offing. Certainly more tuned circuits are coming.

**Reference**

(1) Stamped Wiring, ELECTRONICS, p 82. JUNE 1947.
High-Speed Revolution Counter

Supercharger impellers for DC-6 and DC-9 aircraft cabins are tested up to 30,000 rpm by means of a capacitance pickup, a transducer, and a frequency meter. No mechanical connection is made to the impeller shaft, and no load is added to the system.

By ALVIN B. KAUFMAN
Douglas Aircraft Company
Los Angeles, California

There has long been a need for a revolution counter for high-speed machinery which does not attach to the rotating shaft or load it in any way. A device which fulfills these requirements and which is particularly suited for indicating rpm or rps of rotating fan, propeller or impeller blades is described.

The units illustrated are presently employed for determining the rpm of engine-driven cabin superchargers. The impeller of such superchargers operates at 30,000 rpm or more. Similar units can be adapted for use with turbines, or any rotary-blade machinery, without altering or adding anything to the machine.

Three items of equipment are required. These are: the pickup, a capacitance transducer, and an electronic frequency meter or tachometer. The pickup consists of one or more insulated vanes, located adjacent to the rotating shaft or attached blades so as to vary its capacitance to ground with rotation of the shaft. The capacitance-transducer supplies an alternating voltage whose frequency is proportional to shaft rpm. The alternating voltage is applied the electronic frequency meter or tachometer which employs a scale calibrated in terms of rpm revolutions per minute.

Pickup

As the pickup works on a capacitance principle, it is necessary to use a connecting cable whose capacitance is low and yet constant despite movement or vibration. A suitable cable is RG8/U coaxial.

The variation of pickup capacitance should be at least five percent of the total input capacitance, but operation on smaller percentages is possible under low vibration conditions. A one-vane pickup was originally used and proved satisfactory up to 10,000 rpm, but was later discarded in favor of a four-vane pickup pictured in Fig. 1. It should be noted that the number
of pickup elements does not change the output frequency, which is determined by the number of vanes or blades on the rotating shaft. However, under extremes of vibration or weaving of the rotating blades a high degree of hash may be produced. These stray variations in capacitance are corrected by the use of a multielement pickup which automatically balances them out. As one blade weaves closer to a vane its increase in capacitance is balanced by another blade. 180 degrees away, moving away from a vane or pickup element. With the four-element pickup, good waveform is delivered to the electronic frequency meter.

There are several other factors that must be considered in the design of the pickup. In theory it is nothing but an insulated metal plate. The size and shape is not critical, but is chosen so that the impeller blade is not under the plate for more than 50 percent of its travel before the next blade passes under the plate. This gives roughly a 1-to-1 low to high capacitance cycle, delivering through the transducer a substantial sine wave. The electronic frequency meters or tachometers require an on-to-off or vice-versa alternation of input voltage preferably 1 to 1 but not to exceed 4 to 1 for a highly accurate indication.

The spacing of the plate or pickup vane to the element depends upon input cable capacitance, spacing between impeller blades, and transducer sensitivity. Using a two-foot RG8/U cable with the pickup illustrated, spacings up to one-quarter inch have been employed. Spacing may best be determined by test, but in any case close tolerances are unnecessary. Airflow restriction may be limited to a low value by proper design of the pickup. This again hinges upon use of the pickup in different fields.

**Transducer**

The transducer unit changes variation in pickup capacitance into useful audio-frequency voltage suitable for application to the electronic frequency meter or tachometer. It consists of the familiar capacitance relay or radio-frequency oscillator, a detector and a one-tube amplifier, as shown schematically in Fig. 2.

The r-f oscillator is adjusted to oscillate feebly. The pickup is connected so that every time its capacitance increases it shunts the oscillator-feedback circuit more, and thus causes the oscillator to drop its r-f output voltage. The r-f carrier is rectified and the a-c component caused by variations in signal due to changing pickup-plate capacitance is amplified. Output must be over two volts, but not over two hundred, to operate the frequency meters or tachometers in use. As the output voltage is not critical and does not affect the rpm indication, the transducer requires no gain stabilization.

The oscillation frequency of the

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**FIG. 2**—The capacitance transducer. Plate series capacitor is variable
transducer is not critical and for this reason the oscillator coil is not tuned. Where the particular coil specified in the drawings is not available, the oscillator should preferably be set to operate between 500 and 2,000 kilocycles. This, in part, depends upon the capacitance change available in a particular application. Input capacitance as well as the size of the feedback variable capacitor determines optimum frequency.

The setting of the variable capacitor will depend upon three feedback functions: frequency of oscillation, feedback ratio in tank coil, and cable and pickup shunting capacitance. Optimum capacitor setting may best be determined experimentally for each individual application. The capacitor is adjusted to the point where the oscillator is not oscillating strongly. This is accomplished with the aid of the 1.5-ma meter, which indicates rectified r-f current from the detector. The output winding on the tank coil is wound so as to give a 1.0 to 1.5-ma indication on the meter when the oscillator is functioning correctly.

The output impedance of the original transducer was not considered critical, as the output voltage was high and a shielded cable was to be used. However, this developed into a critical point because of the high output frequency. A sixteen-blade impeller, rotating at 30,000 rpm, has an output frequency of 16 times 30,000 divided by 60. This gives an output frequency of 8,000 cycles. Therefore, in the first units it was necessary to use RG7/U cable (14 μf per ft.) to connect the transducer to the frequency meter. The amplifier tube and circuit components were then changed to give lower output impedance.

It would be desirable, in new units, to use a plate-to-500-ohm-line transformer in the transducer and a 500-ohm line to grid transformer at the frequency meter or tachometer. Thus there would be no limitations on cable length between the two units.

The rpm may be read directly on the electronic tachometer diagrammed in Fig. 3. One cycle is produced per revolution at the pickup. Where many-bladed devices are used it is preferable to use an electronic frequency meter. In this case, rpm may be read by using the calculation rpm = freq. x 60 ÷ no. blades. This calculation may be reduced to chart form, but it is preferable to draw a new scale to be used with the instrument, as shown in Fig. 4.

Acknowledgment

The author wishes to thank Bruce Duncan of Douglas Aircraft for his cooperation in the mechanical designs and helpful criticism leading to the successful completion of this device.

FIG. 3—Circuit of Hewlett-Packard frequency meter and tachometer used as a speed indicator for testing cabin superchargers

FIG. 4—Redrawn frequency-meter scale, giving rpm directly
Dielectric Heating of Thin Films

Development of electrode structures for applying high power to dielectric films is described. Limitations imposed by air gap for usually encountered applications are analyzed. It is also shown that average power should be close to instantaneous peak power and several feet long and wide, constitutes the dielectric of a flat-plate capacitor. The dielectric constant of the load material is rarely less than four, and the power factor is generally not very high, perhaps five percent. If the film remains dry and solid during the heating process, so that it may touch the electrodes, the electrodes may be of the conventional parallel-plate type.

An examination of such a load shows: (1) high capacitance, due to close spacing and large area of the plates, (2) short air gap between plates, (3) necessity for flat, rigid, and parallel electrodes (to avoid air spaces which cause cold spots in the load), (4) loss of heat because the electrodes have high thermal capacity, (5) heating the plates by external means helps in eliminating this problem, (6) necessity for a high frequency to obtain rapid heating, because the short plate-to-plate spacing will not permit the use of high voltages, (7) difficulty of obtaining uniformity of field with h-f and long dimensions due to standing waves across the electrodes. Stubbing is helpful in reducing nonuniformity, but does not eliminate the problem. If the load is moving through the electrodes, standing waves in that one direction are unimportant (7) generation of sufficient power at h-f required by a short cycle may be difficult (8) transmission of power to, and establishment of voltage across such a low capacitance at the desired h-f is often impractical (resonating the load by parallel stub inductances is sometimes possible), and (9) circulating currents required are often prohibitively high, because these loads raise allowable minimum generator tank-circuit current.

Air Gap Lowers Load Voltage

The parallel-plate problem is even more severe in loads which may not be touched on one or both surfaces by the electrode plates. There are several reasons for such a restriction. The surfaces may be wet, as

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Although dielectric heating has established itself as an industrial process, its application in some fields has been limited by difficulties in load matching; that is, the design of appropriate electrode structures for the efficient transfer of power to the work to be heated.

One field of application in which load matching has been particularly troublesome is the heating of thin films or sheets of either liquid or solid material. This field embraces a large group of industrial processes, as shown in Table I.

Difficulties of Heating Films

To appreciate the problems presented by loads consisting of thin films, consider Fig. 1A. A typical film, often less than 3-inch thick.

TABLE I—Principal Applications

<table>
<thead>
<tr>
<th>Drying Plastic Coatings</th>
<th>Waterproofing textiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glazing cloth and paper</td>
<td></td>
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<tr>
<td>Drying Liquid Films</td>
<td></td>
</tr>
<tr>
<td>Baking paint and lacquer</td>
<td></td>
</tr>
<tr>
<td>Drying printing inks</td>
<td></td>
</tr>
<tr>
<td>Heating adhesive films (such as bookbinding and adhesive tapes)</td>
<td></td>
</tr>
<tr>
<td>Setting flocked coatings</td>
<td></td>
</tr>
<tr>
<td>Heating Solid Films</td>
<td></td>
</tr>
<tr>
<td>Curing sheets of resin (such as gutta-percha)</td>
<td></td>
</tr>
<tr>
<td>Heat-sealing laminates (such as gloss to paper, paper to wood, paper to paper and cloth to paper)</td>
<td></td>
</tr>
<tr>
<td>Drying Impregnants</td>
<td></td>
</tr>
<tr>
<td>Sizing cloth and yarn</td>
<td></td>
</tr>
<tr>
<td>Setting impregnated paper and cloth</td>
<td></td>
</tr>
</tbody>
</table>

Solvent, used to flow film onto a cellulose backing, is preheated before being removed in an oven. Using the electronic preheater increased productivity of the plant 40 percent.
in the case of adhesives and paints. The surfaces may give off water or other solvent vapors while heating which must escape freely. In the case of curing sheets of natural resins, the material is often too fragile to withstand pressure.

In the above examples, an air gap (Fig. 1B) must be maintained between load and one or both electrodes. This air gap creates further load-matching problems. In both Fig. 1A and 1B the minimum voltage $V_n$ at which ionization will occur in the air space extending from the edge of one electrode plate to the edge of the opposite plate is $V_n = K_s D$ where $D$ is the spacing between plates and $K_s$ is the dielectric strength of air, which is nearly constant for well-rounded plates spaced fairly close together.

The load voltage $V_L$ required to accomplish the desired heating (at any one frequency) is $V_L = (P/\cos \theta C_s/\sin \theta)^{1/2}$ where $P$ is the average power required by heating cycle plus losses, $\omega$ is $2\pi$ frequency of operation, $C_s$ is capacitance represented by the load itself, and $\cos \theta$ is the power factor of the load.

In Fig. 1A, $V_L$ is equal to the plate-to-plate voltage $V_p$ because there is no airgap. In Fig. 1B it is $V_L$ is somewhat higher than $V_p$ due to the series air-gap capacitor $C_h$ of thickness $G$, the same area as $C_h$, but having a dielectric constant of only unity.

Neglecting the effect of the resistive component of the load $R_L$ the plate-to-plate voltage must be at least $V_p = V_L (C_L/C_s)$ where $C_s = C_L/C_h^2 / (C_L + C_h)$, the equivalent capacitance of the load capacitor and air-gap capacitor in series.

Because air has a dielectric constant of unity, and the lowest dielectric constant commonly encountered for film materials is about four, it is apparent that, if $G$ is made equal to $F$ (and it often must be ten or more times as large) the plate-to-plate capacitance $C_s$ is no more than $C_s/5$.

The required plate-to-plate voltage $V_p$ has thus been increased, by the presence of the air gap for $G = F$ to 5 $V_n$, or five times the plate-to-plate voltage required with no air gap. This illustrates the fundamental difficulty introduced by air gaps. In the above example, the minimum breakdown voltage with air gap is only twice the minimum without air-gap, because $F = G$.

Of course, when the dielectric constant of the load is nearly that of air, or when the spacing is very small compared to the film thickness, the effect of an air gap may be small. Figure 1C is a plot of $V_p/V_L$ vs $G/F$ for different values of $K$, the dielectric constant of the load.

The above analysis holds for any load in which the power factor is low enough so that the resistive component of the load may be neglected. The difficulty increases if the power factor is high, because the ratio $V_L/V_h$ becomes even larger.

Some advantage is obtained because the air gap reduces the heat losses to the electrode plates, and thus reduces the required load voltage. This advantage does not, in general, compensate for the rise in $V_p$, except for very small air gaps.

The basic limitation inherent in the parallel-plate method arises from attempting to heat the material through its thin dimension. Most of the difficulties outlined above would disappear if it were possible to cause large r-f currents to flow through one of the long dimensions of the film.

There are two methods of achieving longitudinal currents: (1) by direct connection to the edges of the film, and (2) by stray-field configurations. Figure 1D shows that the aspect ratio of the capacitor formed by the direct-connection method is extremely high, thus causing very low efficiency; electrical and thermal radiation losses and fringing are high, and the apparent power factor of the load is many times lower than the actual power factor of the load material. The only applications in which a high aspect ratio is acceptable are those in which both power factor and dielectric constant of the load material are very high, as in the case of thin films of water-borne adhesives, although even then aspect ratios greater than 100 are to be avoided.

**Stray-Field Heating**

The stray-field method of causing longitudinal currents to flow is generally superior to the parallel-plate method. A number of practical configurations are shown in Fig. 2. The field intensity due to any of these electrodes is nonuniform across the length of the film, which requires that, if the film does not normally move continuously past or through the electrodes, it (or the electrode structure) must be moved...
by a suitable oscillating or continuous conveyor system. However, at least 80 percent of the thin-film loads encountered in h-f heating are incorporated in continuous-production processes which not only require very little mechanical revision for the use of the electrodes of Fig. 2 but also provide the motive power for the film.

Electrodes of the type illustrated have none of the disadvantages outlined previously. Furthermore: (1) the capacitance represented by the electrodes (with the load in place) is relatively small, (2) the air-gap between electrodes is relatively large, and the electrodes themselves are generally cylindrical or of a similar shape which discourages arcing, (3) exact alignment of the electrodes is unnecessary because the relative motion between the film and the electrodes tends to cancel misalignment errors, (4) little or no heat loss occurs because the electrodes may be designed with small mass, and, even when in direct contact with the film, present a very small area of contact, with a consequently small conduction loss, (5) the field intensities required to perform a given job of heating are generally lower than those required by parallel-plate electrodes, (6) by means of relatively simple coupling networks it is possible to feed long sections of these electrodes with h-f power without difficulty due to standing waves, (7) because voltage requirements are not as restrictive, and because arcs are discouraged by this type of electrode, most work can be done below 30 mc, which simplifies the power generation problem, (8) the transmission of power to and the establishment of voltage across these electrodes may be accomplished by ordinary methods, and (9) the circulating currents required by loads of this type are not excessive, and conventional generators will readily handle them.

The disadvantages of maintaining an air gap have not been eliminated by selecting this different method of introducing r-f currents into the load. But selecting this type of electrode permits a wider margin of safety between required plate-to-plate voltage and the minimum breakdown voltage of the structure.

All of the electrodes illustrated in Fig. 2 are practical. Selection of the proper one for a given problem is dictated by such factors as: (1) whether or not the electrodes may touch the load, (2) the type of mechanical structure permitted by the process to which h-f heating is being added, and (3) the power factor, dielectric strength, and mechanical characteristics of the film to be heated.

Because of the shape of the electrodes, they tend to radiate considerably, and must be shielded. Tunnel shields which fit around the electrodes snugly and extend some distance beyond them are quite effective. Radiation losses under shielded conditions are negligible. It is important that all surfaces of the electrode structure, particularly the ends of the electrode bars, be well rounded and polished. It is best to use large diameter rods with half-sphered ends.

Design engineers will find that there is an optimum ratio of spacing of the electrodes to their diameters for any given configuration and load. This ratio is often affected by the number of electrode pairs used in an array. Arrangements which permit the electrodes to acquire a coating of any foreign substance, such as adhesive drippings or bits of plastic film should be avoided. Such particles encourage arcs.

**Filtered Power Supply**

In dielectric heating applications where the power to the load is limited by the arcing voltage dictated by the electrode shape, the maximum average power transmissible to the load may be increased up to 100 percent by filtering the plate supply to the oscillator tubes, if it is not already a pure d-c. That this is so may be seen from Fig. 3.

The author is indebted to John F. Dreyer, Jr., consulting engineer, and Ernst Massey, who devised the arrangement of Fig. 2B, for their cooperation and collaboration in various phases of this development.
New 33-1/3 rpm recording system, cuts up to 300 grooves per inch, achieves low noise with Vinylite and pre-emphasis. Result: a six-record album on a single 12-inch pressing.reasonable domestic consumer price.

Philco has also designed a two-speed turntable with a separate arm for the LP records.

Keys to the success of the new system are the use of Vinylite plastic for the pressings, the development of a new, efficient, light-weight reproducing arm and cartridge and mechanical refinements in the turntable driving mechanism. A pre-emphasis characteristic designed especially for the system, resembling closely the NAB standard transcription curve, was introduced to achieve high signal-to-noise performance. Also, many unconventional techniques have been adopted, including a degree of over-cutting which would not be acceptable in making conventional recordings.

**Design Details**

The grooves are about 0.003 inch in width, roughly one third the size...
for the Home

of the standard record groove. Consequently, it is not possible to record at as high a level, by about 9 db as if the cut were held proportional to the groove width. Actually, the level recorded is about 4 db below the usual reference. The 4-db loss in level would not be acceptable if the record material were of the shellac type, but the low-noise properties of Vinylite together with the lightweight pickup permit a highly acceptable noise level to be achieved while maintaining a dynamic range in the order of 45 db. The consequent smaller excursion of the reproducing needle reduces the cartridge output by 4 db, but an efficient crystal has been developed which provides 0.7-volt output at reference level. Accordingly, no high-gain preamplifier is needed in the reproducing system.

The groove shape has an included angle of about 90 deg, and the tip radius is under 0.0002 inch. Accordingly, it is not possible to reproduce the new pressings with a standard 0.003-inch stylus. The cartridge perfected by Philco engineers, uses a balanced Rochelle-salt crystal and a groove pressure of only 6 grams (one-fifth ounce). It employs a semipermanent metal stylus lapped to a tip of 0.001 inch radius. The light pressure and small radius permits the stylus to follow the fine groove with tracking distortion lower than conventional practice. The stylus may be replaced without replacing the cartridge, if desired. To keep distortion at a low level, the diameter of the innermost groove has a minimum value of 5½ inches, which is almost two inches greater than that of conventional commercial domestic 78-rpm pressings.

The practice of pre-emphasis has been standardized in the new records, using the characteristic shown in Fig. 1. Above 200 cps, the curve is identical with the standard NAB transcription characteristic, reaching 16 db pre-emphasis at 10,000 cps, relative to the 900-cps value. Below 200 cps the characteristic is higher than the NAB, being about 7 db above constant amplitude at 50 cps. The similarity of LP and NAB curves makes it possible to use the LP recordings on standard broadcasting transcription tables with no change in equalizing, although simple RC circuits suffice for equalizing in any event.

Turntable Requirements

The wow problem assumes a serious aspect at 33½ rpm, since the speed ratio (1 in 2.35 relative to 78 rpm) requires that variations in turntable speed be reduced by the same amount. The turntables thus far used are of the rim-driven type. Care has been taken in centering the inner edge of the table, and in balancing the motor. Use of a high-grade rubber rim on the idler wheel is mandatory. Moreover, the edge of the rubber rim must be mechanically ground to assure near perfect circularity. In the Philco turntable, the idler wheel is withdrawn from the motor shaft when the table is not turning, to prevent developing a flat in the rubber. The design of the table is such that no appreciable wow was discernible.

Releases and Results

The early releases of the new records consist of rerecordings from existing masters in the Columbia files. Fortunately, in recent years these masters have been made on lacquer, rather than wax, so they may be dubbed without damage directly to the 33½ master. More than usual care is required, however, to exclude dust and other foreign matter at every stage in the production of master, mother, and pressings, and the difficulty of securing freedom from blemishes for a 25-minute period (one side) is considerably greater than for 4 minutes. Before release, pressings are checked for technical excellence by engineers on the Columbia staff, a revolutionary procedure in the recording business.

The results, as judged by critical listeners, both technical and non-technical, are excellent. In frequency range, dynamic range and distortion, the LP records outdistance shellac pressings and, with the possible exception of noise surpass 78-rpm Vinylite pressings.—D.G.F.
FIG. 1—Windings can be on one core (A) and (B), or on separate cores (C) to (F)

FIG. 2—Simple transductor connection (A) can be analyzed using portion of idealized magnetization curve (B). Voltage-time curves show action during operating cycle with zero

**Transductor**

By SVEN-ERIC HEDSTROEM and LENNART F. BORG

If a low alternating voltage is applied to a coil wound on an iron core the coil acts as an inductance the value of which is determined by the permeability of iron.

If the operating position on the curve is displaced by applying direct current through a separate winding the incremental permeability then acting diminishes as the position approaches saturation. In this way it is possible to vary the inductance between wide limits.

Because comparatively small direct control current is required the losses incurred in regulating large power are small. Thus a large power amplification is obtained.

In practice, efficient operation of a direct-current presaturated reactor necessitates employing wide variations of flux. Under such conditions it is inappropriate to base investigations on incremental permeability. Work carried out by Boyajian, Kramer and Lamm has paved the way for an appreciation of the mode of operation and that indicates the basis for calculation and design. On this basis Lamm and others have investigated different couplings and dynamic properties. Instead of studying variations of permeability, variations of flux are investigated and an idealized magnetizing curve having constant slope and abrupt complete saturation is used.

To obtain an indication of flux variations, consider Eq. 1 where \( \phi \) represents the flux in a coil, \( N \) the number of turns, and \( e \), the induced voltage. From Eq. 1 we can write Eq. 2

\[
e_i = N \frac{d\phi}{dt} \\
\int_{\phi_1}^{\phi_2} e_i dt = \phi_2 - \phi_1
\]

which shows that a variation in the flux corresponds to an area (voltage times time) on the voltage-time oscillogram. Using this principle, properties and operation of the d-c presaturated reactor can be analyzed. In this way the mode of operation is found to be different from what is generally termed a reactor, justifying another name.
Fundamentals

Magnetic amplifiers are analyzed on the basis of voltage oscillograms, which facilitates interpreting laboratory measurements. Results of the analysis show the effect of load impedance on mode of operation and of supply frequency and inductance on speed of response.

These controlled reactors are therefore called transductors.

To avoid the voltage that would be induced in the d-c control winding from the a-c power winding if the two windings were arranged on a single core, a symmetrical arrangement has to be used. Three or four-legged cores could be used. However, the three legged core shown in Fig. 1A has the drawback that its leakage flux impairs the transductor properties. On the other hand the four legged core of Fig. 1B is expensive to manufacture. A simpler arrangement is shown in Fig. 1C in which two separate cores are used. The induced voltages in the d-c windings of the connection shown in Fig. 1D do not counteract each other, but the connection has other advantages and interesting properties. Naturally the windings may be arranged in many ways. Especially, the need for d-c excitation can be minimized if the alternating current is rectified and used to excite the transductor by additional windings as shown in Fig. 1E. This is called a self-excited arrangement. Oscillograms of currents in the a-c and self-excitation windings of Fig. 1E show that the resultant ampere turns every moment are the same as would be obtained by means of only one winding connected in series with a rectifying element. The arrangement thus deduced is shown in Fig. 1F and is called simplified self excitation. By using this connection, winding space is saved in the same way as in an autotransformer. Simplified self-excitation connections can be varied in numerous ways. Single and multiple phase connections are used; the three-phase connections have been treated by Lamm.4,5

Mode of Operation

The mode of operation of the connection shown in Fig. 2A can be explained simply if certain assumptions are made: (1) the magnitude of the control circuit current Ic is

UTILITY OF TRANSDUCTORS

Transductors can be self-excited and made to operate as trigger circuits. Thus they can be employed as relays; their opening and closing values are set by applying counter-biasing amperere turns.

Like the electronic amplifier, the transductor can also be made to oscillate. Low-frequency oscillations can be obtained readily.

Electronic amplifiers possess speed that is difficult to obtain with transductors. On the other hand, transductors provide stable low-frequency a-c and d-c amplification with a minimum of equipment. Where loads inherently have long time constants, as in many regulators, inertia of the transductor is negligible.

Transductors require current, whereas electron tubes require voltage for control. A combination of the two may provide excellent solutions of difficult problems. For instance, the transductor may supply voltage for controlling tubes, or tubes may supply current for controlling transductors effectively despite the induced voltages in control windings.

THE AUTHORS

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constant and independent of time, represented in the diagram by a large series inductance, (2) the magnetizing curve possesses the ideal shape, (3) the resistance of the a-c circuit may be neglected, and (4) the number of turns on the a-c and d-c windings are the same.

The control current \( I_c \) gives element \( A \) the initial flux position \( P \), shown on Fig. 2B and gives element \( B \) a corresponding position on the negative side. Fig. 2C shows the time variations of the characteristic magnitudes. The impressed alternating voltage \( E \sin \alpha \) must be fully balanced in the circuit by variations in the flux in the two transductor elements. However, a change in flux is only possible when the number of ampere turns of one or both elements is zero, which means that an alternating current of the same magnitude but directed against the control current must pass continuously. Owing to the counter connection of the control windings on the two elements, this is not possible unless the alternating current commutates between positive and negative values in zero time, the values being of the same magnitude as the control current. No other current combinations are possible. Thus this transductor has a typical current-transformer characteristic, the linear relations between alternating and direct currents being independent of the magnitude of the alternating voltage. The phase of the a-c is determined by the requirement that the voltage across the transductor element cannot include any d-c component. In reference to Fig. 2C this means that the voltage-time areas \( M \) and \( N \) must be equal, making the control angle \( \alpha \) equal to 90 degrees.

It must further be observed that an alternating voltage at twice the supply frequency appears across the d-c terminals. The reactor \( L \) prevents this voltage from passing a superimposed current that would altogether change the mode of operation of the transductor.

When there is resistance \( R \) as load in the a-c circuit of the transductor, it might be expected that the current-transformer characteristic would be impaired. However, this is not the case, as shown in Fig. 2D. Also in this case the transductor element can only absorb voltage when the alternating and direct currents are of equal magnitude, and, as the resistive voltage drop is assumed to be insufficient to balance the supply voltage, the latter voltage will be split between the resistance and the element (area \( M \)) in the time interval \( \alpha \) to \( \alpha_1 \), as indicated in the figure.

The lowest point \( P \) on the magnetizing curve is reached at \( \alpha \), and a change in the current still cannot take place because, for it to do so, the magnetic state of the element from \( P \), up to the saturation point would have to change by an amount requiring a voltage-time area just as large as that previously required to bring it down from the saturation point to \( P \). Thus commutation will take place first when the area \( M \) becomes equal to \( N \). When \( \alpha \), at an increased resistance drop reaches such a low value that \( RI \) becomes equal to \( E \sin \alpha \), it deviates from the rectangular shape as shown in Fig. 2E and \( R_i \) coincides for a time with the sine wave. The current-transformer characteristics are thereby jeopardized and,
Dry-Cleaning

By JOSEPH ALBIN
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Solvent-spray cleaning is one of the maintenance operations undergone by all aircraft and ground radio equipment that is sent to the American Airlines radio overhaul base at La Guardia Field, New York. Overhaul is scheduled after 90 days (average of 900 hours) of operation even though the equipment is operating perfectly. The types of electronic gear cleaned by the spray method include h-f and vhf communication units, adf receivers and indicators, marker, range, glide path and localizer receivers.

A member of the maintenance crew is shown in Fig. 1 going over the chassis of a ground transmitter in one of the hangars. He uses an improvised spray gun constructed as shown in principle in Fig. 2 and connected to a compressed-air line. Solvent contained in the can feeds to the nozzle of the air gun and is sprayed as a fine mist. Because of the pressure, hard to reach places such as capacitor plates and tube sockets are quickly cleaned.

The chassis is supported on blocks in a tray which serves to catch the dirty solvent. As this operation is done in an open space within the hangar, ventilation does not become a problem. To air-dry the equipment after cleaning, it is only necessary to lift the rubber hose out of the solvent can.

The nozzle for the air gun operates on the Venturi principle and consists of a section of metal tubing through which the solvent is aspirated by the air blast. A connection for a rubber hose for insertion in the liquid solvent is made on the side of the tubing a few inches from...
According to Fig. 5C the relation between the voltage areas is
\[ N = T \quad \text{and} \quad \theta = U = S = M \quad (4) \]
Furthermore, because the reactor voltage cannot contain a direct component
\[ P = Q \quad (5) \]
By comparing the voltage areas between, for instance \( a_\alpha \) and \( a'_\alpha \), the magnitude of the direct voltage \( D \) can be determined
\[ D (a_\alpha' - a_\alpha) = D \tau = \int_{a_\alpha}^{a_\alpha'} E \sin \alpha d \alpha - P + Q \quad (6) \]
but from Eq. 5 and the relation
\[ 1 = \int_{a_\alpha}^{a_\alpha'} E \sin \alpha d \alpha = E_u - E_T \]
where \( E_u \) represents the mean value of the alternating voltage and \( E_T \) the mean value of the transducer voltage, Eq. 6 becomes
\[ D = E_u - E_T \quad (7) \]
Thus the relation is of the first power, and not of the second as might be expected.

**Dynamic Response**

The preceding analysis has shown that the static conditions in a transducer are determined by the control current, which in effect governs the average flux. The average flux is also the deciding factor in determining how the transducer will momentarily follow the control current until the latter attains a new stationary value. However, the manner in which the control current behaves to a voltage impulse in the control circuit depends on the actual amplification and frequency. Different connections behave differently.

The scope of this article prohibits analyzing all connections, so the following discussion will be limited to the circuit of Fig. 1F. It is assumed that a voltage impulse \( \Delta \phi \) is impressed on the control winding, which, under steady-state conditions, would cause an alteration \( \Delta I_s \) in the control current. At the same time the lowest value of flux would be changed from \( \phi_t \) to \( \phi_s \), both values being below saturation. The problem is to find the manner in which the load voltage \( D \) changes with time \( (\Delta D = D_t - D_{t-1}) \).

The average load voltage during a half cycle corresponds to the difference between the supply and the transducer voltages so that
\[ D_t = E - 2 N_s (\phi_t - \phi_s) \quad (8A) \]
\[ D_{t-1} = E - 2 N_s (\phi_t - \phi_s) \quad (8B) \]
f representing the supply frequency, \( N_t \) the number of turns on the a-c winding. Hence
\[ \Delta D = D_t - D_{t-1} = 2 N_s (\phi_t - \phi_s) \quad (8C) \]
but the control current must change the average flux from \( \phi_m \) to \( \phi_m' \) so
\[ \phi_m = (\phi_t + \phi_s)/2 \quad (9A) \]
\[ \phi_m' = (\phi_t - \phi_s)/2 \quad (9B) \]
\[ \phi_m = (\phi_m + \phi_m')/2 \quad (9C) \]
If the fictitious inductance of one control winding is \( L_s \) and the number of control turns is \( N_s \) then
\[ \text{the control current is constant, the time constant can be reduced either by increasing the frequency of the supply voltage} \]
\[ \text{or by selecting a magnetic-core material possessing properties that allows} \ N_t \text{to be reduced. The three properties, power amplification, power sensitivity, and time constant, of a self-excited transducer depend on each other in such a way that one of them can be improved only at the expense of the other two. The rapidity of the transducer is limited by the fact that the control current cannot exert any influence on the transducer during the interval when any of the elements carry the main current; that is, between \( a_\alpha \) and \( \alpha \).

The development of the transducer techniques of which this article is a brief review has been carried forward especially by A. U. Lamm and U. H. Krabbe and by many collaborators. The authors are indebted to ASEA for permission to publish this article.

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is set by means of the control current \( I \), giving an initial position \( P_0 \), which represents the lowest possible value of flux because the alternating current will be prevented by the rectifier from passing through the transducer in such a direction as to force the flux still lower. In relation to the rectifier, the alternating voltage will be negative immediately before the point \( \alpha = 0 \). At that time no current \( i \) can pass, but after the voltage has changed sign at \( \alpha = 0 \) it can pass in the forward direction of the rectifier, producing not only a voltage drop in load \( R \) but also a change in flux in the transducer element.

It is now of great importance to assume that the voltage drop in \( R \) is small as long as \( i < I_1 + i_2 \) and consequently may be neglected. The entire voltage-time area between the zero axis and the sine wave can therefore produce change in the flux as long as the magnetizing curve permits. The knee of the curve is reached at \( \alpha_0 \) and further area beyond that of \( M \) of the same polarity cannot be absorbed by the transducer element. Instead, the entire voltage is transferred to the load, the current through \( R \) momentarily assuming a value at which the voltage balance; \( Ri = E \sin \alpha \) and area \( N \) is swept out. When the voltage changes sign at \( \alpha = \pi \) and the diminishing current passes the knee at the same time, the element can again absorb voltage (area \( O \)). At \( \alpha' \), the current becomes zero and the remaining voltage-time area \( P \) acts across the rectifier until \( \alpha \) becomes equal to \( 2\alpha \), whereafter the cycle is repeated. Because the voltage across the transducer element cannot contain a d-c component the areas \( M \) and \( O \) are equal and consequently areas \( N \) and \( P \) are equal.

**Effect of Magnetizing Curve**

Even if magnetizing curves of modern magnetic materials can be made to approach more nearly that of Fig. 3B, it is of practical value to be able to predict the properties of a transducer whose magnetizing curve departs from the ideal. How this is done, in comparison to the technique described in connection with Fig. 3, is shown in Fig. 4.

At \( \alpha \), the current cannot assume a value that impresses the whole voltage across the load because a change in the flux continues to take place within the saturation range. Thus the voltage is divided between the load and the transducer element (areas \( N \) and \( O \)). At \( \alpha \), however, the voltage across the element becomes zero, which means that the maximum point \( P_0 \) of the flux has been reached and that the current has reached its maximum value. Because the negative area \( P \) depends upon the current from \( P_0 \) falling off, the current will thereafter be maintained at a value exceeding that required by the alternating voltage. The relations between the areas (and as shown in Fig. 4B) are \( M = Q \) and \( N = P \), so that \( O = S \).

Within the range \( \alpha_0 \) to \( \alpha_0 \), the current may be expressed as

\[
i = \left( \frac{E}{R} \right) \cos \phi \sin (\alpha - \phi) - \sin (\alpha_0 - \phi) \exp - \cot \phi (\alpha - \alpha_0) \]

where \( \phi = \tan X/R \), \( X \) being the reactance, which is represented at the prevailing frequency by the slope of the magnetizing curve within the saturation range.

**Multielement Transducers**

The transducer connection just described, containing only one element, operates satisfactorily but in practice units comprising several elements are usually employed. There are two reasons for using at least two units: d-c excitation of the transformer feeding the transducer is avoided, and smoothing of the control current can be omitted because the voltages induced in the elements counteract each other in pairs.

The mode of operation and method of designing transductors comprising several elements can be predicted in the same manner as described above for one element. To show how this is done consider the connection of Fig. 5A, which is a widely used circuit in which the load is taken out as smoothed d-c. The magnetizing curve and oscillogram are also shown in the figure. The rectified current \( I_0 \) is assumed to be smoothed to the extent that it is entirely relieved of pulsations. Within certain intervals the a-c will then be lower than the d-c and can pass through the rectifier without having to flow through the load.

This mode of operation is termed current-peak rectification and is analogous to voltage-peak rectification by means of a rectifying element and a capacitor.

If the resistance of the transducer elements is assumed to be zero, the rectifying elements will never be subjected to reverse voltage. Consequently a change in flux in one of the magnetic elements produces an equal but opposite change in the other one; the rectifiers determining the direction of the current. Figures 5B and 5C show the behavior of the A element. A magnetic displacement in this element produces an equally large but opposite displacement in the other one. After \( \pi \) has become zero the entire alternating voltage is impressed across the A element. A very small excitation current \( i \) passes through the rectifier that is carrying load current without causing any voltage drop. The knee of the magnetizing curve is reached at \( \alpha_0 \) and \( i \) rises more rapidly thereafter but still under the control of the magnetizing curve and the voltage areas \( M, N \) and \( O \). At \( \alpha_0 \) the current \( i_0 \) becomes equal to \( I_1 \) and flows in branches 1A and 2A of the rectifier and to the load. The reactor then prevents any further increase in \( i_1 \), for a certain interval. Because no change in flux in the transducer can take place, the entire alternating voltage appears as a constant voltage \( D \) across the load and a voltage across the reactor corresponding to area \( P \). Even after \( \pi \), when \( E \sin \alpha \) becomes smaller than \( D \), \( i_0 \) retains its value because there is no voltage available that might produce a change in flux tending to lower the current. After \( \pi \) such a voltage becomes available as indicated by area \( S \) and \( \alpha_0 \) decreases. From \( \alpha_0 \), \( D \) is maintained by the reactor voltage (area \( Q \)) which has changed sign due to the tendency of the current to decrease. At \( \alpha' \) current \( i \) regains the value corresponding to the lowest point on the magnetizing curve and the A element becomes inactive for the remaining half of the cycle. Because the connection is symmetrical, current in the B element begins to rise to rise at \( \alpha' \) but does not affect the behavior of the A element.
Transducers, like transformers are basic components that can be applied in numerous ways. One type transductor possesses characteristics of a current transformer. It can be used to measure heavy direct currents or high direct voltages as shown in the accompanying illustration. Measuring transducers can be built from ordinary transformer laminations and have an accuracy sufficient for service supervision (±2 percent). By employing special laminations, higher accuracy can be obtained. In addition to the feature of complete isolation between the main circuit and the metering circuit, the measuring transductor has the advantages that the quantity operating the indicating instrument is a-c and therefore can be transformed to any desired value; measurement of summation and differential quantities can be made simply because the quantity to be measured appears as ampere turns, current is measured directly and not translated into voltage as in using a shunt (particularly important with remote measurements), and the power consumption is exceedingly low.

Voltage and current regulation is the most important application of transducers. For simplicity in drawing diagrams of circuits using transducers, rectifier bridges and the several windings of the transductor elements are shown in abbreviated form.

A metallic rectifier can be controlled by a simple series resistance giving the characteristics shown below, or a series transductor can be used. In the latter case power required for regulation is small and the output current is more perfectly determined by transductor control current. Until limited by voltage, the current is independent of load resistance. Such circuits are extensively used in battery chargers for trucks and other cases where constant current is required. (For clarity the control portion of the circuit is drawn in lighter lines than the power portions.)

In charging batteries where the voltage must be kept constant, as in broadcast stations and telephone exchanges, a slightly more complex circuit is used. A self-excited transductor provides the regulation. This transducer is, in turn, controlled by a smaller unit the output voltage of which is determined by the total number of ampere turns of its excitation windings. A constant current supplied to one control winding in the same direction as the self excitation sets the regulated value. Another control winding fed in opposition to the first carries the sensing current that is proportional to the load voltage. Because two transducers are used, the regulation is high. A rectifier of this type which can operate on both constant current and constant voltage is called an avostat. Avostat-regulated rectifiers can be built for all outputs for which metallic rectifiers can be used.

When very little power is available from a quantity to be measured, the high amplification of self-excited transducers can be used. The accompanying circuit shows a push-pull connection giving an output voltage the polarity and magnitude of which are determined by the control current. Power amplifications as high as a hundred million may be obtained from similar connections. If gain is sacrificed for stability, such transducer circuits are suitable for amplifying currents from photocells and thermocouples—

THE AUTHORS

as shown in Fig. 2F, the relation between the currents follows a straight line only up to a certain point, whereafter it is deflected and asymptotically approaches a limiting value corresponding to the full alternating voltage being balanced by the resistance drop.

**Transductor as Amplifier**

For a transductor (Fig. 2A) with a resistive load in series with the a-c winding, amplification takes place because the a-c winding requires an input corresponding to only half the copper losses, whereas the load may rise to a value corresponding to the entire transformer output of the transductor. The method, described previously, of decreasing the need for d-c ampere turns by rectifying the a-c and feeding it back by means of a separate winding, or by inserting rectifying elements in series with the a-c windings, is analogous to the feedback used in electronic amplifiers whereby amplification is increased at the expense of linearity. The connection providing simplified self excitation (Fig. 1F) has advantages over that of Fig. 1E and is also easier to analyze. Therefore this connection will be treated in detail.

A transductor element and a rectifying element connected in series between two current-dividing points constitutes a common feature of all simplified self-excitation couplings. The connection, the assumed shape of the magnetizing curve and the mode of operation as represented by the oscillogram are shown in Fig. 3. A certain d-c bias
Electronic Equipment

Rapid removal of soot, dirt and grime is accomplished with pressurized air and a solvent. Used at an airline radio overhaul base, the method can be adapted to maintenance of other electronic equipment.

The booth is similar in all respects to the type used in spray painting, and is vented in the upper rear portion. Used solvent flows down a drain into a receptacle located below the booth.

In cleaning the radio unit shown, the air pressure is between 30 and 40 pounds. To dry, the operator turns a valve which shuts off the flow of solvent into the nozzle. In the overhaul shop, each man cleans the particular piece of equipment he is assigned to service.

A few changes are necessary when cleaning parts having more tenacious deposits of dirt, hence requiring higher air pressure, sometimes as high as 110 pounds. An extra long nozzle is used as well as protective gloves for the operator. Higher pressures can be safely applied to motors and heavy equipment.

Dry-cleaning solvents are of comparatively low inflammability and are nonexplosive. They follow in general the specification for Stoddard solvent, a standard fraction of petroleum, having a flash point between 100 and 105 °F. At this temperature sufficient vapor is given off to flash momentarily on the application of a small flame.

In the Airlines laboratory, the chief characteristic checked in solvents is a minimum flash point of 110 °F, determined by the Cleveland open-cup test. This is slightly higher than Stoddard solvent. Clarity and dryness are important factors. These flash points may be compared with that of ordinary gasoline at room temperature.

For regular production schedules, solvent-spray cleaning is best done for general comfort and health in a hood or booth that is vented to the outside atmosphere by means of a blower. Where the booth is lacking, the spraying should be carried out in an open and well-ventilated area. Ordinary fire extinguishers, such as those containing carbon tetrachloride, are precautionary equipment. A settling tank can be used for reclaiming a high percentage of the solvent.

FIG. 3—Solvent spray booth for permanent installation in a factory, shop or laboratory. Fumes are vented to the outside air and additional equipment provided for control of air pressure, filtering and safety.
**SUPERREGENERATIVE**

**By WILLIAM E. BRADLEY**

Director of Research
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September, 1948 — ELECTRONICS

An investigation into the operating mechanism of the superregenerative detector, has used physical reasoning and results of measurements.

The specific object of the investigation was to develop a theory that would identify the factors controlling selectivity, optimum quenching, signal-noise ratio, and account for the difficulty of reproducing a given response from one design to another. Because most superregenerative detectors combine in one tube at least four distinct functions, it is not surprising that the behavior of the circuit is complex.

A superregenerative detector, the elements of which are shown in Fig. 1, ordinarily consists of an oscillator having a resonant circuit tuned to the frequency of the desired signal. This circuit is fed from an r-f stage, converter, or an-

tenna, which can be considered a generator of current i(t). The oscillator is caused to operate intermittently by means of a quenching signal supplied from an auxiliary oscillator or from low-frequency oscillation of the same tube. This quenching action can be represented by a varying conductance g(t). The combination of resonant circuit and varying conductance constitute the active element.

In addition there are the auxiliary elements, an oscillation detector and an audio or video amplifier. An automatic regeneration control feedback from beyond the oscillation detector to the active element may also be included.

The circuit performs four fundamental operations in sequence: (1) Quenching erases the effect of the previous cycle of operation, clearing the circuit for reception of new impressions; this is done by cutting off the oscillating tube or by damping the circuit. The varying conductance is positive during quenching. (2) Reception takes place when the incoming wave sets up a signal in the circuit as the quenching is withdrawn. (3) Amplification begins when the quenching is sufficiently withdrawn (conductance made negative) so that oscillations will grow in the circuit. This action continues until the overloading level is reached or the circuit is again quenched. (4) Detection, usually in the form of a change in oscillator grid or plate current and sometimes using a separate crystal or vacuum diode or a change in quenching rate, produces an output that varies according to the rapidity with which full amplitude of oscillation is reached, and depends on the principle that the stronger the incoming signal the sooner the oscillation will reach full strength, usually several volts.

At the end of this operation the varying conductance may fall to zero and the oscillations cease to grow, but nevertheless the requisite energy is delivered to the detector and amplifier.

Of the four operations, least is generally understood of the reception action. It is not obvious at what instant and in what manner the forced oscillation of the circuit produced by the incoming signal changes to free oscillation of the resonant circuit. To determine this and other circuit actions, an approximate solution of the differential equation of a tuned circuit with varying damping was made.

Another rigorous approach, based on the superposition integral, has verified the results and indicated the trivial nature of the error in the approximate solution.

**Reception and Amplification**

To obtain a detailed picture of the behavior of the active element during reception and amplification of an incoming signal consider that a current i(t) = I exp/ωn.t is continuously applied. At negative time (during the quenching operation) the varying conductance g(t) has a large positive value; it varies in some manner through zero at t = 0 to a generally negative value for positive values of t. The problem is to find the level of oscillation during the amplification operation.

The problem involves the solution of a linear second order differential equation with the coefficient of the first derivative varying with time. This is Eq. 1 (Fig. 1); the primes indicate differentiation with respect to time. The instantaneous voltage on the resonant circuit is e(t); incoming signal is i(t).

The rigorous solution of Eq. 1 is difficult to obtain and use because, to be mathematically complete, it
**Detection Theory**

Operation of the superregenerative detector is developed, leading to the concept of a time aperture function. Bandwidth, signal-noise ratio, and other circuit properties are shown to depend on this function, whose values in turn depend on the quenching waveform.

must include the effect of the resistance on the resonant frequency and all of the phenomena that hold for large values of \( P(t) \), the damping factor, including the transition between oscillating and nonoscillating states. For present purposes such a solution is unnecessary because, in the practical case \( P(t) \leq \omega_c \), and for quench frequencies low compared to the resonant frequency \( P'(t) \leq \omega_c \).

Under these conditions a very similar second order equation (with its right hand member zero), Eq. 2, can be used for comparison. The first two coefficients of Eq. 2 are identical with those of Eq. 1 and the third is negligibly different; hence, over a limited time, the solutions of the two equations cannot be very different in nature. In fact in the practical case of a high-frequency superregenerative detector the third coefficients of the two equations differ by less than the error in measuring \( \omega_c \). For the purpose of this analysis the solution of the comparison equation Eq. 2 differs negligibly from the correct solution of the reduced or homogeneous form of the circuit equation.

Knowing the two functions \( e_i \) and \( e_c \), that satisfy the reduced equation, the complete solution of the equation with right hand member can be found by the method of variation of parameters (Lester R. Ford, "Differential Equations", McGraw-Hill Book Co., New York, 1933, p.75.) The solutions are Eq. 3, 4 and 5.

Equations 3, 4 and 5 embody a complete solution to the problem. The function \( F(t,\tau) \) is called the time aperture function and, as will be shown, is of basic importance in describing superregenerative detection. Equation 3 states that the voltage envelope amplitude across the resonant circuit at a particular instant of observation, \( \tau \), depends on an integral of the product of the time aperture function and the input signal, the integration being performed over the preceding time, \( \tau \), so that each time element of input signal contributes to the output with a relative importance determined by the value of the time aperture function. Usually the time aperture function has one very large peak, at the moment when the damping passes through zero, and falls rapidly to small values on either side of this moment. Therefore the incoming signal at the moment of zero damping has the greatest effect on the output. This behavior gives rise to the sensitive period of the detector.

Equation 4 expresses the output due to a carrier that remains substantially constant in frequency and amplitude during one quench cycle. The integral is of the same form as the Fourier analysis integral that gives the frequency spectrum of a pulse. As a consequence the time aperture function is related to the selectivity curve of the superregenerative detector in the same way that the waveform of the envelope of a pulsed carrier is related to its spectrum. Thus, for example, a narrow time aperture function causes a broad band receiver and a broad function causes a narrow acceptance band.

The time aperture function is given by Eq. 5 provided the variation of damping with time is known; that is, when \( P(t) \) is known. In geometrical terms, if a function of time is drawn having everywhere a slope of \( 0.6 \frac{dP(t)}{dt} \) and intersecting the time axis at time \( t \) of observation of the resonant circuit voltage, the curve for time prior to \( t \) is the natural logarithm of the time aperture function. This process is illustrated in Fig. 2.

Suppose that a sine wave is used for quenching, and that it cuts off the oscillator tube for a large part of the cycle; this sort of operation is usual in some of the older separately quenched superregenerative detectors. Then \( P(t) \), the exponent \( F(t,\tau) \) are shown in Fig. 2B.

By sketching the form of \( F(t,\tau) \) for various values of \( t \) it is discovered that the area under \( F(t,\tau) \) increases rapidly with increasing \( t \), showing that \( E(t) \) is growing rapidly with time during the amplification phase. It is also found that the peak of \( F(t,\tau) \) as a function of \( \tau \) occurs at the instant that
The theory developed in the foregoing analysis can be applied exactly in a few interesting cases. Suppose that a square quenching wave is used such that \( P(t) \) is positive and equal to \( P \), prior to \( t = 0 \) and that it is negative and equal to \( -P \), thereafter. The quench waveform and time aperture function for this case are shown in Fig. 3A and B. The relative amplitudes of the signal in the amplification phase are also shown (Fig. 3C); this later curve is effectively the selectivity curve of the detector.

For a sensitive, narrow-band detector with a square quenching wave, \( -P \), should be made as small as is consistent with the chosen quench frequency. For thorough quenching in a short interval \( P \), must be large.

Another practical case is that of linearly changing \( P(t) \). The commonly used sine wave quenching wave cause \( P(t) \) to change from positive to negative nearly linearly. The bandwidth and time aperture function \( P(t, \tau) \) depend on the rate of change of \( P(t) \). If \( P(t) \) has been changing linearly in a negative direction since \( t = -\infty \) and at \( t = 0 \) passes through zero, the voltage \( E(t) \) at time \( t \) due to an input \( I \cos \omega_{0} t \) can be found as outlined at Fig. 3D through 3F. For this special case both the time aperture and the frequency response have the shape of a probability function.

**Requirements for Optimum Quenching**

The almost proverbial poor signal-noise ratio of superregenerative detectors is mostly due to the short effective duration of the time aperture function. In most cases the time aperture function has an effective duration, measured between points of half-peak sensitivity, much less than a tenth of the total quench period. Statistical theory indicates that the signal-noise ratio should vary directly as the square root of the ratio of the effective duration of the time aperture to the total quench cycle duration.

The narrowest band and greatest sensitivity as well as the best signal-noise ratio appear to be obtainable when \( P(t) \) has a large positive value during the quenching period (first operation), which is made as short as is consistent with thorough quenching, followed by a value of zero during the entire reception period (second function), which is made as long as possible. The amplification (third function) and detection (fourth function) periods should be as short as is practical. To achieve this result, \( P(t) \) should become quite negative so as to amplify quickly the voltage existing at the end of the reception period to a usable level. The required waveform is shown in Fig. 3G.

Certain additional precautions must also be observed in designing superregenerative detectors. The quenching must be complete, otherwise remnants of oscillation persist from the preceding cycle, spoiling the sensitivity of the receiver. Ringing or spurious modes of resonance associated with r-f chokes, quenching circuit coils, or other components can interfere with the quenching, retaining a remnant signal to compete with the new incoming one. Typical symptoms of this difficulty appear when a sharply resonant circuit such as a wave-meter is momentarily held close to the active element. Another effect, usually serious only in low-frequency superregenerative detectors, is shock excitation of the active element by the quenching wave. This action reduces the sensitivity; it is eliminated by restricting the frequency content of the quench.

A simple way of testing for the presence of any of these difficulties is to examine the shape of the selectivity curve with a weak incoming signal. The selectivity curve should be smooth and single peaked. Any of the above difficulties will cause peaks separated by an interval equal to the quench frequency.

Although superregenerative detectors may take a bewildering number of special forms depending upon application, the theory developed above has been found to explain the behavior of all forms investigated during the past five years in this laboratory. In each case the development centered around obtaining the prescribed aperture function. Once this has been accomplished the selectivity and signal-noise ratio measured on the detector agreed substantially with the calculations.
SUPERREGENERATOR DESIGN

Gain and selectivity of superregenerative receivers can be predicted by the principles that are developed. Circuit operation and the effects on operating characteristics of changing various components are explained. Effects of specific quenching waveshapes are discussed.

By ALAN HAZELTINE, D. RICHMAN and B. D. LOUGHLIN

A SUPERREGENERATOR consists of a resonant circuit and an oscillator or regenerator tube, as shown in Fig. 1A. The resonator has a positive damping $G$, consisting of the inherent and coupled losses of the tuned circuit. The resonator is also periodically supplied with an effective negative conductance ($-G$) by regenerator tube, which is switched on and off by a quenching voltage to produce this effect.

Much prewar information on this circuit is vague, particularly that concerning gain and selectivity. Extensive war-time application of superregeneration in IFF equipment required a thorough investigation. Late in 1942, H. A. Wheeler developed the basic concepts that lead to a clarification of the characteristics of this device. A summary of this theory is given and it is shown how it can be used as a guide in designing superregenerative receivers.

The Superregenerator

In the circuit described above, transient oscillations, excited by a signal in the tank (Fig. 1B), build up exponentially during the period of negative conductance. When the

INDEPENDENT INVESTIGATIONS

This and the preceding article present similar material. One might ask why the duplication. There are two reasons:

1. Simultaneous investigations of the superregenerative circuit were made, each deserving recognition through publication.

2. Use of this circuit has been hampered by lack of an adequate explanation of its operation. The subject might still be considered controversial had independent investigators not come to similar conclusions. It is important to progress that there be duplication of effort so the investigators will constantly be checking each other's results.

Now that some agreement has been reached on theory and design factors, numerous applications of the superregenerative method for obtaining stable and extremely high amplification will be found.

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quench voltage turns off the regenerative tube, a period of positive conductance results during which the oscillations are quenched. In most applications it is desirable for the transient oscillations of one quench cycle to almost completely die out so that the transient of the next quench cycle is started mainly by the applied signal.

In the linear mode of operation (Fig. 1C) the regenerative tube is turned off and oscillations are quenched before they reach saturation. The oscillations at the end of the negative conductance period, which are generally fed to a peak detector, are linearly related to the applied signal amplitude.

In the logarithmic mode of operation (Fig. 1D) the regenerative tube stays on until the oscillations reach saturation. The duration of saturation varies with the amplitude of the applied signal, giving, for separately quenched operation, a saturation pulse width that is approximately a logarithmic function of signal amplitude. For self-quenched operation a quench rate that is approximately a logarithmic function of signal amplitude results. Detection of a-m in the logarithmic mode may be obtained by using a separate averaging detector or by using the variations in the regenerative tube electrode currents. The transient oscillation energy of a logarithmic-mode superregenerative has also been used to feed an f-m detector. For studies of gain and selectivity it is convenient to ignore the detection action, and to consider the superregenerative as merely a carrier-frequency amplifier.

Calculating Gain

Action of the superregenerative as an amplifier can be described by considering the tank with its inherent and coupled positive conductance as being shunted by a periodically varying negative conductance, representing the regenerative tube. A general shape of conductance-time variation is shown for the two operating modes in Fig. 1C and D.

For calculating gain and selectivity, it is convenient to consider that a cycle of quench operation starts at \( T_s \) when the oscillations of the previous cycle are being damped out and the input current \( I \) begins to establish a normal signal in the tank, and that the cycle ends at \( T_s \) when the oscillations have again built up to maximum amplitude.

The superregenerative transient oscillation resulting from a short r-f pulse at \( t = 0 \) (when \( g = 0 \)) has an amplitude at time \( T_s \) of

\[
E_s = E_0 \exp \left( -\frac{1}{2C} \int_0^{T_s} g(t) dt \right)
\]

where \( E_0 \) is the amplitude at \( t = 0 \) and \( E_s \) is the amplitude at \( T_s \). It is convenient to express the ratio of the superregenerative transient amplitude to the applied signal amplitude as a gain \( A \) in nepers (one neper equals approximately 8.7 db) so that

\[
A = \ln \frac{E_s}{E_0} = -\frac{1}{2C} \int_0^{T_s} g(t) dt
\]

Thus, 1/2C times the area under the negative conductance-time curve between \( t = 0 \) and \( t = T_s \) represents the gain in nepers to a short r-f pulse applied at \( t = 0 \) and measured at \( t = T_s \).

For the linear mode the total superregenerative gain is given by integrating the total negative conductance area. For the logarithmic mode the effective superregenerative gain is obtained by integrating the negative conductance area up to the time of saturation. This is illustrated in Fig. 1D where \( T_s \) is the period of the constant amplitude (saturation) oscillations of the logarithmic mode of operation.

The superregenerative gain just described is not the total gain for a continuous carrier at the frequency of the resonator. Some further gain results because the r-f signal is present during the entire quench cycle. This produces a regenerative gain \( R \) which is generally considerably less than the superregenerative gain.

Sensitivity Limitations

The manner of decay of the oscillations during positive conductance is similar to the transient build-up during negative conductance, and the same equations hold for the transient amplitude in the positive conductance area. With repetitive quench, as shown in Fig. 1E, the net transient amplitude at \( T_s \) due to the energy remaining in the tank from the previous transient of oscillation initiated in the tank at \( T_s \) is given approximately by 1/2C times the net area under the conductance-time curve between \( T_s \) and \( T_s \).

Thus, for the transient hangover to be less than the applied signal, the net area over a complete quench cycle must be positive. This excess damping, shown as \( A \) in Fig. 1E, should be at least 3 to 5 nepers for most applications.

Sensitivity of a superregenerative receiver is determined by the minimum usable signal level. For the logarithmic mode, sufficient superregenerative gain is obtained to amplify thermal noise to saturate the regenerative tube. In this case the sensitivity is limited by the signal-noise ratio or by the signal level necessary to overcome hangover.

In a linear mode superregenerator, sensitivity may be limited by insufficient gain, as well as by signal-noise ratio or hangover. This is particularly true in applications using a very high quench rate, low-transconductance regenerator.
tubes, or high-capacitance resonators.

If a short r-f pulse is applied to a superregenerator, highest gain is realized if the pulse is applied when the conductance passes through zero going from positive to negative. If applied later, there is less remaining negative conductance area and thus less gain. If applied earlier, the oscillations decay again, giving less gain. Thus, the superregenerator can be considered to have a sensitivity which varies during the quench cycle, having a maximum at the time when \( g = 0 \) and is going from plus to minus.

Variation of sensitivity in nepers with time can be found directly from the conductance-time function, and from this a linear sensitivity-time pulse can be calculated, as in Fig. 2. The magnitude of the superregenerative selectivity curve has the same shape as the frequency spectrum of this sensitivity-time pulse. The corresponding frequency spectrum can be found by Fourier analysis or by Campbell and Foster's tables. The four steps, ignoring effects of hangover and assuming high gain, in finding the bandwidth of a superregenerator with a known variation of conductance with time, are shown in Fig. 2; at the bottom of the figure the response in the presence of hangover is shown.

**Design Data**

To illustrate how these steps might be applied, consider the design of a superregenerator that is quenched as in Fig. 1A. From an assumed quench waveshape and a knowledge of the variation in transconductance with grid bias (as obtained from published tube data), the variation of transconductance with time can be found. By applying the equations of Fig. 1B, the variation of \( G \) can be found. This is subtracted from an assumed (or known) value of \( G \) for the resonator, giving the net conductance-time function needed for applying the steps of Fig. 2. The sensitivity function \( l(t) \) in nepers can be obtained by integrating (graphically, if necessary) the conductance-time function and multiplying by \( 1/2C \). The linear sensitivity-time pulse \( s(t) \) is obtained by \( \exp l(t) \), where \( l(t) \) is conveniently taken to be zero at \( t = 0 \). The superregenerative selectivity shape is found from the frequency spectrum of \( s(t) \). If \( s(t) \) is not found in Fourier transform tables, an approximate answer may be obtained by graphical Fourier analysis.

If it is desired to calculate the selectivity of an existing superregenerator, it may be convenient to find the plate-current waveform of the regenerator tube (by inserting a small resistor in the plate circuit and observing the quench-frequency voltage waveform across it on an oscilloscope). Then the selectivity can be calculated as before.

**Equations for Gain and Selectivity**

The variation in superregenerative sensitivity with time due to the effect of the current supplied to the resonator varies with time. This is exactly equivalent to a variation in input current amplitude with time. It can be shown that the magnitude of the superregenerative selectivity response characteristic is equivalent to that of an unvaried and undamped resonator to which an a-m signal is applied. The spectrum of that a-m signal is continuous because each cycle of quench is independent of the others, if hangover is negligible. The selectivity characteristic of the superregenerator is exactly equivalent to the frequency spectrum of the amplitude modulated signal, or of the sensitivity pulse.

The sensitivity pulse is defined as

\[
s(t) = \exp \left( -\frac{1}{2C} \int_0^t gdt \right)
\]

(3)

where this relation holds for \( T_q \leq t \leq T \), and \( g(t) = 0 \) outside of these limits.

The gain of the superregenerator, \( H \), is defined as the ratio of the voltage existing at the peak of a superregenerative cycle to the voltage which would be developed across the tank at resonance if the conductance had remained at the value \( G \). That is

\[
H = \frac{E_s}{f G}
\]

(4)

It can then be shown (for example, by conservation of energy or by superposition of the effects of a series of impulses) that

\[
H = \exp (\frac{A}{2C} G) \int_0^\infty \exp \left( -\frac{1}{2C} \int_0^t gdt + j\omega t \right) dt
\]

(5)

If hangover is ignored and the superregenerative gain is large, Eq. 5 reduces to

\[
H = \exp (\frac{A}{2C} G) \int_0^\infty s(t) \exp (j\omega t) dt
\]

(6)

Equation 6, which ignores end effects, indicates that the selectivity of a superregenerator can be found from the inverse Fourier transform of the sensitivity-time pulse. The factor, \( \exp A \), in Eq. 6 is the superregenerative transient gain where

\[
A = -\frac{1}{2C} \int_0^\infty gdt
\]

(7)

The remaining factor, evaluated at resonance, defines the added gain.
that is obtained by regeneration. The regenerative gain ratio is

\[ R = \frac{G v}{2C} \int^{+\infty}_{-\infty} s(t) dt \tag{8} \]

As before, these steps have ignored effects of hangover and assume that the superregenerative gain is large.

Effects of hangover can be computed from the net attenuation, \( A_n \) and phase shift per cycle, \( (-\Delta A - j\alpha T_0) \). The resulting selectivity is

\[ S = F(\omega) \left[ 1 - \exp(-\Delta A - j\alpha T_0) \right] \tag{9} \]

where \( F(\omega) \) is the selectivity ignoring hangover. The curve at the bottom of Fig. 2, showing hangover, is plotted to a linear scale; the peaks are very nearly separated by \( F_0 = 1/T_0 \) and the troughs are halfway between.

Effects of Special Waveshapes

Figure 3 gives examples of three conductance-time curves with their corresponding selectivities as calculated by the foregoing method, as well as the equations for superregenerative gain \( A \), regenerative gain \( R \) and selectivity \( F(\omega) \), ignoring hangover and end effects.

In the case of symmetrical squarewave quench (Fig. 3A), a selectivity equal to that of two cascaded, isolated single-tuned circuits (one having conductance \( G_a \), the other \( G_b \)) is obtained. When \( |G_a| = G_b \), the equivalent phase characteristic of the selectivity has no phase distortion. This distortionless phase characteristic is produced by all conductance-time functions which have skew symmetry about \( g = 0 \) (Fig. 3A and 3B). When gain \( A \) is large, departure from exact skew symmetry in regions remote from \( g = 0 \) can be neglected.

The triangular conductance waveform of Fig. 3B produces a selectivity having the form of a probability curve. (A probability curve plotted to a db scale forms a parabola.)

The conductance waveform of Fig. 3C is similar to that found in the usual self-quenched superregenerator, particularly those using grid quench and having the grid leak returned to a positive bias. This waveform produces a selectivity following a probability curve, but considerably wider than that of Fig. 3B.

The reason for this is that, for the same quench frequency and gain, the shape of Fig. 3C has a greater rate of change of conductance with time, giving a narrower sensitivity-time pulse and thus a wider frequency spectrum.

When a converting superregenerator is used, such as the Fre-Modyne circuit, an unusual result is obtained. The conversion efficiency varies during the quench cycle so that the r-f sensitivity-time pulse is the product of the i-f sensitivity-time pulse and the conversion efficiency pulse. This generally results in an r-f sensitivity-time pulse that is slightly narrower than the i-f pulse, and thus gives a slightly wider r-f bandwidth than i-f bandwidth.

In the foregoing discussion it has been assumed that the resonant frequency of the superregenerative tank circuit does not vary during the quench cycle. This gives symmetrical selectivity curves. If the superregenerative tank frequency varies appreciably during the period when the sensitivity-time pulse has significant amplitude, then a result much like a combination of simultaneous a-m and i-m is obtained, which can produce unsymmetrical selectivity curves.

Practical Considerations

It can be shown that the shape of the selectivity curve near the nose of the curve is determined primarily by the shape of the conductance-time curve near the time when \( g = 0 \). If the conductance waveform is approximately a straight line in the vicinity of \( g = 0 \), then the selectivity curve is a probability curve to approximately as many db of attenuation as are represented by the superregenerative gain obtained during the linearly sloping part of the conductance wave form. This leads to the useful approximation that the total bandwidth at one neper (8.7 db) from the peak is

\[ f_w = (1/\pi) \left[ |g(0)| (dG/dt) \right] \tag{10} \]

where \( dG/ dt \) is the slope of the conductance-time curve at \( g = 0 \).

In a separately quenched superregenerator, Eq. 10 shows that, in general, if the quench voltage amplitude is increased, the selectivity curve will become wider. Also, if the quench voltage frequency is reduced, keeping the same waveform, that the selectivity curve will become narrower. However, if the quench amplitude is increased, or the frequency decreases, the available superregenerative gain will be increased, producing more total gain for a linear mode operation or producing an earlier saturation in logarithmic mode. Thus for a given quench waveshape, and for a specified superregenerative gain, the narrowest selectivity is obtained by using the lowest possible quench frequency. However the minimum quench frequency should be at least equal to twice the maximum modulation frequency of the received signal.

The question frequently arises of how to measure the selectivity of an existing superregenerator. Conventional methods may be applied in certain cases, but are generally inadequate. With certain types of superregenerators the problem is like measuring the selectivity of a conventional receiver having a very flat avc that cannot be disconnected. The following method is suggested as being applicable to substantially all forms of superregenerators normally used.

The audio output noise of the receiver, without an applied signal, is measured by an output meter (rms type preferred). A signal is applied at resonance and adjusted in level until the noise is suppressed by some convenient amount such as 10 or 20 db. Then the signal is detuned and readjusted in level until the noise is suppressed by the same amount. The difference between the two levels is the attenuation or selectivity at the detuned frequency. By this method of constant noise suppression, the complete selectivity curve may be measured (assuming an adequate signal generator) to as much as 80 to 100 db of attenuation.

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Circular Polarization in F-M Broadcasting

Experimental field intensity measurements substantiate theoretical advantages to be gained over plane polarization. The high-gain omnidirectional broadcast transmitting antenna described allows most convenient location of home receivers.

More than two years ago the United Broadcasting Company initiated an experimental program to investigate the use of circular polarization for f-m.

The early experimental work was carried on with a prototype circular-polarization antenna consisting of a vertical half-wave dipole and a horizontal loop, mounted on the same vertical axis. A report covering this work was furnished to the Federal Communications Commission in October 1946. Within 30 days the Commission had amended the Standards of Good Engineering Practice to permit the addition of a vertical component having the same magnitude as the horizontal component and thus making it possible to supply the service area with a diversely polarized signal from a circularly polarized f-m broadcasting antenna by radiating twice the power of either component operating alone.

During the past year field measurements have been made on W8XUB and WHKX in Cleveland to determine quantitatively the im-
improvement of circular polarization over plane polarization, and a research program has been carried on by the Ohio State University Research Foundation in Columbus to develop a high-gain circularly polarized broadcasting antenna.

**Theoretical Advantages**

One of the principal advantages of circular polarization over plane polarization is that space is more completely filled with a diversely polarized signal. Figure 1 shows that in a plane-polarized field a simple receiving antenna can be placed in only one position for maximum signal pickup and in a whole plane of positions for zero signal pickup, while in a circularly polarized field a simple receiving antenna can be placed in a whole plane of positions for maximum signal pickup and in only one position for zero signal pickup.

It should be emphasized that although the radiated power can be doubled in going from plane to circular polarization the more important consideration is that the polarization changes from a single line or linear dimension to a surface or two-dimension phenomenon. The radiated power from many F-m stations using plane or horizontal polarization is limited to an equivalent 20-kw, 500-foot antenna in accordance with FCC allocation standards. All of these stations have the privilege of improving their service to the public by employing circular polarization and radiating up to an equivalent 40-kw, 500 foot antenna.

If reception patterns are investigated on a theoretical statistical basis by placing a half-wave receiving antenna at random the curves of Fig. 2 result. For a circularly polarized field with receiving antennas placed at random in space the median value is 82 percent. In a plane-polarized field with receiving antennas placed at random in the plane of polarization the median value is 63 percent. If the receiving antennas are placed at random in space when the field is plane polarized the median value is 48.7 percent.

If ratios between the curves of Fig. 2 are expressed in decibels of improvement, the two theoretical curves of Fig. 3 result. The median improvement of circular polarization over plane polarization for antennas placed at random in space is 4.6 decibels, while the improvement of circular polarization over plane polarization when the receiving antennas are placed in the plane of polarization is 2.3 decibels. It should be observed that the improvement to 50 percent of the sets will be much more than this value, as indicated by the sharp upward
curvature toward the right end of these curves.

Field Measurements

To determine quantitatively the improvement of circular polarization over plane polarization as it affects the average home receiver it was assumed that the f-m receiving antenna built into the home receiver must be served. Therefore, 372 carefully controlled field-intensity measurements were made in 36 typical homes throughout the service area of W8XUB.

Measurements in the home were made with a half-wave dipole placed six inches in front and with the center of the dipole level with the top of the home receiver. In other words, an effort was made to reflect into the results the effect of the position of the home receiver as selected by the housewife.

With the test half-wave dipole horizontal, the transmitting antenna was caused to radiate, first horizontal polarization and then circular polarization of equal maximum field intensities. The ratio of these measurements made in 36 homes shows in Fig. 4 that the median improvement is 3.71 decibels. The theoretical curve was also drawn in this figure for comparison purposes. It will be noted that the field measurements data is in fair agreement with the theoretical curve. It is believed that cancellations and reinforcements due to reflections from metallic plumbing and wiring in and around the home cause the measured points to fall below the theoretical curve toward the left end and rise above the theoretical curve toward the right end.

If the receiving antenna is placed at random in space it should be possible to check the theoretical curve of Fig. 3. To accomplish this, measurements of circular polarization transmission with vertical receiving antennas were compared to both vertical and horizontal-polarized transmission with the same vertical receiving antennas. Then a similar set of ratio measurements were made with horizontal receiving antennas. Figure 5 presents 72 such ratio measurements with a median improvement of 4.87 decibels. This is in good agreement with the theoretical median improvement of 4.6 decibels. Again cancellations and reinforcements are believed to be the reason for the statistical data to fall below the theoretical curve at the left and rise above the theoretical curve at the right.

Another case of interest is the improvement that can be expected when the receiving antennas are vertical. A practical application is whip antennas on automobiles and power-cord antennas such as are commonly used on table-model receivers. The 21 statistical measurements for this condition are presented in Fig. 6, which shows a median improvement of 9.25 decibels. The improvement for three points was too great to plot; however, their effect is reflected by shifting the other points to the left.

Summarizing the results indicated by the above field measurements, it is more profitable for a broadcaster to divide the available power between the horizontal and vertical components and employ circular polarization even for serving only horizontal receiving antennas placed in the home. However, such division of total power is not necessary under the Standards of Good Engineering Practice for f-m broadcast stations. Under these standards the broadcaster can expect to more than double the power (3.71 db) in horizontal receiving antennas and increase the power more than eight times (9.25 db) in vertical receiving antennas within the service area.

Antenna Development

The program at the Ohio State Research Foundation embodied basic research on two methods of producing circular polarization. The first employed excitation of a single element geometrically shaped, such as spiral slots or helical antennas, to produce the desired polarization. The second group consisted of horizontal and vertical radiating elements, each fed with the proper proportion of energy to produce equal-magnitude fields and with the proper time-phase difference to produce circular polarization.

In developing the antenna the

FIG. 5—Improvement of circular over plane polarization with randomly placed receiving antennas

FIG. 6—Improvement of circular polarization over horizontal with vertical receiving antennas
problem was attacked theoretically and experimentally by means of model technique. The theoretical work was devoted to slots in cylinders since it appeared early in the development that this type of antenna would probably be used as the radiating element to produce the horizontal polarized component of the circularly polarized antenna.

To produce circular polarization in the horizontal plane it should be remembered that both the horizontal and vertical radiating elements must have a uniform pattern in magnitude and phase. It has been shown that two diametrically opposed axial or longitudinal slots in a cylinder will satisfy the requirement for the horizontal component, as the magnitude was essentially uniform and the phase shift was less than three degrees through the 1-m broadcast band for cylinders whose diameters were 16 inches. By making the cylinder a half-wavelength long and feeding the slots at the center, the desired horizontal component can be produced. The vertical component can be obtained by feeding the half-wavelength cylinders as full-wavelength vertical dipoles. The 90-degree time-phase requirement was satisfied by using a phase control as shown in Fig. 7, which also shows the basic elements and how they were developed and combined to produce the circularly polarized experimental antenna as used by station WHKX, and illustrated on the cover of

**FIG. 7**—Development of the circular-polarized antenna from dipoles and a slot array

ELECTRONICS for April 1948.

Experimental data on the slots showed them to have vertical patterns which were similar to the vertical fat dipole and indicated that the units or full-wavelengths 'says' could be stacked suitably for high gain. Vertical patterns at 100 mc for both elements are shown for half-wave cylinders 16 inches in diameter, in Fig. 8. The horizontal-plane patterns for the two elements are quite uniform, as shown in Fig. 9. With this basic information a model for a circularly polarized antenna was constructed and tested. Pattern tests proved the antenna to be circularly polarized in the horizontal plane and that the units could be stacked for high

**FIG. 8**—Vertical field patterns for both vertical and horizontal-polarized elements at 100 mc, using 16-in. diameter cylinder

**FIG. 9**—Vertical and horizontal-polarization components of horizontal-plane pattern at 100 mc
The full-scale model employs a balanced four-wire line. The copper-clad steel conductors are stretched from the top to the bottom of the supporting mast and on the inside of it. One pair of conductors is used to feed the vertical radiating elements and the other pair the horizontal radiating elements. The correct phase relationship for the two slots in each cylinder is obtained by properly crossing the connectors from the transmission lines to the slots as shown in Fig. 10. Since the feed points from one cylinder to the next cylinder are a half wavelength apart, altering the crossed connectors keeps the units in phase so they can be stacked. The feed points for the dipoles are one wavelength apart and can thus be fed in phase to produce a simple collinear array of stacked elements.

Each section of the galvanized-iron cylinder shell is fastened to a standard 10-inch steel mast with metal castings to support the shell to the mast. This is possible because the support point is at zero potential, being an odd quarter-wavelength away from the vertical-polarization feed points and equidistant between the horizontal feed points. This keeps the entire antenna free of insulators. A quarter-wavelength skirt is placed at the bottom of the antenna to minimize currents on the supporting structure. Bazookas are used to transform from balanced to unbalanced transmission lines as shown in Fig. 7.

With independent phase and power control it is easy to adjust for true circular polarization. The condition of polarization is determined at WHKX by a half-wave sampling dipole mounted level with the center of the circular-polarization antenna on a wooden pole at a distance of about 100 feet. This dipole can be rotated by a rope control to any position in a plane at right angles to the direction of propagation. The r-f meter at the center of the dipole can be observed by using a telescope mounted in the transmitter building.

The gain of the antenna is a function of the number of units or bays and may be determined by the conventional method used in computing the gain of collinear arrays.

**Commercial Antennas**

For commercial antennas it may be more desirable to use a concentric transmission line harness-type of feed throughout. By first resonating and then controlling the resistance magnitude at the various antenna-element feed points the standing waves on the feeder lines can be reduced to a minimum. The commercial broadcast antennas can be fabricated in this fashion. All openings in the cylinders will be covered with plastic to minimize effects from weather conditions. It will then be practical to bulk heat the antenna structure if icing is expected to be severe enough to require it. A ladder can be mounted on the cylinders without affecting the radiation pattern, thus making it easy to service the flasher beacon at the top of the antenna.

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**REFERENCES**

Stable oscillations from 0.3 to 252 cps are obtained in three ranges. The ganged variable-resistance tuning elements give small stepped increments of frequency. Lamps are used for nonlinear negative feedback.

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OSCILLATORS in the frequency region below 20 cps have numerous laboratory uses, particularly in the study of vibration problems and in the design and testing of amplifiers which use a large amount of negative feedback.

The two major obstacles to be overcome in designing a satisfactory low-frequency oscillator are the large sizes of the components and the time required for transients to disappear. Because of the low impedance and low Q of inductors in this region, the frequency-controlling elements are almost always resistances and capacitances; and with the comparatively low resistances of wire-wound resistors and potentiometers it is difficult to hold capacitors to a reasonable size. In oscillators with only vacuum tube nonlinearity controlling the amplitude, circuit changes in adjusting the frequency and selecting the range of frequencies cause transients lasting as long as 15 cycles, which is 30 seconds at 0.5 cps, making additional amplitude stabilization desirable.

Beat-frequency oscillators, with the fixed frequency at 1,000 cps, have operated satisfactorily in the low-frequency regions. Time, however, is required to be certain that the zero-beat error is negligible; and a good quality filter is required to eliminate the unwanted modulation components from the desired signal.

The circuit diagram shown in Fig. 1 is fundamentally that of a resistance-capacitance oscillator with nonlinear feedback for stabilizing the amplitude. The frequency-controlling network is of the series R-C, parallel R-C type, and was chosen because only two variable elements are required. Resistance changes are used to control the frequency over a range of 10 to 1, and the decades are selected by varying the associated capacitance. Resistors R₁ and R₂ are the variable parameters, and C₁ through C₄ are the fixed. They give an overall range from 0.32 cps to 252 cps. Negative feedback is controlled by R₅, R₆, and R₇, with R₄ and R₅, the nonlinear resistors. Tube V₁ is a voltage amplifier, and V₂ drives the frequency-controlling and negative-feedback networks.
FIG. 1—Circuit diagram of the low-frequency oscillator. The stepped variable frequency control detail indicated

Oscillator

Cathode-follower \( V_a \) isolates the output. The power supply is conventional.

In the circuit of Fig. 1, \( f = \frac{1}{2\pi RC} \), where \( f \) is the frequency of oscillation; \( R \) is the resistance of \( R \), or \( R_a \), assuming them equal; and \( C \) is the capacitance of the associated capacitors, assuming they also are equal. Resistors \( R \) and \( R_a \) are controlled by a two-section, eleven-point frequency selector switch. At each range setting, if a factor of 10 in frequency is desired for a complete sweep of the frequency switch, along with a proportional increase in frequency with each step of the switch, then the ratio of increase is \( 10^{1/10} \), or approximately 1.23 per step. This relation, in turn, means a division of the previous value of \( R \), or \( R_a \) by 1.23 for each increasing step of the frequency switch. One megohm was a convenient value for the maximum of \( R \), and \( R_a \). Using this, the incremental resistances were computed, and the nearest SMA-value resistor was selected. One half-watt resistor was used for each incremental resistance; these mount conveniently on the frequency switch, and result in a neat and compact control. The switch and resistor combination gives a stable, variable resistor with high resistance, so that only a 0.5 \( \mu \)f capacitance is required for the 0.3 cps to 2.5 cps range. The schematic diagram of \( R \) and \( R_a \) is shown at the bottom of Fig. 1.

Capacitors \( C_1 \) and \( C_2 \) and \( C_3 \) were selected and trimmed to fit the decade relationship with \( C \) and \( C_a \), respectively. The capacitors \( C_1 \) and \( C_3 \) were chosen within 5 percent of each other.

Thermal Elements

The choice of the thermal characteristics of the nonlinear resistors in the feedback circuit is a compromise between two requirements. It is desirable that the thermal time constant be as short as possible, so that transients caused by changing the frequency or the range will be as short as possible. Yet there should be no appreciable change in resistance during a cycle of oscillation at the lowest frequency, or waveform distortion will result. Two 115-volt 6-watt candelabra-base lamps connected in series were found experimentally to give acceptable waveform at 0.5 cps, damp transients quickly, and have satisfactory electrical characteristics.

The chief limitation of the oscillator is that the frequency cannot be varied continuously. In most work encountered, the steps have been adequately close. Additional increments, however, can be obtained by using a selector switch with more steps, using ranges of 3 and 30 in addition to 1, 10, and 100, or by connecting auxiliary decade capacitors across the frequency-controlling capacitors.

As noted previously, the lower frequency limit of oscillation is determined by the thermal elements in the feedback circuit. The upper limit, with \( R \), and \( R_a \), is reached when the tube, switch, and wiring capacitances become appreciable compared with those of the oscillating circuit. A convenient limit for the present oscillator is 252 cps.

Accuracy

The finished oscillator has been calibrated carefully, and the range capacitors adjusted so that the error in frequency is less than 2 percent of any given setting. The use of tubular paper capacitors and composition resistors in the frequency-controlling network, however, means that errors as great as 4 to 6 percent can be expected. This error can be reduced by the use of more stable elements; or a spot calibration can be made whenever a critical situation is encountered.

The low-frequency oscillator has given good service for several months, and seems to be a generally satisfactory instrument. Through the techniques of a switch-controlled variable high resistance and nonlinear negative feedback, a simple, stable, easy-to-use oscillator has been built in a frequency region once noted for its difficulties.

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Digital Computer Switching Circuits

Basic operational requirements of digital computers and fundamentals of the means for obtaining them are set forth. For the most part familiar switching circuits can be used but they must meet the special requirements of positive action that are described here.

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Automatically sequenced digital computers are machines that have no intelligence, yet carry out, without intervention, lengthy routines of mathematical calculation. An understanding of general design considerations requires a survey of the procedures followed by a human computer using desk calculator.

A human computer does more than arithmetic; he not only carries out the elementary processes of addition, subtraction, multiplication, and division, but also decides what numbers to add, multiply, etc., and what to do with his results. These results of his arithmetic are only stepping stones to his final goal, just as the numbers upon which he performs his arithmetic were previous stepping stones. Some problems require millions of arithmetic operations to arrive at a relatively small set of numbers representing the final answer.

If we reduce the human computer to an automaton having only the ability to read, write, and do arithmetic, we need to give him a very detailed set of working instructions. These instructions include original numerical data from which he works, and an explicit program of operations to be performed. He must be told, for example, to read numbers in two specified places, add them, and write the result in a specified place. He must then be told where to find his next instruction, unless all instructions are serially listed and no variations in their order are to be made. Explicit instructions as to where to write partial results and when and where to refer back to them for further use comprise a sort of automatic memory. The sheets of paper, numbered for identification, form a storage for numbers; his whole program is stored on paper before he starts to work.

Even the power of decision can be mechanized. If a human computer is supposed to compute one intermediate result to a specified degree of accuracy by a method of successive approximations, he must continue until further steps make insignificant changes. He is therefore instructed to keep repeating the procedure until a tentative answer, taken to ten places, equals the previous tentative answer, and then to proceed with the main program.

We see that our automaton must be given instructions, or orders, incorporating the following information: (1) where to find operands; that is, the two numbers to be combined by addition, multiplication, subtraction, or division, (2) which arithmetic operation to perform, (3) where to write the result, either in a specified place for further reference or on his final answer sheet, and (4) where to find his next set of similar instructions.

An electronic computer operates on a similar routine. Machines being designed and built will perform this cycle of operations in a millisecond or less, working with numbers having ten decimal places. Such speed means that these machines will make it practical to solve problems requiring so many millions of arithmetic operations as not to be considered at present. Directing such a machine is a major administrative problem. As Dr. von Neumann of the Institute for Advanced Study expressed it, "Programming a problem for such a machine is equivalent to writing a detailed set of instructions for twenty automatons with desk calculators sufficient to keep them busy for two years, working a forty-hour week." These automatons have no ability to think for themselves!

Leaving the mathematical and administrative problems to others, we can proceed to the basic electronic problems. We must first have (A) an electronic alphabet for writing numbers and orders, (B) a medium on which to write, (C) means of writing and reading, and (D) means for interpreting the written word. These words may be numerical, as 3721499825, or coded orders, as A0173Q758. When a number-word (number) is read, it must be translated into what the machine recognizes as numerical form. An order-word (order) must be interpreted by being converted to a set of voltages, to operate switches.

Reading a word consists in part of transmitting it to the organ which is to interpret and be affected by it. Thus numbers are transmitted from storage to arithmetic unit, or vice versa, and orders are sent from storage to the central control organ, or dispatcher. In ad-
rival of two numbers causes the transmission of a third number. Whether this third number is the sum, difference, product, or quotient of the other two depends upon the dispatching system of the arithmetic unit. Separate arithmetic units can be built for the four cases, but it is also feasible to make a universal arithmetic unit which will perform any one of the four processes upon request of the central control. Hence the central control must not only dispatch numbers and words and orders, but must also interpret orders and actuate circuit changes.

Transmit and Representation

A number, say 43712, can be read and transmitted in two fundamentally different ways. If one transmission channel is used for each column, we can simultaneously transmit a 2 along the first channel, a 1 along the next, 7 along the next, etc. This simultaneous transmission of the digits of each position along their appropriate channels is a PARALLEL operation. Its characteristic feature is that it distinguishes between digits by a spatial relation, transmitting all digits at the same time.

Conversely, we could transmit all digits over a common channel, at successive times, in the order 2, 1, 7, 3, 4. The separate digits would be distinguished by their time of arrival on a common line. This is a SERIAL process, digits being distinguished by a temporal relation.

If ten pulses, made recognizable from each other by modulation, are available, any number can be transmitted either serially, over one line, or in parallel, over many lines, from one organ to another. We will consider only serial operation because it is more illustrative of traffic (switching) dispatching problems, as well as because it is the system employed in the machines that will first be constructed.

Orders to various parts of the machine must also be capable of transmission, hence they can be expressed conveniently as numbers in some arbitrary code. Thus numbers and orders are represented in the same way, being strings of digits. We know which is which when we put them into the machine, so that if our programmer dispatches only orders to central points and numbers to arithmetic points, it will not matter that the machine by itself cannot distinguish orders from numbers. In fact, this is a convenience, because by considering an order as a number we can modify an order by operating on it with the arithmetic unit.

Representing the ten digits by pulses of different amplitude would reduce machine reliability, making results depend upon tube constants and supply voltages. It is better to have only two amplitudes to distinguish. If these two amplitudes represent digits 0 and 1, we must find a way of representing numbers in terms of these two digits. In decimal notation, the number 352 means

\[ 2 \times 10^2 + 5 \times 10^1 + 3 \times 10^0 = 200 + 50 + 30 \]

Each successive digit position to the left represents the coefficient of the next higher power of 10. We therefore need digits only to 9; a coefficient of 10 in any place is equivalent to a coefficient of unity in the next place. If we drop the use of 10 as our base, and use 2 instead, we write a number such as 37 in the following binary manner, 100101, meaning

\[ 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 1 + 4 + 32 = 37 \]

We pay for the simplicity of having only two different digits by needing approximately three times as many columns to write a number in the binary system as in the decimal system.

To represent 0 and 1 and the corresponding pulse trains, we choose a basic pulse repetition rate of 2 mc, and synchronize all parts of the machine so that successive pulses (representing 0 or 1) occur at these half-microsecond intervals. If all trains of pulses are locked to this represe (repetition rate), we can use the presence of a pulse to represent 1, and the absence of a pulse to represent 0. Thus the six-microsecond pulse train shown graphically in Fig. 1A represents the binary word 11010100111 (read from right to left) which has the (decimal) value 3431. Voltage and tube parameters need only be held within the tolerance range to...
keep the pulses within their amplitude range of reliable operation.

Now that we have a scheme for representing numbers as pulse trains, we are ready to analyze problems of storing numbers.

Storage — Typical machines operate with numbers of ten significant figures in the decimal system, so will require roughly 35 binary places. A 35 binary place number at 2-mc rep rate will be represented by a pulse train having a duration of 17.5 microseconds. It is impractical to put information into a machine or to print results at such a rate, over 50,000 words per second. We need a speed changer, or device for storing the many words being written into it at one speed, and capable of being read at some other speed, either faster or slower. One scheme is magnetic recording of the pulse trains on either wire or tape. Magnetic pulses cannot be packed more closely than about 200 per inch if they are not to overlap and become incapable of resolution. The reprise of reading and writing magnetically for a given packing is proportional to the speed at which the wire is transported. Hence we can magnetically record pulse trains leisurely and run them into the machine rapidly or conversely, can record fast signals on a fast wire, and later read the wire at a speed which an electric typewriter can reliably be expected to follow.

Inside the machine we need two types of memory, one that stores a train of pulses statically and another that stores the high reprise trains of pulses.

Static Register — The first of these, the static register, is needed, among other places, in the arithmetic unit, to set up central voltages in accordance with the 0's and 1's of a number. Basically a static register is a flip-flop such as that of Fig. 1 which has two stable states. High and low plate voltages can be taken to represent the storage of a 1 or a 0.

In a practical flip-flop, grid capacitors are used to speed transition from one state to the other. Minimum transition time depends upon mutual conductance of the tubes. A more rapid flip-flop than the one shown can be made by using such tubes as the 6AK5, connected either as pentodes or triodes. Provision is also made for setting the flip-flop in either state by applying a negative pulse to the appropriate tube. The diodes are isolation buffers to disconnect the pulse sources when pulses are not being applied. This not only reduces loading on the transfer pulse from one tube to the other, but also prevents this pulse from being transmitted to other flip-flops via the input circuit.

Tying the two input leads together provides a binary counter. The plate-grid coupling capacitances provide enough memory (time lag) for the flip-flop to remember in which state it was prior to the application of a pulse applied to both tubes. As a result, an input pulse changes the state of the flip-flop and provides a scale-oftwo, or binary counter. Cascaded binary counters have many applications. For binary counter purposes, the grid input arrangements can be omitted and a positive pulse applied to the common cathode lead.

By using 35 flip-flops, one for each binary column, we can statically store a 35 place binary number. Writing a number into a register consists of setting its flip-flops in accordance with the succession of 0's and 1's in the binary number. Reading the register consists of causing it to generate the pulse train corresponding to its array of 0's and 1's.

Feeding Register — There are
two ways of converting a serial train of pulses into the parallel form for storage in the static register. The pulses can either be fed into the register from the end or set up in parallel alongside it.

The latter scheme is indicated in Fig. 1C; the train of pulses is fed into a delay line of 0.5 μs sections, so that just as the last pulse appears at the input the previous pulses appear at the various junctions. The delay line thus momentarily converts the serial pattern of voltage peaks versus time into a spatial pattern of voltage versus position; voltage appears at the junctions corresponding to the positions of the binary 1's in the number represented, no voltage appears at the positions corresponding to 0's. When this space pattern is obtained, all the gates are opened by an activating pulse, and the 1's are entered into the register via the set 1 input leads. The register can be cleared by applying a pulse to the set 0 inputs.

If the plate outputs of the flip-flops are connected to successive junctions of a duplicate delay line, clearing the register (by simultaneously setting all flip-flops to 0) will introduce pulses into the line at the 1 positions; these pulses will come out of the delay line as the desired train.

The other scheme for sending a train into a static register is somewhat similar to the operation of some desk computing machines that have only 10 keys, 0 through 9. Pushing 3 enters 0003 on the dials, then pushing 5 shifts the 3 along as the 5 is entered, showing 0035, etc. This sequential to parallel conversion can be accomplished by the shifting register of Fig. 1D.

The set 0 lines are all connected to a shift pulse bus. A shift pulse then clears all flip-flops, and any registering 1 generate output pulses. These pulses arrive at the set 1 leads of the next flip-flops, transferring the 1's one place to the right. Clearing a flip-flop registering 0 generates no pulse, so leaves the next flip-flop cleared to 0. Hence every time a shift pulse is sent in, the contents of the register shift to the right. If the shift pulses come at a 2-mc reprise, evenly interspersed between the 2-mc signal pulses sent into the left-hand flip-flop, every time the register is shifted it will find the next digit of the train in the left-hand flip-flop and 35 shifts will result in a static storage of the 35 pulses in the train. We now stop the shifting and have the number stored.

Reading the register (regenerating the train of pulses) is simple. The output of the right-hand flip-flop is connected to a transmission bus and 35 shifts are made, sending the successive 1's and 0's onto the line, and leaving the register cleared to all 0's, assuming that no signal is coming in from the left.

The static registers described above require two tubes per binary digit, or 70 tubes per word stored, so are uneconomical for the main storage. (A general purpose computer needs storage facilities for at least 1,000 words.) However the static register is useful in the arithmetic unit for intermediate storage between two organs with different speeds, such as internal parts of the machine and the magnetic wire. One word at a time can be written at any speed, and then read at any other, permitting synchronizing input data pulses with the 2-mc clock, which would be impossible to do by trying to run the wire at an exact speed.

The other internal high-speed memory, or scratch paper, of the machine can either hold pulse trains as a static array, or remember them dynamically; that is, in the form of pulse trains available for retransmission on demand. Only the latter choice will be discussed here.

Dynamic Memory.—The simplest way of achieving dynamic memory is to feed pulses into a delay line whose output is connected back to the input to keep the pulses circulating. An amplifier and pulse regenerator are needed at the delay line output to compensate losses. Distorted pulses from the line are used to control a gate feeding fresh pulses from the master pulsator, or clock, back into the line. Such a gating combination in the recirculating system is referred to as a pulse reshaper.

The losses of an electric delay line are too great. Each word to be stored requires 17.5 μs of line to hold it; this implies a total of 17.5 milliseconds of electrical delay line, whether in one or several segments. To transmit the individual 0.2 μs pulses without excessive distortion requires a bandwidth of 10 mc. Even with the optimistic figure of 6 db per μs attenuation in lines having this bandwidth, attenuation would be 105,000 db, requiring 7,000 tubes such as the 6AK5 having a gain of 15 db per stage. This is excessive.

A practical way to simplify dynamic storage is to store pulses acoustically rather than electrically. We can convert the 0.2 μs pulses into 0.2 μs packets of h-f using a carrier frequency of 20 or 30 mc. These h-f pulses can then be used to drive a quartz crystal which in turn generates waves in a mercury column. A receiving crystal at the far end senses these waves giving a signal that is amplified and rectified to regenerate the pulses. Attenuation in mercury is approximately 0.06 db per μs at a carrier frequency of 30 mc, or one percent of that for the electrical line. The pair of crystal transducers used with the line introduces a loss of about 50 db.

If one long delay line is used, coupling losses would be negligible, but a single delay line of 17.5 milliseconds would require on the average a waiting time of 9 milliseconds before the desired word would be available. This is too long. A practical compromise between equipment and speed is to subdivide the memory into lines, or tanks, of 20 word capacity, each having a delay of 350 μs. Thus 50 lines are needed, involving 50 pairs of transducers having 2,500 db attenuation. Adding the attenuation of 1,050 db in the mercury, we have a total of 3,550 db attenuation (to be compared with the 105,000 db of electrical lines) and requiring only about 250 amplifier tubes. A typical recirculating tank circuit is shown in Fig. 1E.

We now have conceptually a source of input signals, a receiver for output signals, an arithmetic unit, static registers and dynamic memory tanks. Signals must be dispatched from one to another of

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receivers connected to
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are
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result
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source to
the
arithmetic unit output

Buffers, on the other hand, that
feed two or more signals to a
common point give an output signal if
any one of the sources is excited;
that is, if one OR another input of
the row of buffers is stimulated.
Hence two buffers connecting two
inputs to one output constitute the
logical concept of OR, one signal
AND another.

Typical gate and buffer circuits
using tubes are shown in Fig. 2.
The series gate of Fig. 2A has both
ggards normally biased beyond cut-
off; both must be driven above cut-
off to produce an output. The paral-
lel gate of Fig. 2B has all tubes
normally conducting. If the load
resistor is large compared to the
conducting resistance of a single
tube, the common plate voltage will
remain low unless all tubes are cut
off by signals.

The series and parallel buffers of
Fig. 2C and 2D represent inverse
operating conditions on the cor-
responding gate circuits. The nor-

use of a buffer between an oscil-
lator and a modulated r-f amplifier
is well known. In our case of pass-
ing pulses of only one polarity, we
do not need a triode or pentode
buffer, but can use a diode. This
diode is normally biased with back
voltage so that it presents a high
impedance to the common bus. A
pulse on the bus increases the back
voltage on the diodes and is pro-
tected. A pulse from a source, how-
ever, reverses the polarity on that
one diode and goes through with
small loss. The advantage of such
buffers is that germanium diodes
can be used, greatly reducing shunt
capacitance.

With gates and buffers we can
perform circuit switching, or spa-
tial selection for traffic control. If
we stored our 1,000 words in 1,000
one-word tanks, there would be an
exorbitant number of switches with
their attendant losses and control
problems. We could compromise on
50 tanks holding 20 words each. We
can choose any one of these 50
tanks by spatial switching and any
one of the 20 words in a tank by
temporal selection. The temporal
selection requires no switches
aside from the timing gate.

The timing circuit can be oper-
ated by dividing the master clock
rate. The 2-mc rephase drives a
counter which counts up to 35 and
then throws a flip-flop, giving an
output which is on for 35 pulses, or
one word time, and off for the next.
By feeding these rectangular
waves of word duration into a scale-
of-20 counter, we can devise a cir-
cuit which will give an output (to
control a gate) for the duration of
any desired one of the twenty
words.

Arithmetic Circuits

To understand how to combine
gates and buffers to make a circuit
that will do arithmetic, it is con-
venient to interpret gates and buf-
ers in terms of their logical
behavior.

A GATE is essentially a device
having two inputs and one output.
Either input can be considered
as the signal, and the other as the
control. Obtaining output from a
gate is dependent upon stimulating
both inputs; that is, it requires
stimulation of one input AND the
other input. Logically the gate de-
tects the AND concept, one thing
AND another.

Typical gate and buffer circuits
using tubes are shown in Fig. 2.
The series gate of Fig. 2A has both
ggards normally biased beyond cut-
off; both must be driven above cut-
off to produce an output. The paral-
lel gate of Fig. 2B has all tubes
normally conducting. If the load
resistor is large compared to the
conducting resistance of a single
tube, the common plate voltage will
remain low unless all tubes are cut
off by signals.

The series and parallel buffers of
Fig. 2C and 2D represent inverse
operating conditions on the cor-
responding gate circuits. The nor-
mal-abnormal conduction states are interchanged, and the circuits are stimulated by pulses of sign opposite to those required by the corresponding gates. A signal on any input produces a change in the output.

The diode circuits of Fig. 2 are all parallel circuits. Gates, requiring the AND or multiple coincidence, have all their diodes normally conducting, while buffers have all their diodes normally non-conducting. Diodes are generally of the germanium type.

Adder is Basic Element

To add two digits, the basic operation of arithmetic, we need two inputs and one output. If the sum of the two digits is greater than 9 in the decimal system, or greater than 1 in the binary system, a carry will be produced to add in the next digit position. Hence we need three inputs, one for each digit in the given position, plus one for the possible carry from the previous position. We also need two outputs, one for the output digit, and one for the carry. Thus each digit position requires a device as shown in Table I. Operating characteristics of this elementary adder can be deduced from the laws of arithmetic. The desired outputs for the eight possible input combinations of 0 and 1 on the three inputs are listed in the table.

There are two types of adders: parallel and serial.

A parallel adder is made of 35 elementary adders, one for each digit position. Various digits are set up in a static register, as previously discussed, and the steady register output voltages representing 0's and 1's activate static elementary adders. The carry output lead of each place can be permanently connected to the carry input lead of the next, requiring one type of elementary adder to satisfy the rules of arithmetic. Alternatively the sum and carry digits can be formed statically in each place, and the carrier transmitted to their neighboring adders an instant later. Part of the difference in the circuitry is involved with the fact that a carry may generate a carry, as in adding 7774 to 2226. Propagation of the carry down the line can be handled in various ways.

The serial adder uses a single complicated elementary adder for successive digit places in sequence. Pulse trains are not set up in static form, but are fed in dynamically, the two numbers arriving simultaneously. If an output 1 pulse is generated, it is transmitted immediately as one digit of the sum. If a carry pulse is generated, it is delayed 0.5 μs and returned to the carry input, arriving there coincident with the input digits of the next place.

An elementary adder can be made of gates and buffers. Rules of arithmetic shown by the list of input digit combinations are stated in Table I. The preventing operation in case (2) implies a negative gate, or logical AND NOT, which is easy to devise from diodes by using several bias levels. With this terminology, the functions of an elementary adder can be described logically as at the bottom of the table. The complicated combinations of AND and OR are straightforward logically and electronically, but lead to a practical circuit employing (in one design) nine pentodes and 36 diodes! Some of these elements are incorporated to reshape pulses, and several diodes are used as limiters and d-c level restorers.

Any adder can be considered as a problem in traffic control where the signals (numbers) that are put in control the transmission of pulses throughout the adder. This local control is one step more complicated than the central control, or traffic dispatch between organs. In the central control problem, control voltages set up the paths to be taken by signal pulses. In the local control, pulse paths, and times (clock beats) at which pulses occur are set by the signals themselves, so that there is no longer a clear-cut distinction between signal and control pulses.

Multiplication is a more complex problem. Ordinary longhand multiplication consists essentially of adding the multiplicand (574) as many times as the right-hand digit of the multiplier (51) shifting columns, adding on the multiplicand as many times as the next digit, etc., as in the example:

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>371</td>
<td>101101</td>
</tr>
<tr>
<td>51</td>
<td>101</td>
</tr>
<tr>
<td>574</td>
<td>111001</td>
</tr>
<tr>
<td>1722</td>
<td>100011</td>
</tr>
<tr>
<td>17794</td>
<td>101111</td>
</tr>
</tbody>
</table>

Because in the binary system, only 1's and 0's occur, we have for the partial products either the multiplicand itself, or zero.

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>10111</td>
</tr>
<tr>
<td>3</td>
<td>101</td>
</tr>
<tr>
<td>115</td>
<td>101111</td>
</tr>
<tr>
<td></td>
<td>10111</td>
</tr>
</tbody>
</table>

This allows us to use a shifting register (previously described) together with a basic adder, to perform multiplication. We do or do not add in the multiplicand according to whether the right-hand digit of the multiplier is 1 or 0, shift the number in the register, and repeat. Thus a basic arithmetic unit consisting of registers, which can be shifted when desired, gates and buffers, can either add or multiply according to whether it gets a simple signal to add, or whether it gets also a signal to shift and repeat. Other modifications permit subtraction and division. Which operation is to be performed is controlled by signals from central control, usually quasi-static voltages to keep certain gates open until the operation is completed.

Before examining means for converting pulse trains representing arbitrarily coded orders into gate control voltages, let us glance at the overall organization of the computer.

The input portion of the machine sends all its words, both numbers and orders, to the high speed memory storage. From storage, orders go to the central control, logically through a decoder, but this decoder is the main part of the central control and so is not usually considered separately. Central control must dispatch operating instructions to all machine units, including the input, for it must tell the input when there is room in the memory for more data and orders.

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to continue the problem. The general scheme is shown in Fig. 3. The only feature of the diagram that is unnecessary is the transmission of orders (not control voltages) to and from the arithmetic unit. This is a useful way of pyramiding the hierarchy of control to achieve versatility of operation. Because orders themselves are coded to appear as numbers, orders can be modified by performing arithmetic upon them. This feature simplifies programming the mathematical problem in terms of dispatching orders, but need not concern the electronic circuit designer.

We have mentioned that orders are coded in numerical form. Suppose for example that eight different orders are desired; that is, eight different lines are to be energized. Any eight things can be represented in code form by the binary numbers 0 to 7; that is, 000, 001, 010, 011, 100, 101, 110, 111. These are the eight combinations of three places, each having either of two values. Electrically, we can have three wires, each of which may have voltage applied. If orders are pulse trains they can be converted to the static three wire combination by setting up a static register of three flip-flops. We then have three wires, any one or more of which may be hot, representing eight different possibilities, and we wish to excite any one of eight leads in accordance with these choices. In general, we have N wires of two possible states each (hot or cold) giving 2^N combinations, and wish to excite only one of 2^N outputs. In practice, instead of using N wires from N flip-flops, having some hot and some cold, it is better to bring two wires from each flip-flop, one from each side. We then have N pairs of wires, each of which has only one side hot. All input pairs are thus excited one way or the other, avoiding complications of zero-voltage input signals.

The simplest case of a decoder is where N = 2, so that there are two input pairs and four output leads. The circuit of Fig. 4A shows this case. The horizontal and vertical lines are connected through diodes, so that the diodes in any column form a gate, or AND circuit. If upper and lower lines of the top pair are excited positively, output from the left-hand lead is excited, and so on for the four possible combinations of input.

For larger decoders, it will be convenient to indicate the presence of a diode connection between two lines by a circle at the, crossover. There are no direct connections. Figure 4B shows a simple decoder for four input pairs, yielding 16 possible output excitations. Combinations of upper and lower pair excitations that result in excitation of each of the 16 lines are indicated on the figure.

This direct check of the possible combinations can be called a one-stage decoder. Fewer diodes are required if we decode in two stages, namely, by mixing two pairs as in Fig. 4A to get one line out of four, and doing the same with the other two pairs to get one line out of another set of four. We then have two sets of four lines each, in which only one line of each set is excited. These two sets can be fed into the circuit of Fig. 4C. Thus in using Fig. 4B, each output line requires a quadruple coincidence for excitation, and 64 diodes are needed. By using two circuits of Fig. 4A and one of Fig. 4C, making successive simple coincidences, we need 8 + 8 + 32 = 48 decoders, or a saving of 25 percent.

Multistage decoding exhibits even greater savings as N increases. For N = 8, allowing selection of any one of 256 memory tanks by virtue of the 2 = 256 different gates that may be opened by an 8-pulse signal, a three-stage decoding requires only 608 diodes as against 2,048 for single-stage decoding.

Traffic Handling Systems

Having seen how a coded order can be converted to the selection of a gate opening voltage, it is of interest to consider briefly the general traffic handling plan. The mathematician prepares his instructions to the machine in terms of numerical data, coded orders to select which basic operation the arithmetic unit is to perform, for sequencing the machine or for expressing the routine to be followed. In general two kinds of words are put into the machine memory; numbers and orders.

Assume that the memory is capable of storing 1,000 words and, for
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simplicity, that the two kinds of words are of equal duration, or number of pulse positions. These 1,000 words occupy definite positions in two dimensional space-time. Hence we can consider their positions as pigeonholes numbered from 1 to 1,000 and call for transmission of a word to or from any pigeonhole. The simplest way of entering the input data is to take the first thousand words from a magnetic wire and store them sequentially in the thousand cells. This can be done by using a counter to measure off a word, and cause unity to be added to the address to which the next word is to be sent.

High speed reading of the memory can also be done sequentially by giving the address as the instruction for the cell to be read and by having a built in arrangement for automatically adding unity to the address of the cell to be read. It will then automatically read cell 2 as soon as it has finished with cell 1 and is ready to read again.

A procedure that may be more flexible for repeating subsequences and setting up branch operations (choice of next order depending upon present results) and also more convenient in practical programming is the four address code. In this system each order is composed of four addresses (or memory cell locations): the address of the first operand (number to be arithmetically operated upon), the address of the second operand, the code for the operation to be performed, and the address of the next order to be read after completion of the present instructions. This system is more efficient if memory reference is slow compared to other operations; that is, if waiting time for a word to be reached in the sequential reading of a dynamic memory is relatively large because it allows the essentially simultaneous look-up of both operands.

A variation of the four address system is the use of a fifth address in the words on the input wire, to designate the cell into which that word is to be stored. The fifth address is automatically deleted as the word is entered into the machine.

In electronic digital computers, the tubes, for example, are called upon to develop a pulse of usable level, or not called upon at all. Variations between tubes, aging, or tolerances of resistors do not affect accuracy, until they become so extreme that the signal falls out of usable range. A ten to twenty per cent variation of signal strength has no effort on a series of pulses. Ideally a computing machine works perfectly or not at all. Actually, as tubes deteriorate, there is a threshold at which operation may be erratic. By setting a limit checking circuit for a safe level margin, this otherwise possible operation can be put in the class with complete breakdown.

Errors can occur due to noise generating a false pulse at an allowed pulse time when the word transmitted has a zero in that position. This noise pulse may be indistinguishable from a proper pulse. Occurrence of errors due to such random causes can be guarded against by one of several checking schemes.

One of the most elaborate checking schemes that has been proposed is to check the arithmetic and the transmission. The arithmetic can be checked in a fashion similar to the ancient system of casting out 9's, where each number is expressed as its excess over a multiple of 9; that is, it has a value of 0–8. This is done by adding sideways. The 9's excess of a sum of numbers is equal to the sum of their individual excesses, (expressed as an excess if larger than 9). The 9's excess of the product of two numbers equals the (excess of the) product of their excesses. A simple auxiliary addition or multiplication on the excesses has often been used for checking arithmetic. For example, multiplying 371 by 24 gives 8904. The 9's excess of 371 is found by adding the digits 3 + 7 + 1 = 11, 1 + 1 = 2. Similarly, the 9's excess of 24 is 6. The product of these two excesses is 12, having itself an excess of 3, which agrees with the excess of 8904, 8 + 4 = 12, 1 + 2 = 3. A corresponding procedure of casting out $(2^n - 1)$ can be set up for binary computation, and a small auxiliary arithmetic unit operated simultaneously with the main unit.

This type of checking lends itself to verifying correct transmission of a number. The excess count of a number can be stored with it in the memory for performing the parallel arithmetic check. It can be used as a transmission check by taking the excess count of a number received by the arithmetic unit and comparing it with the received check count. Very peculiar transmission errors are required to make the new count of an incorrectly transmitted number agree with either its original count or an incorrectly transmitted count. This type of checking is based on arithmetic.

Checking the address selection exercised by central control can be done by storing with each word its address. When the word and accompanying address is read, the read address is checked against the called-for address. This checks both the spatial and temporal phases of word selection in the machine.

Electronic design of machines is fast progressing to the point where they will be more perfect than the mathematics set up for them. I refer to such varied factors as round-off error, inevitably introduced by working to a fixed number of significant figures. If a machine performs 1,000 arithmetic operations a second for days on end, what relationship does the final answer have to the original hypotheses? Some mathematical research is being done on this point. A more vital question is the design of mathematics suited for machines. Many procedures use machines for replacing human computers, using numerical computational schemes developed for the human brain. Characteristics of an electronic machine are different from those of a human brain, and it is reasonable to suppose that computational procedures can be devised which, although unsuited for hand computing, are well adapted to machine routines. Such procedures have been developed for a few special problems.

The writer thanks the Raytheon Manufacturing Company and the Eckert-Mauchly Computer Corporation for supplying some of the circuit details shown in the figures.
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Mobile Television Receivers

Television receivers mounted on three jeeps operated by an automobile club made it possible for several additional thousands of people to see the telecasts of the national political conventions from station WCAU-TV, Philadelphia.

The receivers were mounted so that they faced the sidewalk when the jeep was parked on the right-hand side of the street. Thus each jeep could be parked along the highway enabling spectators to watch the television picture from the sidewalk without producing a traffic hazard.

Table model television sets were used, standard Philco model 1001 receivers with 10-inch direct-view screens. As the picture shows, each television set was mounted on a special rack at the right rear of each jeep, and a 12-foot aluminum antenna was also mounted on the side of each jeep. The antenna comes in 6-foot sections, and two sections were used.

For driving along highways with bridges or low-hanging trees, the top mast section and dipole were detached and strapped to the top of the jeep. A single half-wave dipole without a reflector was fastened to the top mast section. This was connected to the receiver by a 70-ohm coaxial line to minimize ignition interference from passing automobiles.

Such an installation is useful for observing television reception in various locations. Measurements of field strength may be taken by checking age voltage and multipath may be observed by watching the picture. The jeeps had standard JAN ignition suppression and in the absence of bad standing waves it was possible to obtain a steady picture when the jeep was traveling at 30 mph.

Power for each set was supplied by three 120-ampere-hour storage batteries in the back of each jeep. One battery supplied heater voltage at 14.4 amperes to all tubes. For the purpose, the 5V4 damper tube was replaced by a 6W4.

The other two batteries supplied two Mallory VP-555 Vibrapacks whose total output was 340 volts d-e at 140 ma. Cold-cathode 6Z4 rectifiers were used and filament power was applied at least 30 seconds before the Vibrapacks were energized.

Initially planned by the staff of WCAU-TV, the idea was executed by Philco engineers under the direction of Joseph Fisher, project engineer, Research Division, Philco Corporation. One engineer from Philco Service accompanied each jeep, with the regular uniformed drivers of the Keystone Automobile Club. The jeeps are normally used for emergency calls and are equipped with mobile radiotelephone, and now have mobile television.

Taxi Tele

Taxicab operation of a television receiver is reported by G. W. Fyler of Motorola. The receiver used was a Motorola VT-71 in which the 12 and 25-volt tubes were changed to 6-volt tubes of similar characteristics. A Mallory Vibrapack was added for plate supply. This was mounted away from the receiver to prevent hum components in the picture. Filters designed for the television frequencies to be used were also added.

Modifications to the receiver included series-connected VR tubes for plate supply regulation and adjusting the time constant of the age circuit to about 0.01 second. This permitted fast circuit action in standing waves but not so fast as to lose too many low-frequency components, including the vertical sync.
Tight production schedules will not be upset by varying quality of electrical insulation if you always specify Dieflex. In any grade, size, and color, every piece of Dieflex Varnished Tubing or Sleevings is exactly like the next one. Faithful adherence to high standards of quality have long made this product a time- and money-saver for manufacturers. Such features as ability to be cut evenly and cleanly, rapid return to roundness after cutting, and excellent flexibility make Dieflex Varnished Tubing Products an important help in cutting manufacturing costs.

Dieflex Varnished Tubings and Saturated Sleeving, of finely braided cotton or inorganic glass fiber base, are available in all VTA and ASTM grades. Write for information, or call your local representative.
pulse. Adequate heater voltage was found important to stabilize sync action.

To cover both the high and the low channels, an all-band antenna was shortened and modified at the center as a compromise between good performance at the proper length and ease of mobility of the vehicle.

Ignition suppressors and special generator filtering were found desirable but no special shielding was added to the receiver circuits. It was found to be important to have low set and car noise during minimum signals in the standing wave pattern.

The high-channel signals seemed to have more standing waves and ghosts. In severe standing waves the age was able to follow signals on the low channels better because the standing waves occur about three times as far apart. Video and audio signals seemed to have different standing wave patterns.

Signals from the high-band channels were stable in open flat country but tend to have somewhat deeper shadows behind hills as expected. Standing waves were found to be greatest near large metal structures such as a bridge but were often perfectly stable under the bridge. Strangely, slight ghosts appeared in a few areas in flat open country without overhead wires or other objects that cause reflection.

**Industrial Tube Tester**

The efficiency of gas or mercury-filled industrial tubes such as thyratrons and phanotrons is tested by the circuit shown in Fig. 1.

In most cases, gas or mercury vapor tubes are used as high-current, low-voltage devices. For that reason, this General Electric tube tester is designed to test the ability of the tube with high current passing through it. The passage of current may readily be seen by noting the familiar blue glow.

Tube efficiency can be determined by measuring the voltage drop from anode to cathode when rated peak anode current is passed. With the TT-1 tube tester, the rated peak, anode current is carried by the tube under test for a half-cycle shot once per second, thus preventing the cathode of the tube from warming up due to the passage of current. The lowering of the voltage drop due to passage of current can easily be checked by allowing the tube to conduct during short portions of each cycle for a few minutes and noting the change in the dial setting required to light the indicating neon tube. This is the reason for making the test reading on the first five conducting cycle positions. A voltage drop of 25 volts is usually considered the maximum limit for good tubes at rated peak anode current.

An anode-to-cathode voltage of 110 volts is placed across the tube for one-half cycle of a 60-cycle source by means of a contactor which is opened and closed by an electronic circuit when the test button is pushed. Various peak currents may be put through a tube by changing the load resistor to various selector settings. When current passes the tube under test, a voltage drop appears across the tube which lights the indicating neon light if the voltage drop exceeds the rated value. The zero calibration is set for a series of tests to compensate for the slight change in the tube characteristics in the electronic calming circuit.

In testing ability of the tube to pass current, other defects of the tube are automatically tested. If a tube is leaky or gassy, has an open filament or low emission, it will immediately show up as having poor ability by a high voltage drop.

Mercury vapor pressure inside of tubes nearly doubles for every 10°C rise in temperature. Too low a mercury pressure causes a high-voltage drop from anode to cathode and therefore speeds up the positive ions in the region between the anode and cathode, resulting in bombardment of the delicate cathode coating. A higher mercury pressure lowers the tube's voltage drop but also lowers the ability of the tube to withstand inverse voltage. For these reasons, mercury tubes have a minimum and maximum temperature limit, usually from 40 to 80°C.

Temperature is measured at the point where condensation takes place, usually at the bottom of the tube. A test of the ability of the tube as given by the TT-1 tube tester is made at the lower temperature limit so that tests will be under the highest voltage-drop condition. However, in low ambient temperatures a longer period than the cathode heating time is required in order to get the condensed mercury temperature of the tube to this lower temperature limit.

For this reason, and also because it is necessary for the mercury to be properly distributed (all condensed in the bottom of the tube), a heating time longer than the normal cathode heating time is called for in the instructions for use of this tester. A condensed mercury temperature of 40°C is usually taken as the temperature for measuring the ability of the cathode.

Gas-filled tubes differ from mercury-filled tubes in that the gas pressure does not vary excessively in normal temperature conditions of

(Continued on p 136)

![FIG. 1—Complete circuit of tube tester for phanotrons and thyratrons](https://www.americanradiohistory.com/assets/images/figures/1948_09_FT-1.jpg)
FILTRONS

STOP CONDUCTED AND RADIATED INTERFERENCE at the source

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THOUSANDS of FILTRONS—radio interference filters—are standard equipment on the majority of the current production of Aircraft. Thousands of others are in use in vital equipment where radio interference must be suppressed.

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All measurements are made in our new modern specially-designed shielded Radio Noise Suppression Laboratory, which is equipped with the most modern and approved radio frequency measuring instruments.

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ELECTRONICS—September, 1948
Detection of Microwaves

A BS ORPTION OF MICROWAVES by gases has been studied to determine such physical constants as molecular dipole moments. In these investigations thermal and acoustic effects have also been observed. Using the expansion produced in gases by their absorption of microwave energy it has been possible to detect as little as 10 milliwatts with relatively simple apparatus. The absorption phenomena can also be used, at low gas pressure, to stabilize the frequency of microwave oscillators as effectively as oscillators of lower frequency are stabilized by quartz crystals.

Microwave Wattmeter

Figure 1 shows a wattmeter. The resonant gas-tight metal cavity is filled with a highly absorbing gas such as ammonia or one of the Freons. The cavity communicates with the U-tube in which is a light liquid that does not react with the gas. When a transmitter generating 10 watts is coupled to the resonator the liquid is deflected about 12 inches in a second; equally rapid response is obtained when the power is cut off.

This type of wattmeter can be used with 1.25-cm and 3.2-cm transmitters delivering either continuous or pulsed power. The action is a consequence of the conversion by resonant molecular absorption of the microwave energy, followed by collisions of the excited molecules thereby converting their internal energy into an increased gas pressure.

Resonant Absorber

The conversion of microwave energy into gas pressure can be used directly as a detector of modulated microwaves. If a balloon, filled with an absorbing gas, is placed in the throat of a horn excited by a microwave transmitter, the modulation will be heard for some distance as the gas in the balloon expands and contracts in proportion to the instantaneous energy of the wave. Such an arrangement constitutes a true wireless receiver.

The technique can be used in a sensitive detector having square-law response. A gas-filled cavity is arranged that is acoustically resonant at the modulation frequency and electromagnetically resonant at the carrier frequency, as shown in Fig. 2. A study of the optimum wave configurations for excitation of the cavity indicated that the microwave energy should be confined to only half of the cavity. A cutoff guide can be inserted at the midsection to confine the electromagnetic waves without disturbing the acoustic waves. A Rochelle-salt crystal is coupled to the aluminum disc that seals the end of the cavity. A conventional audio amplifier and vacuum-tube voltmeter complete the experimental equipment. It is sufficiently sensitive to detect 10 milliwatts of modulated uhf.

The same technique could be used by a football coach to communicate with a quarterback. The coach would use a highly directional voice-modulated microwave transmitter. The quarterback would have a helmet equipped with a gas-filled ear piece.

(2) W. D. Hershberger, E. T. Bush, and G. W. Leck, Thermal and Acoustic Effects Attending Absorption of Microwaves by Gases, RCA Review, p 422, Sept., 1946, on which the foregoing article is based.

Plotting Electron Paths

By PAUL J. SELGIN

TRAJECTORY OF AN ELECTRON is frequently determined graphically. The method described here uses a universal set of curves developed on the assumption that the electron trajectory between equipotentials is an arc of a parabola. The curves are used in conjunction with a map of the electric field in which the electron moves, and requires knowledge of the initial position and velocity of the electron in that field.

Development of Method

While the greatest difficulty in most engineering problems lies in

September, 1948 — ELECTRONICS
BEAT FREQUENCY GENERATOR
TYPE 140-A

This instrument has found universal acceptance because of its wide frequency coverage from 20 cycles to 5 megacycles. A five step decade attenuator provides a means by which extremely small output voltages can be accurately set and a six position switch enables any one of a variety of output impedances to be quickly selected.

SPECIFICATIONS:
FREQUENCY RANGE: 20 cycles to 5 megacycles in two ranges.
Low range: 20 to 30,000 cycles.
High range: 30 kc to 5 megacycles.
FREQUENCY CALIBRATION: Accuracy ±2 cycles up to 100 cycles, 1/2% above 100 cycles.

STABILITY: About 5 cycles drift below 1000 cycles. On low range, drift becomes negligible percentage with increasing frequency. On high range, drift is 3% or less.

ADJUSTMENT: High and low ranges have individual zero beat adjustments. Low range may be checked against power line frequency with front panel 1 inch cathode ray tube.

OUTPUT POWER AND IMPEDANCES: Rated power output: One watt, available over the low frequency range from output impedances of 20, 50, 200, 500, 1000 ohms, and over both high and low frequency ranges from an output impedance of 1000 ohms.

DISTORTION: 5% or less at 1 watt output, 2% or less for 1/2 voltage output.

VOLTMETER ACCURACY: ±3% of full scale reading.

For further details write for Catalog E

QX-CHECKER TYPE 110-A
This production-test instrument is specifically designed to compare relative losses or Q simultaneously with inductance or capacitance in one operation and with a single setting. Built to laboratory precision standards, the QX-Checker is a sturdy, foolproof instrument for use in production work by any usual factory personnel.

SPECIFICATIONS:
FREQUENCY RANGE: 100 kc to 25 mc in 6 ranges using plug-in coils.
ACCURACY OF COIL CHECKS: May be checked against standard to within about 0.2% with coil values of 10 microhenries to 10 millihenries and Q of 100 or greater.
CAPACITANCE RANGE: Capacitance values ranging between approximately 2-1000 mmf may be checked against a standard to an accuracy of a few tenths of one mmf if the Q of the capacitor is high.

DESIGNERS AND MANUFACTURERS OF
THE "Q" METER...QX-CHECKER
FREQUENCY MODULATED SIGNAL GENERATOR
BEAT FREQUENCY GENERATOR
AND OTHER DIRECT READING TEST INSTRUMENTS

BOONTON RADIO CORPORATION
BOONTON, N. J., U. S. A.

For the Laboratory

For the Production Line

ELECTRONICS — September, 1948
reducing the problem to a mathematical statement, in the study of electron path the equations of motion, though readily obtained, are difficult to solve. In most design problems the electron does not reach relativistic velocities, so that its mass can be considered constant. Usually there is negligible magnetic field, and, for beams of low density, the region is also free of electrostatic charges. Although this latter assumption will introduce an error, the error is slight and can be taken into account geometrically. These simplifications lead to the equation of motion

\[
\frac{d}{dt} \mathbf{v} = \frac{e}{m} \mathbf{E} + \frac{e}{m} \mathbf{A}
\]

where \( \mathbf{v} \) is a vector representing the electron's velocity, \( \mathbf{U} \) is a vector representing field potential, whose value in a charge-free region can be obtained by calculation or by an experimental technique such as the electrolytic tank; \( m \) represents the mass, and \( e \) the charge of an electron. Because the values are expressed in MKS units, there are no numerical constants. Equation 1 cannot readily be integrated because of the difficulty of expressing \( \mathbf{U} \) in analytical form for usual configurations. On the other hand, because \( \mathbf{U} \) is usually available in the form of equipotential contours, the partial derivatives of \( \mathbf{U} \) along Cartesian coordinates \( X, Y, \) and \( Z \) can be determined, and can be considered constant within a small region of the field.

The basis of this graphical method is to assume that the potential gradient is constant between equipotentials, and to compute the trajectory through this region. Then another short span is similarly treated, and so on. To make it practicable to repeat the process, a simple graphical method is developed.

**Universal Curves**

To systematize the construction, an analytical expression for the motion of an electron is obtained and a universal plot is made from which individual problems can be solved by projection.

**Graphical Construction**

To plot the path of an electron, a sheet on which the universal curves are plotted is placed on a map of the potential field as shown in Fig. 3. The lower edge of the chart is

\[
X_i = V_{x0} t + \frac{1}{2} \frac{e}{m} \frac{U_i - U_0}{X_1} t^2
\]

\[
Y_i = V_{y0} t
\]

At time \( t \), the electron crosses contour \( U \) at position \( X_i, Y_i \). From the above equations it is seen that, under the assumed conditions, the trajectory between contours is a segment of a parabola.

Because the time of flight is usually not of interest, it need not be found. The magnitude of the final velocity can be determined from

\[
V^2 = 2 \left( \frac{e}{m} \right) U
\]

in which \( U \) is the total potential difference through which the electron has fallen. From the geometry of the problem as shown in Fig. 1

\[
Y = \frac{V_{y0} t}{V_{y1}} = \tan \phi
\]

\[
(V_{y1}/V_{y0}) = \tan \theta_i
\]

where \( \phi \) determines the point where the electron intersects \( U_0, \theta_i \) indicates the path of intersection, and \( \theta_i \) is the angle of intersection of \( U_0 \).

Using these relations, the pairs of parametric equations (Eq. 4) can be reduced to

\[
\cot \phi = 0.5 (\cot \theta_i + \cot \theta_h)
\]

\[
\cot \theta_h = \pm \left( \frac{X_i}{U_i} \right) \left( 1 + \cot^2 \theta_i \right) - 1/2^2
\]

Only the second of these relations need be considered, and only the positive sign need be chosen for it. The negative value would apply if the electron described the entire parabola, cutting the equipotentials.

Although the position of the electron at equipotential \( U_i \) could be obtained from Eq. 4 or 7, and the process repeated at the next contour, the trajectory can be obtained more conveniently by constructing a universal family of curves from the second of Eq. 7. The curves are hyperbolas symmetrical about the axes, but not with common foci. Mutually reciprocal values of \( U_i/U \), are associated with curves symmetrical about the \( x = y \) line. The chart is thus as shown in Fig. 2, but only one half of it need be constructed for actual use.
mended load impedance is 5 megalohms.

Two-Speed Changer
MAGNAVOX Co., Fort Wayne 4, Indiana. A new two-speed record changer that makes it possible to play the new long-playing records at 33.3 rpm will also play conventional discs at 78 rpm. Pickup weight is 5 grams.

F-M Monitor
DOOLITTLE RADIO, INC., 7421 S. Loomis Blvd., Chicago 36, Ill. The FD-12 f-m frequency and modulation monitor handles up to four frequencies anywhere between 25 mc and 170 mc and has an accuracy of 0.0015 percent. A 500-ohm output is provided for audio monitoring. Power consumption is 80 watts.

Tone Arm
GENERAL ELECTRIC Co., Syracuse, N. Y. A new tone arm equipped with a variable reluctance cartridge for playback of 10 and 12-inch records has a 1-ounce stylus pressure. Designated No. UPA-002, the unit is a companion to the professional transcription arm (illustrated) type FA-21-A with stylus pressure adjustable by means of a calibrated scale.

Alignment Generator
PHILCO CORP., Philadelphia, Pa., introduces a portable visual alignment generator, model 7008, for television and f-m receivers, and for research and engineering work in frequencies from 3.2 to 250 mc. Price is $395.

Two-Jaw Clip
MUELLER ELECTRIC Co., 1583 East 31st St., Cleveland 14, Ohio. The new no. 22 clip has jaws at both ends. Either jaw or both may be opened by properly applied pressure. The clip is two inches long and has a screw connection. Free samples are available.

Lab Counter Set

New Converters
RADIO CORP. OF AMERICA, Harrison, N. J. Types 6BA7 and 12BA7 high-gain pentagrid converters are identical except for heater ratings. They have a conversion transconductance of 90 micromhos with 250 volts on the plate. The short internal leads are so designed for service in f-m broadcasting. A brochure is available.

UHF Signal Generator
BOONTON RADIO CORP., Boonton, N. J. Type 218 signal generator is a portable signal source for receiver measurements in the band from 400 to 1,000 megacycles. Maximum power output is 1 milliwatt.

The unit has a built-in recording clock and uses the Higginbotham scaling circuit.

Ceramic Pickup
ASTATIC CORP., Conneaut, Ohio. Model QC pickup cartridge with ceramic element has great physical ruggedness. It has a frequency range of 50 to 10,000 cycles and needle pressure of one ounce.
Wheelco uses a RAYTHEON CK-5608 Tube because of its reliability and stability—the result of:

1. Proven design and precise manufacturing control, backed by the experience of 25 years of continuous production involving $125,000,000.00 worth of special purpose tubes.

2. Unsurpassed engineering knowledge and ability in the development and manufacture of tubes especially to meet long life, industrial application.

Says the chief engineer of Wheelco Instruments Company, "We use this special Raytheon tube to be sure of uniform characteristics, long life and greater stability throughout its operating life."

The Wheelco Flame-Otrol guards life and property against the danger of explosion of any gas or oil fired furnace or industrial heating equipment. It does it ingeniously and positively by utilizing the electrical conductivity of a gas flame or spectral response of an oil flame translating resistivity change or response of sensing element, due to flame failure, through the use of a single Raytheon CK-5608 Tube, into change of current sufficient to operate a relay which acts to close the fuel valves. Action, being electronic, is instantaneous and sure.

Write for Detailed Information on RAYTHEON Special Purpose and Subminiature Tubes
New products, components, tubes, testing apparatus and products closely allied to the electronics field. A review of catalogs, handbooks, technical bulletins and other manufacturers' literature

500-Me Tube
RAYTHEON MFG. Co., Newton, Mass.
Type CK5703 (formerly CK608CX) has a mutual conductance of 5,000 micromhos and amplification factor of 25. It has a 3-watt plate dissipation and can be made to produce about a watt of output power at 500 megacycles.

Old-New Record Turntable
ALLIANCE MFG. Co., Alliance, Ohio.
A new dual-speed turntable operating at either 33.3 or 78 rpm is a modification of the model 80, containing two motors instead of one. Only one motor is used at a time.

Ultrasonic Thickness Gage
PHOTOCON RESEARCH PRODUCTS, 1062 North Allen Ave., Pasadena 7, Calif. The Metroscope measures wall thickness of metal, plastic, and glass parts from one surface and will also detect flaws or imperfections in these materials. Using ultrasonic frequencies, the device operates on the basis of thickness vibrations, and gives a cathode-ray presentation of its findings.

Geiger Tubes
NUCLEAR DEVELOPMENT LAB., Box 7601, Kansas City, Missouri. Thin-window, thin-wall, and all-metal cosmic ray counters illustrated are completely described in Bulletin 10.

Diversity Reception
DECEMETER, INC., 1428 Market St., Denver 2, Colorado. The DM-430 Diverse Adaptor selects the better of two antennas for receiving the desired signal on a little as 0.05 volt of ave. It operates on 200 to 300 volts at 15 ma and filament supply of 6.3 volts a-c at 1.5 amperes.

Ceramic Microphones
ASTATIC CORP., Conneaut, Ohio. Two new microphones using ceramic elements are now available. Chief feature of the unit illustrated is its independence of high ambient temperatures. Its response is essentially flat from 30 to 10,000 cycles. Output level is minus 62 db.
IT'S GLASS...

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ANAconda VITROTEX magnet wire withstands temperatures up to 130°C., is highly flexible and has a remarkable space factor. All this is made possible by insulation of alkali-free glass—the ideal insulating material that is soft as silk and is comparable to steel in tensile strength.

Besides, Vitrotex offers high dielectric strength and a smooth surface that is resistant to moisture, acids, oils and corrosive vapors. For tighter, safer coils, to operate in confined spaces under high heat, make windings of Vitrotex.

For details on the complete line of Anaconda Magnet Wire, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, New York.

Ten years ago the first AUDIODISC was manufactured... manufactured by a patented precision-machine process, which produced the finest recording disc known.

During this decade AUDIODISCS have been rated first in every field of sound recording... radio broadcasting, commercial recording studios, the phonograph record industry, motion picture studios, educational institutions, home recording, research laboratories and governmental agencies. In every country throughout the world, AUDIODISCS are regarded as the true standard of recording quality.

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NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Rural industrial radio; URSI-IRE meeting; tv reallocation; Army tests transistors; utilities radio group; IRE-RMA Fall meeting

Stratovision Demonstration

Stratovision’s flying television station over outskirts of Pittsburgh

RURAL AND SMALL TOWN television coverage is now in the offing by means of Stratovision, whereas service in such areas could not otherwise be expected for years. A recent experiment in which some 40 reporters were flown to Zanesville, Ohio, was not too successful due to weather conditions, but a solution for the problem has been promised.

The principal purpose of the recent experiment conducted by Westinghouse and Glenn H. Martin Co. was to show the FCC why the sponsor should get channel 8 in Pittsburgh for regular ground service and Stratovision and why no other channel 8 station should be permitted within 200 miles of the city.

Immediate plans called for making KDKA-TV the conventional ground station operating several hours a day. It would then go off the air and would relay its programs by microwave to the plane, which would spray the channel 8 signal over a 200 to 250 mile radius.

Electronic equipment aboard the plane consists of a 5-kw video transmitter, the size of an ice-box; a 1-kw audio transmitter, intended to be placed in the same rack with the video; a transmitting mast 25 feet long, with 2 bays, lowering from the bomb-bay; and a receiving mast 8 feet long projecting from the tail fin.

The system when perfected would use four planes at each station. Two would alternate in the air, four hours at a time, while two were being serviced on the ground.

Highlights of RMA Convention


Objectives of the committee are to persuade government officials to establish a four-man committee to centralize and coordinate procurement of equipment and components, and to seek means of expediting production of military equipment through spreading work among all segments of the radio industry.

Other accomplishments of the convention were the reelection of Max F. Balcom as president of RMA for his second term, election of three new division chairmen and three new directors, re-election of 12 directors and two division chairmen, and the admission of 13 manufacturers as new members.

New division chairmen are: Set Division—George M. Gardner, president of Wells-Gardner & Co., Chicago; RMA Parts Division—A. D. Plamondon, Jr., president of the Indiana Steel Products Co. of Chicago; Transmitter Division—T. A. Smith of RCA Victor Division, Camden, N. J.; Tube Division—R. E. Carlson of Newark, N. J.; Amplifier & Sound Equipment Division—Fred D. Wilson of Operadio Manufacturing co., St. Charles, Ill.

New directors are: Allen B. DuMont, president of Allen B. DuMont Laboratories, Inc., Passaic, N. J.; John C. Craig general manager of the Ohio Division of Analytical Manufacturing Corp., Cincinnati, Ohio; and Herbert W. Clough, vice-president and president of Telecraft Manufacturing Co., Chicago.


Leslie F. Muter of Chicago was reelected RMA treasurer for his fourteenth year. Dr. W. D. Baker of Syracuse, New York, was reelected director of the RMA Engineering Department, Bond Geddies was reelected executive vice-president.


Following action by the RMA set Division and upon recommendation of retiring chairman Paul Galvin,
Lavvie

UHF Precision Instruments

Provides harmonic output voltages in 10 or 40 mc series with crystal-controlled accuracy.

Selects 10 or 40 megacycles series by means of front panel switch.

Used for calibration of receivers, wavemeters, or (with Beat Detector built into instrument) for calibration of oscillators and signal generators. May also be used in conjunction with a low-frequency communications-type receiver to determine UHF oscillator drift. A mixer unit is available for this application.

Completely portable. Accuracy 0.1%. Models available from 100 to 2000 megacycles with 2 to 1 frequency coverage on each model.

Recommended for:
- Production testing
- Measurement of oscillator drift
- Independent alignment of transmitters and receivers
- Precise measurements of frequencies

Full details on request

Lavvie Laboratories

Radio Engineers and Manufacturers
Morganville, N. J.

Specialists in the Development and Manufacture of UHF Equipment
Fred R. Lack, vice-president of Western Electric, addressing membership luncheon at annual convention of RMA in Chicago

the board of directors voted to continue the policy not to sponsor or endorse any public or trade shows of television or radio receivers. The board also adopted a resolution asking the FCC to retain the present numbers of the twelve television channels for the avoidance of confusion.

Finally, associate director Virgil Graham reported that the Rochester Fall Meetings in the future will be under the sponsorship and direction of the RMA Engineering Department in cooperation with the IRE, instead of the Rochester Fall Meeting Committee which originated these annual engineering conferences.

Instrumentation Conference

A THREE-DAY conference on electronic instrumentation in medicine and nucleonics, jointly sponsored by the AIEE and IRE, is scheduled to be held in New York City, Nov. 29 to Dec. 1, 1948. Arrangements are to have the area of common interest fall on the second day of the meeting. On the first day, devoted to electronic aids to medicine, such items as biological amplifiers and recording devices (c-r oscillograph, electrocardiograph and electroencephalograph) will be covered. The second and third days will cover nucleonic instrumentation, including subjects of interest to medicine and physics. The second of these three days will be devoted to matters of interest to medical personnel, including stable isotope measurement.

Further information on the conference and registration may be obtained by writing to C. C. Wilson, AIEE Headquarters, 33 W. 39th St., New York 18, N. Y.

Soviet Television

INDICATIVE of the status of television in the USSR is the fact that one electrical appliance store in Moscow now has on sale to the general public the Moskvich T-1 television receiver. It is a 20-tube set with combination f-m radio reception but only an adapter for recording.

However, reconstruction work is being carried out at the Moscow Tele-Center television broadcasting station, which is still using 343-line pictures, for changeover to 625-line pictures. Image clarity at the Leningrad center has been increased to 411-line pictures compared with the prewar 240-line images. Regular

(Continued on p 212)
Here's Federal's line of standard D-C Power Supplies which offer you a convenient, economical and always dependable source of direct current for a wide range of industrial and laboratory applications.

These attractively styled, compact and efficient units are completely self-contained—ready to connect to your a-c power supply—ready to supply d-c power wherever and whenever you want it. Because they are powered by Federal's long-life Selenium Rectifiers, their service life is practically unlimited—with no expendable parts which require frequent replacement. These equipments are conservatively rated, using the new heavy-duty stacks which assure a wide margin of safety to withstand momentary heavy overloads.

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   A-C Input—115 volts, 1-phase, 60 cycles

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3. FTR 3128-BS  
   D-C Output—22-30 volts, 10 amperes (filtered and regulated)  
   A-C Input—115 volts, 1-phase, 60 cycles

4. FTR 3341-AS  
   D-C Output—28 volts, 5 amperes  
   A-C Input—115 volts, 1-phase, 50/60 cycles

5. FTR 3246-BS  
   D-C Output—6 volts, 10 amperes (filtered)  
   A-C Input—115 volts, 1-phase, 60 cycles

6. FTR 1342-AS  
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Federal Telephone and Radio Corporation

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ELECTRONICS — September, 1948

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Western Electric — QUALITY COUNTS —


TUBES AT WORK
(continued from p. 122)

10 to 80°C. For this reason, less heating time is required in testing gas-filled tubes.

In general testing, a few points should be reviewed before a tube has definitely been considered bad.

Heater voltage at the heater terminals of the tube must be at the rated value. Any poor connection on one of the heater terminals will cause a lowering of voltage at the terminal with a resulting lowering of cathode temperature and an increasing voltage drop from anode to cathode during conduction.

The anode, cathode, and grid leads of thyratrons must make good contact with the caps of the tester to insure proper current conduction.

Sensitive Transducer

A device for electrically measuring mechanical motions or displacements that places no friction load on the transmitting device and exerts little or no reaction force on the transmitting device, is the Atcotran. It has a linear electrical response when actuated by a linear mechanical motion and operates from 60-cycle current.

Essentially the Atcotran is a differential transformer with a linear response. It consists of three coils as shown in Fig. 1. These are wound on a single spool, with a free-moving armature of magnetic material mounted inside the spool.

Alternating current is supplied to the center or primary coil C and the magnetic flux generated by this coil is distributed by the armature so
DE MORNAY • BUDD
STANDARD TEST EQUIPMENT
For Precision Broad Band Microwave Measurements

A typical, K Band, bench test set-up with power supply and amplifier

The complete line of De Mornay-Budd standard test equipment covers the frequency range from 4,000 mcs to 50,000 mcs. It provides all R. F. waveguide units necessary for broad band precision test work requiring extremely high accuracy in attenuation measurements, impedance measurements, impedance matching, calibration of directional couplers, VSWR frequency measurements, etc.

To eliminate guesswork, each item of this De Mornay-Budd test equipment is individually tested and, where necessary, calibrated, and each piece is tagged with its electrical characteristics. All test equipment is supplied with inner and outer surfaces gold plated unless otherwise specified.

NOW READY
The new DeMornay-Budd catalogue of Standard Components and Standard Bench Test Equipment is now ready. This catalogue features a 36 page "Introductory Concepts to Microwaves" and "Measurement & Calibration Procedures." This catalogue is available to those requesting copies on company letterhead.

DE MORNAY • BUDD INC., 475 GRAND CONCOURSE, NEW YORK 11, NEW YORK CABLE ADDRESS "DEMBUD," N. Y.
RELIANCE
V*S
DRIVE

ELECTRONIC ADJUSTABLE-SPEED DRIVE FOR A-C CIRCUITS Provides centralized control for simple action. Features starting, quick-stopping, jogging, inching or creeping, reversing, with infinite speed adjustments and controlled acceleration and deceleration.

HAYDON-TIMED for accurate action

The all-electric Reliance V*S Drive employs a special Haydon timer to provide a 30 or 45 second preheating cycle to protect the power tube, while still cold, against premature application of the load. The timer also features delayed reset to permit other relays to operate in the interval and to provide against complete recycling in the event of momentary power failures. Reliance is but one of hundreds of nationally known manufacturers relying on Haydon timers for better product performance. When confronted with a timing problem, take advantage of Haydon Time Engineering Service. There is a Haydon representative near you to discuss and demonstrate timing motors and devices. For immediate reference, see the condensed Haydon catalog in Sweet's File for the Product Designers . . . or write for your complete copy, with illustrations, application information, specifications and dimensional drawings. If it's about time, call for Haydon.

Write 2409 Elm Street, Torrington, Connecticut

HAYDON
MANUFACTURING COMPANY, INC.
TORRINGTON CONNECTICUT

SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

FIG. 2—Output voltage as a function of movement of the armature that a voltage is induced in secondary coils A and B.

If the armature is symmetrically located (centered), the induced voltages will be equal but if the armature moves to the left the induced voltage in coil A will be greater than that induced in coil B. If the armature moves to the right the voltage in coil B will be greater than that induced in coil A.

In normal operation, coils A and B are connected in a series bucking relationship so that, when the armature is centered and both coils have equal voltages induced into them, the resulting output will be zero. If the armature moves to the left a voltage of one phase A will predominate, and if the armature moves to the right a voltage of the other phase B will predominate. Phase A will differ from phase B by 180 degrees. These relations are illustrated in Fig. 2.

If the unit were connected as ill-

FIG. 3—Application of the pick-up unit to a Bourdon tube for pressure measurements
ERIE "GP" Ceramicicons are small and compact, even in high capacities. Tubular in shape, they require less space than rectangular condensers. They can be wired into position more easily and quickly where space conditions are close, and thus are basically easier to handle in any type of installation.

The wide range of adaptability of ERIE "GP" Ceramicicons simplifies the inventory problem, reduces "out-of-stock" bottlenecks, and saves confusion generally.

The enormous popularity of "GP" Ceramicicons is the result of a combination of their superb performance and economical cost. Their inherently simple construction results in higher resonant frequencies that are so important in by-passing applications for FM and Television.

ERIE "GP" Ceramicicons are made in insulated styles in popular capacity values up to 5,000 MMF, and in non-insulated styles up to 10,000 MMF. If you haven't switched to "GP" Ceramicicons for by-pass and coupling applications, write for full details.
There are three!

Sizes 1, 2 and 3 of Ward Leonard's new Solenoid Contactors are now available.

The advantages of Ward Leonard's recently introduced A-C Solenoid contactor can now be obtained in 2 and 3 pole combinations rated up to 100 amperes.

All these sizes provide "Result-Engineered" features which you can't afford to overlook. Let us point them out to you . . . Write for our Bulletins 4451, 4452, 4453 and be convinced. Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

www.americanradiohistory.com
The new alarm-lock works easily enough when you know the right buttons to push. Push the wrong ones, and you bring the cops on the run. Like so many other signaling devices, the alarm-lock is operated by a Telechron synchronous electric motor.

In this lock, the motor is the low-cost Telechron H-3. This is the popular model for range and radio timers, sequence timing, signaling, control and recording devices. Many millions of these versatile motors are giving long, economical service in many different types of timing mechanisms.

These dependable, self-starting motors give your product the extra sales appeal of famous Telechron accuracy. Operating in perfect synchronization with the frequency, they have to be right...can't run fast or slow. Sealed-in lubrication and precision building assure long, trouble-free life.

Telechron motors are produced by the largest maker of synchronous electric timing motors for over 25 years, and are Underwriters Laboratories approved. If you have a special timing, control or recording problem, why not consult Telechron's application engineers? There's no obligation, of course. Address Motor Advisory Service, Dept. M, Telechron Inc., Ashland, Massachusetts. A General Electric Affiliate.

THE FIRST AND FAVORITE SYNCHRONOUS ELECTRIC TIMING MOTOR

ELECTRONICS — September, 1948
Write for Shallcross Akra-Ohm Precision Resistor Catalog R-1. Let Shallcross precision resistor engineering specialists recommend suitable types for your application.

**MOISTURE SEALED OUT . . .**

**Accuracy and Dependability Sealed in!**

Unique, simplified, yet rugged construction characterizes the well-known Shallcross Akra-Ohm hermetically sealed precision resistors. Resistance values up to 20 megohms.

**SHALLCROSS MANUFACTURING COMPANY** Dept. E-98, Collingdale, Penna.

Shallcross—the only complete precision resistor line!

---

**Video Interference**

As Memoed to designers and manufacturers of television receivers by I. J. Kaar, chairman of RMA Committee on Television Receivers, there is a serious problem of radio interference that may be caused by...
CONSTANT VOLTAGE puts the "safety" in safety controls

Without CONSTANT VOLTAGE protection, this self-sustaining link in the chain of relay points that chart the nation's airways, could not successfully perform its safety function.

It is remotely located, at times almost inaccessible to service personnel and solely dependent on local power service. Were it not for a SOLA Constant Voltage Transformer, its delicately engineered electronic and radio equipment would be constantly at the mercy of periodic and unpredictable surges or low voltage levels.

Throughout the entire cross-country system SOLA Constant Voltage Transformers maintain operating voltages at a constant, predetermined level and the nation's air-men fly their courses with confidence.

If you are building electrically energized equipment to operate at precise voltage levels, remember this: it is more economical to include Constant Voltage protection in your design than to install it later as a remedial measure.

Revised Bulletin DCV-192 available on request. Write for your copy.

31 standard types of SOLA Constant Voltage Transformers available in capacities ranging from 10VA to 15 KVA.

SOLA Constant Voltage TRANSFORMERS

Transformers for: Constant Voltage • Cold Cathode Lighting • Airport Lighting • Series Lighting • Fluorescent Lighting • Luminous Tube Signs • Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC COMPANY, 4633 W. 16th Street, Chicago 50, Illinois

Manufactured under license by: ENDURANCE ELECTRIC CO., Concord West, N. S. W., Australia • ADVANCE COMPONENTS LTD., Walthamstow, E., England • UCOA RADIO S.A., Buenos Aires, Argentina • M. C. B. & VERITABLE ALTER, Courbevoie (Seine), France

ELECTRONICS — September, 1948
HOLTITE Engineered Fastenings

The completely scientific production of HOLTITE screws, bolts and allied fastenings is closely supervised through every operation by our skilled Engineering Staff. From the analysis of raw material to the final hardening, heat-treating and finishing every operation is meticulously checked and inspected by the latest scientific devices. Modern comparators throughout the production line supplement inspection devices to insure absolute precision.

Aided by special research in extensive chemical and metallurgical laboratories, our engineers are constantly improving methods, equipment and products to provide users with the most rugged, uniform and accurate fastenings science can devise.

HOLTITE Engineered Fastenings effect tighter, stronger, vibration-defying assemblies with cost-cutting efficiency. Select your next requirements from HOLTITE'S complete line. . . your time study records will prove the wisdom of their continued use.

CONTINENTAL SCREW CO. New Bedford, Mass. U.S.A.

video and scanning circuits of television receivers.

Since the range from 10 kilocycles to 4,500 kilocycles is coincident with those frequencies used in radio communication and radio broadcast, it is to be expected that wiring and components in the television receiver which carry video currents may possibly radiate or produce induction fields of sufficient strength to cause interference to other services employing radio frequencies.

Interference in the broadcast band is of particular importance because receivers for this band may be located in an adjacent room in an adjoining apartment in the same building so that possibly only a few feet may separate the broadcast and the television receivers. The video interference usually sounds quite mushy and makes itself evident as a noisy background of variable intensity riding along with the broadcast program. The intensity may be so severe in some cases as almost to obliterate completely weak broadcast signals. In addition to the mush there may be birdies or tweets caused by more or less steady frequency components in the video signal beating with the carrier.

Intercarrier Audio

A third type of interference may be found at 4,500 kilocycles, in a band used at airports and for some fixed and mobile services. This frequency is found in video circuits as a result of detection of the television sound carrier by the television picture second detector since the difference between the picture and sound carriers is 4,500 kilocycles. This 4,500-kilocycle signal will be frequency modulated by the television sound signal and may be readily identified and received by using slope detection in a standard a-m receiver.

In one instance the 4,500-kilocycle signal interfered with airport operations at an airport located over a mile from the offending receiver. An examination of the receiver revealed that the installation was a custom-built one wherein the video frequency conductor from the last video amplifier to the cathode-ray tube was over ten feet in length and unshielded.

In general, video interference can
Compact... Dependable

Selector Switch Frames—a part of the 15,000-line installation of Federal Rotary Telephone Switching Equipment at the Rochester Telephone Corporation, Rochester, N. Y.

The 7A-2 Rotary System is modern high speed automatic telephone equipment, built by Federal Telephone and Radio Corporation, Clifton, N. J., an I. T. & T. associate. It must be both compact and dependable. This calls for minimum clearances without sacrifice of reliability of performance or ease of maintenance.

In the words of one of their engineers:

"To produce a system which fulfills the many complex circuit requirements of today, which is at the same time sound and robust mechanically, requires the closest cooperation between circuit and mechanical designers."

Natvar Varnished Kraft insulators are an example of this cooperation. Here an electrical insulating material has been used to provide both electrical and mechanical protection to the selector terminal blocks and to the ribbon cable which multiples the terminal banks.

If your requirements call for insulating materials with good physical and electrical performance characteristics, in bulk or cut to your own specifications, it will pay you to use Natvar. Get in touch with your Natvar distributor, or with us direct.

THE NATIONAL VARNISHED PRODUCTS CORPORATION

201 RANDOLPH AVENUE * WOODBRIDGE NEW JERSEY

TELEPHONE RAHWAY 7-2171
CABLE ADDRESS NATVAR: RAHWAY, N. J.

Inserting insulating strips in selector terminal blocks in the final switch assembly. This operation goes smoothly because Natvar Varnished Kraft punchings are all cleanly cut to the same size, and do not stick together.

Natvar insulating materials can be furnished punched to specification and held to close tolerances, in the finish best suited to the operation.

Natvar Products

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- 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 and tape
- Extruded vinyl identification markers

Ask for Catalog No. 21

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with these BALLANTINE instruments

MODEL 300 ELECTRONIC VOLTMETER

MODEL 220 DECADE AMPLIFIER

MODEL 402 MULTIPLIER

10 MICROVOLTS to 10,000 VOLTS

ONE BILLION TO ONE—This enormous range of AC voltages—easily covered by the Model 300 Voltmeter, Model 220 Decade Amplifier and Model 402 Multipliers illustrated above. The accuracy is 2% at any point on the meter scale, over a frequency range of 10 cycles to 150 kilocycles. The Model 300 Voltmeter (AC operated) reads from .001 volt to 100 volts, the Model 220 Amplifier (battery operated) supplies accurately standardized gains of 10x and 100x and the Model 402 Multipliers extend the range of the voltmeter to 1,000 and 10,000 volts full scale.

Descriptive Bulletin No. 10 Available

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY, U.S.A.

TUBES AT WORK (continued)

be reduced by using short connecting wires shielded by running them in fairly close proximity to conductors at r-f ground potential. A brute-force method would be to enclose the whole receiver in a cabinet having a screen shield built completely covering its inner surface. Screening cannot be put over the face of the picture tube, so some radiation occurs through the face of this tube. In an experimental receiver the residual interference was further reduced by employing a picture tube having a special conductive but translucent coating applied to its face and grounding the coating to the chassis.

Scanning Circuits

Scanning systems develop pulse-type and sawtooth-type waves having fairly steep decay characteristics (short-time decay). An analysis of the frequency spectrum reveals the presence of fairly strong harmonics of the line (horizontal) and field (vertical) frequencies. The harmonics of the field frequency, being harmonics of 60 cycles per second, are ordinarily not bothersome at radio frequencies because the amplitude usually falls off inversely with the order of the harmonic.

This is not true in the case of the horizontal frequency because the fundamental is 15,750 cycles per second, and is therefore itself a radio frequency. Harmonics of sufficient amplitude to cause interference to broadcast service have been observed. This type of interference makes itself evident in the form of birdies or tweets caused by the harmonics beating with the broadcast station carriers.

This type of interference is quite annoying and does not change in intensity with picture content, but may change in intensity if the size and linearity controls are adjusted or if a person walks up to a television receiver and changes the radiated field intensity by an antenna effect. A satisfactory cure for this type of interference has been found by the employment of grounded shielding. The components requiring shielding usually are the sweep yoke, the high-voltage rectifier system for the picture tube second anode if the h-v supply is
Magnavox presents

8 Important New Speakers

12" and 15" electro dynamic and permanent magnet type speakers specially designed for use in deluxe radio-phonographs, electronic organs, sound film projectors, coin operated phonographs, public address systems, etc.

<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>Max. Field Copper</th>
<th>Magnet Size</th>
<th>Diameter</th>
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<tbody>
<tr>
<td>12E3017</td>
<td>Electro Dynamic</td>
<td>3 lbs.</td>
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<td>12&quot;</td>
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<tr>
<td>12E1037</td>
<td>Magneto Dynamic</td>
<td>—</td>
<td>1.00 lb.</td>
<td>12&quot;</td>
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<tr>
<td>12E1537</td>
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<td>—</td>
<td>1.47 lbs.</td>
<td>12&quot;</td>
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<tr>
<td>12E2237</td>
<td>Magneto Dynamic</td>
<td>—</td>
<td>2.15 lbs.</td>
<td>12&quot;</td>
</tr>
<tr>
<td>15E3017</td>
<td>Electro Dynamic</td>
<td>3 lbs.</td>
<td>—</td>
<td>15&quot;</td>
</tr>
<tr>
<td>15E1037</td>
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<td>15E2237</td>
<td>Magneto Dynamic</td>
<td>—</td>
<td>2.15 lbs.</td>
<td>15&quot;</td>
</tr>
</tbody>
</table>

The 12" size will handle 15 watts maximum speech, music, audio power and the 15" size, 18 watts.

The Magnavox Company specializes in quality speakers for every type installation. Over 100 different models are produced in the modern new Magnavox speaker factory at Paducah, Kentucky.

The nation's most efficient loud speaker plant, plus all the research and experience amassed in thirty-three years of service to the radio industry, enables Magnavox to meet your specifications exactly. Write for complete new speaker catalog today.

The Magnavox Company • Sales and Engineering Offices  
Components Division • Fort Wayne 4, Indiana

Magnavox is the oldest and largest producer of quality loud speakers!

Magnavox

has served the radio industry for over 33 years
How to put faraway suppliers close to “home”

What if suppliers are thousands of miles away? When you specify Air Express, you cut down delivery of equipment, supplies and finished products to a matter of hours. Air Express is the fastest service there is. Remember—large inventories are expensive. You can keep them low by getting what you need in hours.

Air Express goes on every flight of the Scheduled Airlines—places the most distant suppliers only hours away. And you get fast pick-up and delivery service at no extra cost. Rates are low. Use Air Express regularly and keep things hustling.

Specify Air Express—World’s Fastest Shipping Service

- Low rates—special pick-up and delivery in principal U. S. towns and cities at no extra cost.
- Moves on all flights of all Scheduled Airlines.
- Air-mail between 22,000 off-airline offices.

True case history: Sacramento, California, dairy regularly gets replacement parts and equipment by Air Express. Keeps inventory low—gets things in hours. Typical shipment: 32 lbs. of parts picked up in Detroit 7 P.M., in use at Sacramento next morning, 2,430 miles, Air Express charge $19.65. Any distance similarly inexpensive. Phone Air Express Division, Railway Express Agency, for fast shipping action.

TUBES AT WORK (continued)

derived by the “kick” across the horizontal output transformer, the horizontal sweep amplifier tube and horizontal sweep-damping tube, if employed.

Visual Examination of Crystal Modes

Use of the Megasweep, a sweeping oscillator with output between 50-kc and 500-mc (ELECTRONICS, Aug. 1947, p 112), makes possible the visual observation of crystal modes.

The sawtooth sweep voltage of the sweeping oscillator is applied to the horizontal plates of an oscilloscope, providing a horizontal deflection which is proportional to frequency. The frequency-modulated output signal of the sweeping oscillator is applied across a quartz crystal; and the voltage across the crystal, after rectification and filtering, is passed on to the vertical deflecting plates of the oscilloscope. With the sweeping oscillator adjusted for maximum sweep, the oscilloscope pattern will show those crystal modes lying within the sweep width.

The maximum sweep of the instrument is usually about 30 mc, but it can, with some loss of linearity, be brought up to about 70 mc. As the sweeping frequency passes through the crystal frequency or one of its odd harmonics, the crystal impedance and the rectified voltage across it become minimum. Since this absorption occurs periodically at the sweep rate, a stationary pattern is seen on the oscilloscope with pips corresponding to the series resonant modes of the crystal.

As the center frequency of the sweep is shifted, higher modes can be seen to appear on the pattern. With the sweeping oscillator adjusted for narrow sweep, the pattern of an individual “pip” occupies a large area on the oscilloscope and can be studied in detail.

In a typical test using a 10-mc fundamental crystal, the modes were traced up to the 11th, a frequency of 110-mc. The size of the pips was noticeably different, the variation being due either to different mode strengths or amplitude.
Photomicrographics are only part of the story...

**EVERY KNOWN TEST QUALIFIES WILBUR B. DRIVER ALLOYS FOR SUPERIOR INSTRUMENTATION!**

Photomicrographic checking of grain size and quality of metals is only one of the exhaustive tests which Wilbur B. Driver resistance alloys are subjected to throughout production. There are many others including ASTM life, tensile strength, yield point, hardness, micro-meter and thorough testing for resistance. These constant checks plus industry-old experience, are the reasons you can depend on all Wilbur B. Driver alloys to perform as specified. The alloys listed are so produced, and are especially recommended for instrumentation.

**WILBUR B. DRIVER CO.**

150 RIVERSIDE AVE., NEWARK 4, NEW JERSEY
In the field of electronics and the electrical goods industry, MOSINEE stands for paper-base processing materials with scientifically controlled chemical and physical properties, high quality standards and dependable uniformity... with good dielectric strength, high tensile or tear strength; proper softness or stiffness; creped with controlled stretch or flexibility; specified pH for maximum-minimum acidity or alkalinity; accurate caliper, density, liquid repellency or absorbency... or other technical characteristics vital to your quality standards and production requirements.

MOSINEE PAPER MILLS COMPANY - MOSINEE, WIS.
"Essential Paper Manufacturers"

TUBES AT WORK (continued)

modulation in the output. Using the wavemeter incorporated in the instrument, the frequencies of the modes were measured and found to be 20-μc apart.

Acoustic Well Sounder

DETERMINATION of the fluid level in the annular space between the casing and the tubing of an oil well is being done with an acoustic method.

A small pressure-tight chamber attached to a casing outlet at the surface of the ground contains a microphone and a mechanism for firing a blank cartridge. The sound of the explosion travels down the annulus between the tubing and the casing; the sound is partially reflected at all obstructions such as tubing collars and tubing catcher, and is finally reflected almost totally at the top of the column of oil which usually extends some distance above the pump.

The sound of the initial explosion, and also all of the reflected pulses are transformed into an electric current by the microphone within the chamber attached to the well-head. This current is amplified and recorded on a moving strip of paper by means of two pen-and-ink recording galvanometers operating simultaneously.

The reflection from the top of the fluid appears on the record as a large disturbance superimposed on a succession of small kicks which result from the weak reflections at the tubing collars. Thus the top of...

Well attachment ready for firing. Sound traveling down is partially reflected by obstructions and surface of oil

September, 1948 — ELECTRONICS
U.I.C of England, pioneer manufacturers of ceramic transmitter capacitors, now introduce a range of capacitors which embody the accumulated experience of many years. They are acclaimed for their outstanding electrical performance and rugged construction by leading British and European manufacturers of R.F. Heaters and Transmitters who have used U.I.C Ceramic capacitors at the rate of 1,000,000 KVA in 1947 alone. Further details furnished on request. All orders and enquiries to:

**Examples from a wide range of Types**

<table>
<thead>
<tr>
<th>Type</th>
<th>HLS2031</th>
<th>HLT2021</th>
<th>HLT2021</th>
<th>HLC2011</th>
<th>HLC2014*</th>
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<td>300pF</td>
<td>600pF</td>
<td>800pF</td>
<td>1000pF</td>
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<td>50KVA</td>
<td>45KVA</td>
<td>25KVA</td>
<td>40KVA</td>
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<td>Peak Voltage</td>
<td>7.5KV</td>
<td>7.5KV</td>
<td>7.5KV</td>
<td>7.5KV</td>
<td>7.5KV</td>
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<td>Max. R. F. Current</td>
<td>30 Amps.</td>
<td>30 Am &lt;br&gt; 30 Amps.</td>
<td>30 Am &lt;br&gt; 30 Amps.</td>
<td>30 Am &lt;br&gt; 30 Amps.</td>
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<td>1(\frac{1}{4})(\times)3(\frac{3}{4})&quot;</td>
<td>1(\frac{1}{4})(\times)3(\frac{3}{4})&quot;</td>
<td></td>
</tr>
</tbody>
</table>

* Load-through type, all other examples tag type.
Usability Unlimited

the new Astatic OS, OD and OSC MODELS

CRYSTAL, DYNAMIC and CERAMIC MICROPHONES

The Ideal Microphone for Many Uses—Public Address, Recording, Inter-office and Portable Communications.

IT'S A PACESETTER ... a major new accomplishment in terms of quality performance at modest cost. And, still, that is only part of the story of this new Astatic Microphone. It has usability unlimited! It is so designed that it may be used in a variety of ways shown in illustrations. Extra convenience in all applications is offered by optional models with Type “S” off-on switch. Crystal and Ceramic models furnished in dark brown, streamlined plastic case; Dynamic models in die-cast case.

Work on AC-DC or standard circuits. Crystal and Ceramic models available with substantially flat response or rising characteristics in the voice range.

Dynamic models incorporate Astatic's newly developed circular, Alnico 5 magnet, which doubles flux density, providing higher output level, extended range, and more stability, permitting highest quality performance in these more compact units. CB Base, stand adapter and hang-up bracket are accessories, and may be purchased separately.

Write for prices, additional details

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Type</th>
<th>Recommended Load Impedance</th>
<th>Operating Level</th>
<th>Output Level</th>
<th>Frequency Response</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>Crystal</td>
<td>1 Meg</td>
<td>30 db</td>
<td>30-10,000</td>
<td>Substantially Flat</td>
<td></td>
</tr>
<tr>
<td>OD</td>
<td>Crystal</td>
<td>1 Meg</td>
<td>30 db</td>
<td>30-10,000</td>
<td>Substantially Flat</td>
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<tr>
<td>OD</td>
<td>Dynamic</td>
<td>500 Ohm</td>
<td>30 db</td>
<td>30-10,000</td>
<td>Substantially Flat</td>
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<tr>
<td>OSC</td>
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<td>30 db</td>
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<td>OSC-1</td>
<td>Ceramic</td>
<td>1 Meg</td>
<td>30 db</td>
<td>30-10,000</td>
<td>Substantially Flat</td>
<td></td>
</tr>
</tbody>
</table>

Listed in The Radio Industry RED BOOK

Astatic Crystal Devices Manufactured under Brush Development Company patents

Power Converters for Television

Operation of television receivers from a d-c power line can be accomplished by using the vibrator-type converter whose circuit is shown in the diagram. It incorporates a frequency control (potentiometer R) which permits adjusting the vibrator to a frequency of 60 cycles to prevent distortion of the picture.

Although most cities are supplied exclusively with a-c power lines, there is still a significant number that contain d-c districts. New York City, for example, has 316,000 d-c meters, Boston has 58,000, and Chicago has 26,000. And television stations are now operating in all three cities.

The circuit shown is that of one...
SUPERIOR ELECTRIC COMPANY PROTECTS THEIR AUTOMATIC VOLTAGE REGULATORS WITH

HEINEMANN MAGNETIC CIRCUIT BREAKERS

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* 25% more joints per hour per pound of solder!
* Cut your solder cost with Tri-Core’s — 5 to 15% less tin and still get better results than possible with other solders using more tin.

* Tri-Core available in diameters as large as 1/4", and heavier — down to .020" and finer.

TUBES AT WORK (continued)

converter made by Electronic Laboratories. It is filtered to less than one microvolt throughout the f-m and television bands, and powers a receiver rated up to 230 watts. A second model supplies up to 475 watts. These ratings are applicable to equipment having a high power factor, from 80 to 100 percent, such as is normally found on transformer-operated devices.

Baseline for Visual Alignment Systems

By Elliott A. Henry

Globe Products Corp.
Bridgeport, Conn.

ACTIVITY in the television field has stimulated interest in sweep-frequency generators and visual alignment systems. The time saving and ease of adjustment inherent in visual systems outweigh the initial cost of equipment and the difficulty in making accurate gain measurements. Precise gain measurements, as well as a more accurate picture of the gain-frequency characteristic of the amplifier or net work, may be obtained if a reference of zero voltage (baseline) is provided on the cro screen.

The baseline may be obtained by blanking the return sweep within the sweep generator or by blanking the input of the vertical amplifier of the cro. As the majority of sweep generators do not incorporate internal blanking, and as physical or electrical considerations present conversion problems, the latter method is to be preferred.

While electrical blanking, obtained by keying one of the cro amplifier stages, might be used, it will not produce satisfactory results as the d-c component of the rectified

FIG. 1-Simplified circuit using battery to charge capacitor

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- Precision ground, stainless steel, double thread, lead screw guides the rotating contact, guarantees smooth action, low uniform torque and accurate settings—permanently.
- Rotor assembly, supported on two bearings, assures long life and low torque.
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- The 43/8" length of resistance element gives you a finer resolution.

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ELECTRONICS — September, 1948

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Wave will be lost in coupling to the cro and a d-c component, equal to the plate voltage difference of the keyed stage, will be added and appear on the cro screen. Since it is necessary, to produce an accurate picture of the gain-frequency characteristic of the network under test, to transfer the d-c component of the rectified wave to the cro screen and since this is readily accomplished by periodically restoring the cro vertical amplifier to its zero operating condition, mechanical blanking was chosen.

Basic Operation

For an explanation of the transfer of the d-c component, reference is made to Fig. 1. With switch 2 open, when switch 1 is closed, with the battery polarity as shown, C charges through R, and C. The direction of current flow makes the grid of T, go positive and the cro spot to move upward. When C becomes fully charged, current ceases to flow and the grid returns to its static value. The spot returns to its former position and nothing further happens as long as conditions remain unchanged.

Now if switch S, is momentarily depressed, C will be discharged through R, while the battery will be protected by R. The direction of current flow is now such as to make the grid of T, go negative and the cro spot to move downward. Therefore if S, is made to operate rapidly and to have equal off and on time, the pattern obtained will be a series of square waves, the magnitude of which will be an absolute proportionality to the battery voltage as C has had a charge alternating between zero and full battery voltage.

By substituting the load of the linear diode detector for the battery, adjusting switch S, on-time to 180 degrees of the modulation cycle, and providing a means of phasing the start of S, on-time, either the up or down sweep may be blanked and the baseline, equivalent to zero voltage, obtained.

Resistor R, should have a value at least four times greater than the diode load resistor to prevent the discharge of the diode capacitor during switch S, on-time. Switch S, must be capable of very fast action and have very low contact resistance. A relay with the mercury-
for HIGH Resistances

**SPECIFICATIONS**

**RANGE:** 2,000 ohms to 50,000 megohms in five overlapping ranges; zero to 100 volts, d-c as a vacuum-tube voltmeter.

**ACCURACY:** within ±5% of indicated value from 30,000 ohms to 3 megohms; within ±8% from 3 to 3,000 megohms when the central decade of scale is used. Voltage measurement accuracy is ±2% of full scale.

**SCALE:** standard direct-reading ohmmeter calibration is used; scale is illuminated.

**VOLTAGE ON UNKNOWN:** does not exceed 106 volts and varies with meter indication.

**INPUT RESISTANCE:** for voltage measurements input resistance in megohms is indicated by selector switch. On the "infinity" position, resistance is greater than 20,000 megohms.

**TEMPERATURE-HUMIDITY EFFECTS:** over normal room temperature and humidity ranges, accuracy is substantially independent of either.

**DIMENSIONS:** 10 x 8 x 5½ inches.

**WEIGHT:** 8½ pounds, net.

**THIS NEW MEGOHMMETER** is very similar to the usual ohmmeter except that a vacuum-tube voltmeter is used as the indicating device. It is a-c operated and direct-reading in five overlapping ranges from 2,000 ohms to 50,000 megohms. The a-c power supply is regulated to make readings of the instrument independent of supply voltage variations.

This megohmmeter is very useful for moderately high resistance measurements such as leakage resistance of cables and insulating samples, locating defective insulation in electrical machinery, and particularly for the determination of moisture content of wood, paper and other products. By means of a panel switch it is convertible to use as a d-c vacuum-tube voltmeter for measurements up to 100 volts, d-c.

The Type 1861-A Megohmmeter is convenient to use, accurate and stable.

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FIG. 2—Conventional circuit for single image alignment

wetted type contacts is recommended to provide the clean baseline and fast action required.

Single Image Alignment

A common arrangement for single image alignment is shown in block form in Fig. 2. Here the sweep generator uses sinusoidal modulation and a sinusoidal time base is used to produce a linear frequency-time pattern. With the modulation and time base voltages in phase, a single image will be seen, assuming no distortion, with the up and down sweeps coinciding at all points. With this arrangement only the a-c component of the rectified wave is viewed and no knowledge of the actual instantaneous voltage is obtained.

The practice of using a sweep-width very wide in comparison to the pass-band of the network under test to obtain two points of assumed zero voltage ($F_{min}$ and $F_{max}$), may lead to a false picture of the gain-frequency trace. A more accurate picture of the steady-state characteristic of the network under test is obtained by using a narrow sweep-width and the baseline for accurate gain measurements.

Figure 3 shows the blanking unit in block form connected to the common arrangement of Fig. 2.

FIG. 3—Addition of the Baseliner provides zero reference trace
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Reference:
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PHILCO 7008. The only instrument of its kind, combining all functions for complete, accurate visual alignments on Television and FM receivers. Includes 5 different signal generators and their associated controls; a complete oscilloscope with centering, gain, focus, intensity, phasing and blanking controls, and power supplies. Separate RF probe permits measurements of sensitive circuits without disturbance. Removable crosshatch screen for special ultra-short 3" cathode-ray tube. Compartment for storage of all cables, including RF probe.

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NO. 7001 PHILCO ELECTRONIC CIRCUIT MASTER
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The Electron Art
(continued from p 126)

FIG. 3—Chart is used with field map

Unless specific engineering bulletins are required, ask for C-47 Condensed Catalog giving a summary of the various type series and prices in many types. Address Dept. 1-120.

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ELECTRONICS — September, 1948
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**THE ELECTRON ART (continued)**

the construction whereby the electron was followed initially from U₁ to the apex. For this purpose the position of the chart on the field map must also be inverted because the electron is now passing through equipotentials in the opposite direction. In general, more points are needed near the apex than in other regions to retain the accuracy.

Figure 4 shows an electron path plotted by this method. Two paths have been plotted with different numbers of points to show the change in accuracy. For most purposes the construction with fewer steps will be adequate. If electrons enter the field at an initial emission velocity U₁, volts, all contours on the map should be increased by U₁. The direction of emission velocity can be arbitrarily assigned.

Several other graphical methods have been described for plotting electron paths. The simplest and most widely used constructs the path in a succession of arcs of circles. Modifications of this method to overcome the disadvantage on large radii of curvature have been applied to the electron lens and to the cyclotron. Another parabolic method has been described elsewhere. Under the last reference the reader will find a wide survey of other methods.

(1) I. Langmuir and K. Bodegott, Currents limited by space charge between coaxial cylinders, Physical Review, p. 374, 32, 1923; also p. 44, 24, 1924.
(33) H. Riehner, Tracing electron paths in electric fields, ELECTRONICS, p. 50, Oct. 1927.

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**Electronic Circuit has Logarithmic Response**

By A. W. NOLLE

Department of Physics University of Texas Austin, Texas

INSTRUMENTS for measurements in communications and acoustics are most useful if their indicating meters have uniform decibel scales; that is, if they are logarithmic instruments. Such instruments are more versatile if the voltages that they develop are logarithmically re-
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Sylvania Electric

Radio tubes; cathode ray tubes; electronic devices; fluorescent lamps, fixtures, wiring devices; electric light bulbs; photoflash bulbs
THE ELECTRON ART (continued)

related to their inputs, instead of the uniform decibel scale being obtained by modification of the meter movement. The output voltages can then be applied to recording instruments or to oscilloscopes, thus extending the forms in which the logarithmic presentations can be made.

Conventional circuits for this application use nonlinear components such as pentode amplifiers,\(^1\) grid-cathode rectification in triodes,\(^2\) and copper-oxide rectifiers.\(^3\) The circuit described herein uses the exponential characteristics with time of a resistance-capacitance circuit, thus obtaining logarithmic response from an inherent property of the circuit rather than from an approximate characteristic. The exponential response to square-wave excitation of R-C and R-L-C circuits is familiar and need not be reviewed here.

**Basis of Operation**

The exponentially decreasing output voltage \(E_x\) of, for example, an R-C circuit is \(E_x = E_0 \exp \left(-\frac{t}{RC}\right)\) where \(E_0\) is the initially applied voltage. The time \(T_k\) required for the output to decay to an arbitrary value \(E_k\) is \(T_k = RC (\ln E_0 - \ln E_k)\). This equation is the basis for the

![Graph of exponential response](image)

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This is a thermostatically controlled device for the regulation of the temperature of an electric soldering iron. When placed on and connected to this stand, iron may be maintained at working temperature or through adjustment on bottom of stand at low or warm temperatures.

![Electric Soldering Iron](image)

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DETOIT 2, MICH., U. S. A.

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logarithmic circuit. If either the applied voltage or the arbitrary smaller voltage is made a constant of the apparatus, the partial decay time $T_x$ becomes a linear function of the logarithm of the other voltage. In practice it is simpler to fix $E_x$ and to use $E_y$ as the variable to whose logarithm the instrument responds. The instrument is then designed so that a measurement is made of the time interval for the voltage under test to decay to a standard value. This one measurement is sufficient to give the logarithm of the amplitude of the voltage.

**Practical Circuit Design**

Because most voltages that are to be measured vary with time and because continuous indications are usually desired, it is necessary to repeat the process continuously. When this is done, a succession of time measurements is delivered to the final indicating device in such electrical form that an averaged indication of its logarithmic level is always presented.

The repetitive action can be produced simply by applying a square wave whose amplitude is proportional to that of the input signal to an R-C or R-L circuit. The output from an R-C circuit is shown in Fig. 1A in relation to an applied square wave of amplitude $E_y$. Because the capacitor does not charge completely each half cycle, the peak output voltage is $E_o = E_y (1 + F)$ where $F = \tanh (T/ARC)$, $T$ being the period of the applied square wave. At the end of each half cycle the voltage has decayed to $E_y (1 - F)$. In practice the logarithmic response circuit must be designed so that $F$ is nearly equal to unity if differences of the order of 20 db are to be registered. Thus the peak output voltage of the R-C circuit is essentially equal to the peak-to-peak amplitude of the square wave.

The time required for the output voltage of the R-C circuit to decay to the fixed value $E_o$ is $T_x$. Measurement of $T_x$ will give the correct indication of the logarithmic amplitude of the square wave provided that the peak voltage $E_y (1 + F)$ is (1) greater than the reference voltage $E_y$ but (2) small enough that
By way of illustration... 1. Du Mont transmitter unit utilizing Du Mont cathode-ray tubes as indicators. 2. Du Mont television field equipment for picking up remote programs. 3. Scientific research in medicine, aided by Du Mont oscillography. 4. Du Mont Television Transmitting Control Console utilizing Du Mont cathode-ray tubes. 5. Du Mont Type 208-B oscillographs used in nuclear research. 6. Du Mont Type 280 oscillograph for precision measurements of television waveforms utilizing the Type 3RP-A high-voltage tube. 7. Typical scene in most radio repair shops, where servicemen make their diagnosis with a Du Mont Type 274 oscillograph. 8. Du Mont Chatham table set with a 12-inch Du Mont picture tube for clear, bright, truly superlative pictures. 9. The symbol of quality cathode-ray tubes—always your best buy.

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Literature on request

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THE ELECTRON ART

(continued)

the interval \( T_x \) is less than half a cycle.

Figure 1B shows a method for obtaining a signal indicative of \( T_x \). An indicator circuit is so arranged that current of constant amplitude flows through an indicating instrument, such as a d-c meter, as long as the output of the R-C circuit is greater than \( E_x \). The output of the indicator circuit is thus a pulse train modulated in width in proportion to the logarithm of the amplitude of the initial square wave. The average value of this pulse train produces the proper steady deflection of the indicating instrument. If the calibration of the instrument is to remain fixed, it is essential that the period of the square wave be constant.

There are several other practical considerations: The square-wave generator feeding the R-C circuit must have a constant internal resistance. Full-wave operation can be obtained if the indicating circuit operates on both halves of the square wave, responding to \( E_x \), then to \(-E_x\). The meter deflection per db can readily be controlled by varying the resistance of the R-C circuit. The absolute level of the meter scale can be controlled by the amplification of the input signal and by the magnitude of the bucking current through the meter, which should be large enough that, in the absence of signal input, the indicating element will be off scale so as to avoid ambiguity.

A Specific Circuit

Figure 2 shows the diagram of a specific circuit which has a logarithmic range of more than 20 db. This circuit is designed for measuring alternating voltages and therefore is provided with an a-c amplifier stage and a balanced voltage-doubler rectifier. This rectifier converts the signal into direct voltages at \( A \) and \( B \) that are positive and negative respectively by equal amounts as compared to the average potential at \( D \).

A limiting amplifier, excited by the high voltage from the power transformer, develops a square wave at \( D \) whose peak-to-peak amplitude closely equals the voltage difference between \( A \) and \( B \) because of the action of the limiting diodes. A variable bias current is obtained
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Here's your simple guide for every type of electrical instrument and control from ammeters to tachometers. No need to check through dozens of catalogs. No need to make telephone calls by the hour. And no need to spend your valuable time shopping from house to house or clogging your office with salesmen. Here within the covers of this catalog are 64 pages jam-packed with over 3,000 instruments and controls...fully described, illustrated and priced. Just to give you an idea of the wide variety of types in this catalog, we list a random dozen:

- Fluxmeters
- Ammeters
- Meggers
- Bridges
- Audio Voltmeters
- Analyzers
- Oscillators
- Electronic Counters
- Appliance Testers
- Decades
- Voltmeters

Only Electro-Tech, the world's largest jobber of electrical, electronic and mechanical instruments and controls can offer you this exceptional service. Write today for Catalog No. 48, the handy guide for instrument and control buyers. A copy is waiting for you. No obligation, of course.

ELECTRONICS — September, 1948
Here's the sturdy little fellow you've been looking for—it lets you design for compactness. Thinnest switch made, it is no thicker than an ordinary match book and only slightly larger than a postage stamp—yet it delivers long, dependable service with the utmost accuracy. ACRO'S exclusive rolling spring action is the key to its superlative performance—the reason why it's the choice of hundreds of manufacturers. Code 2MD3-1A approved by Air Materiel Command. Write for further details.

**Model M**

- **SNAP ACTION SWITCH**
- **Only 9/32" THICK**

Coin Model M with No. A-22 Wire Leaf Actuator for coin operated machines. Length and form of wire can be made to suit job. Underwriters' Lab., Inc. Insp. 3 Amps, 125 V., 3 Amps, 250 V., A. C.

The ACRO Electric Company

1316 Superior Avenue • Cleveland 14, Ohio
The above condensed version of the Plasticon Line will appear in the new catalogs of leading electronic distributors. Capacitors are manufactured by Condenser Products Company, Chicago 22, Illinois.
Fishing reel gears must operate smoothly at a speed of 3000 revolutions per minute or more, when a cast is executed. These gears must also withstand the strain of hauling in a fighting fish of unpredictable size and strength, thus rendering a dual purpose: speed and velvety smoothness in one direction—strength and durability in the other.

Instruments and machines have individual gear problems. For over a quarter of a century, Quaker City Gear Works has solved thousands of them and produced millions of gears of every description up to 60" in diameter for manufacturers in many diversified industries.

Aircraft controls, dental drills, electric clocks, gauges, indicators, heat controls, machine tools, radar, radios, washing machines and motion picture projectors are but a few of the many conveniences of modern progress which depend upon the heartbeat of Quaker City Gears. Your gear problem is our business, our large productive capacity is at your service.

YOUR INQUIRIES WILL RECEIVE PROMPT ATTENTION

The heart of the Outdoorsman Customatic reel illustrated above is but one of many gear trains developed by our engineers and produced in our fully equipped plant.

Quaker City Gear Works
INCORPORATED
1910 N. Front Street, Philadelphia 22, Pa.
only obtained by careful correction of the rectifier and limiter diodes. Therefore the circuit is shown for a 20-dB scale for which critical adjustments are unnecessary. The sensitivity of the instrument to line voltage changes is 0.07 dB per volt, which represents a uniform scale drift.

**Design Limitations**

The serious source of error is the rectifier-limiter circuit. The portion of the meter following the rectifier-limiter circuit of Fig. 2 is accurate within ±0.2 dB over a 30-dB range.

If it were required to redesign the meter for a 30-dB range, an input stage having a larger output capability than the 6SJ7 would be necessary so that the rectifiers and limiters could be operated farther into their linear ranges. If this were done, the square wave would have to be attenuated before going to the grid of the 6V6 power stage.

The maximum useful range of the logarithmic circuit, which begins after the limiter diodes, is determined by the finite on-off sensitivity of the d-c amplifier. This sensitivity is of the order of 0.1 volt, and must be small compared to \( E_v \) in order that sharply defined pulses be produced. Thus there is a lower limit to \( E_v \) of about 3 volts. If the working range of the circuit is to be as much as 40 dB, the peak-to-peak undistorted output of the square-wave amplifier must be greater than 3 volts by the 40 dB plus a safety margin of about 3 dB, or 400 volts peak-to-peak. Because of this requirement, a reasonably portable instrument is limited to about 30 dB full scale.

The R-C filters between the rectifiers and the limiters are important to prevent slow periodic variations of the instrument indication at certain input frequencies. When the input frequency is nearly a multiple of the 60-cps square wave, ripple in the rectifier output is sampled in stroboscopic fashion in the limiting process. Thus a 10-percent ripple component in the rectifier output could produce a cyclic 1-dB variation in the instrument indication.

These R-C filters are the chief factors in limiting the speed of response of the instrument; the values for them shown in Fig. 2 are commensurate with the mechanical...
SURVIVAL OF THE FITTEST

PUSHOUT: No pushover for speakers is this magnet test which checks the strength of the combination of seal and cement up to 1500 pounds.

MEANS FINER SPEAKERS FOR YOU

ONLY the fit survive the stern tests our G-E speakers meet on the production lines. At frequent intervals speakers are picked from the lines and subjected to rigid tests to assure the maintenance of high standards in the manufacturing process. Test after test is applied to single elements, combinations of elements and to the final, completed units. The test shown here is only one of the many that General Electric speakers face as they roll down the production lines. This unceasing care in building speakers of quality builds confidence and customer satisfaction.

Write today for information on General Electric quality speakers to: General Electric Company, Electronics Park, Syracuse, N. Y.

GENERAL ELECTRIC

THE ELECTRON ART (continued)

performance of usual milliammeters. If more rapid response were desired for operation of a high-speed recorder or for presentation of the results on an oscilloscope, it would be necessary to redesign the instrument for operation at a higher square-wave frequency. This change, although increasing the circuit complexity, would produce a faster response by providing more rapid sampling and by permitting reduction of the time constants of the R-C filters.

Acknowledgements

The author is pleased to acknowledge the cooperation of the Ordnance Research Laboratory of the Pennsylvania State College, with whose facilities a preliminary test of the principle of the logarithmic circuit described above was made, and of the Electodyne Company of Boston, to whom development rights have been assigned.


SURVEY OF NEW TECHNIQUES

Propagation measurements conducted at the National Bureau of Standards under the direction of K. A. Norton indicate that atmospheric ducts may increase the range beyond line of sight of f-m broadcasting stations operating in the 88 to 108 mc band. The effect is most pronounced in the early morning and reaches a maximum during the summer months. (Ed. Note: Listeners have begun reporting reception of distant f-m stations now that the summer is here.) The increased transmission is caused by changes in refractive index in the region from 10,000 to 20,000 feet of air strata of different temperatures and hence different densities. The measurements also indicate that increased transmitter antenna height is more effective in increasing range than increased power. For rural areas, receivers that definitely limit with signals of five
microvolts per meter will not be affected by natural noise, except possibly strong local lightning. For the most part fading at great distances is caused by multipath effects.

**THICKNESS** of cigarette paper can be controlled to within 0.2 micron ($0.2 \times 10^{-6}$ meter) by a beat-frequency capacitance meter. The method, being applied in French factories manufacturing paper having a thickness of about 0.001 millimeter, is based on developments described by J. Coulon in his doctor's thesis at the Faculte des Sciences de l'Universite de Toulouse, France. The thesis reports methods of stabilizing the frequency of crystal oscillators.

**LINEAR** electrostatic accelerator, designed to yield positive ions with energies up to 12 mev, will be built at the University of California Los Alamos Scientific Lab. Although other types of accelerators capable of higher energies are operating or under construction, there is need in nuclear technology for precise measurements within the range for which this new machine is designed; beam energies will be controllable to a precision of one-tenth of a percent (orbital accelerators are accurate to only about two percent). The flexibility of the energy controls will permit experimenters to select particles and target materials to produce monoenergetic neu-

**FOR PRECISION TUBING \nWHATEVER THE...**

**SHAPE** If your electronisms require metal-shielded wire or seamless tubing for pointers, Bourdon gauges, antennas or other uses—Precision Tubing is formed or flattened to the shape you specify with Nth degree accuracy... ready for immediate application.

**SIZE** Precision Tubing is available in outside diameters of 0.500" to 0.010"—wall thicknesses of 0.035" to 0.0015". Through continuous hydrogen atmosphere annealing furnaces and tungsten carbide tooling, dimensions you specify within this range are held to extremely close tolerances.

**ALLOY** Whether it's an aluminum alloy used to acquire high strength-to-weight ratio for instrument pointers, the copper alloy for metal-shielded wire, brass, nickel, or any other non-ferrous alloy—Precision research subjects non-ferrous metals to rigid tests. These assure reliable operation even under extreme conditions. Controlled production cycles make possible correct temper, a clean smooth finish, and the precise uniformity so essential to long life.

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**PRECISION TUBE CO.**
Factory: 3824-26-28 TERRACE STREET, PHILADELPHIA 28, PA.
Do you need a **DRY BATTERY** you can’t find?

There is a **SPECIALTY DRY BATTERY** for your special need

If you are looking for hard-to-get or special dry batteries, write us. We design, create and manufacture to your requirements.

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A SUBSIDIARY OF THE RAYO-VAC RAY-O-VAC COMPANY
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**CARBY**

MANUFACTURERS OF PRECISION EYELETS and MULTIPLE PLUNGER PRESS PRODUCTS

The Carby Manufacturing Company, specialists in small diameter and long draw, through years of experience, engineering "know-how" and excellent production facilities, can accurately produce to the most rigid requirements every electronic requirement for...

- GROMMETS
- EYELETS
- SOLDERLESS LUGS
- TERMINALS
- FERRULES

EYELETS: Eyelets can be produced with square, hexagonal or round barrels with heads to match or in any wanted combination.

METALS: Available metals in .006 to .032 AWG. Accurately fabricated on eyelet machines or by plunger press to meet any requirements in...

- ALUMINUM
- COPPER
- BRASS
- STEEL
- NICKEL-SILVER

DELIVERY: Prompt delivery is a specialty of Carby. Our production facilities, modernly managed, is at your command to meet any reasonable requirement.

STANDARD OR MADE TO SPECS...

Many standard shapes in stock but we specialize in fabricating special needs. Send in your blueprints for prices, deliveries, and engineering advice.

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BURLINGTON, IOWA

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**ONE OF A SERIES**

**BALANCE WEIGHTS**

**WHY BURLINGTON PANEL INSTRUMENTS PROVIDE UTMOST RELIABILITY...**

BALANCE WEIGHTS of helical type phosphor bronze, formed in a manner which eliminates slipping or shifting, are used to balance the moving element. All ranges AC and DC available in 23/16, 31/8, 41/16 rectangular or round case styles and are guaranteed for one year against defects in workmanship or materials. Refer inquiries to Dept. F98.

---

**ACTUAL SIZE**
tron beams of any energy from 0.03 to 30 mev. The accelerator is basically a pressurized version, as developed by R. C. Herb of the University of Wisconsin, of the Van de Graaf generator. The building in which it will be housed is to be located at the base of a cliff, which will give lateral bracing to the tower and serve as a radiation shield for the control room and general laboratory that will be located atop the nearby mesa.

Laboratory rats carrying miniature radio receivers are being used at the University of California, Los Angeles, by Dr. J. A. Gengerelli. The object is to study learning and retention traits of the rats. The rats are enclosed in mazes through which they can run freely. By means of a radio transmitter tuned to the frequencies of the rats' receivers, electrical impulses can be delivered to their brains. In this way traits that might be influenced by electrical shock can be studied without the hindrance of long wires connected to the rats.

A group of cemeteries in Chicago will use a 160-mc Motorola central station and a radio dispatcher to help in the maintenance of extensive grounds and the smooth handling of funeral processions.

Dr. Gengerelli adjusts transmitter that sends impulses to tiny crystal rectifier placed under skin covering rat's skull. Note antenna wire projecting above rat.

The model illustrated is a six pole, six position circuit selector with standard mounting. Ledex Circuit Selector Switches are also available from stock in the following models: three pole twelve position, and six pole six position, all with either standard or panel mounting. Where quantity requirements justify, special selectors for specific applications will be engineered and priced by quotation.

The rotors of Ledex Circuit Selector Switches are powered by Ledex Rotary Solenoids. This compact, powerful solenoid is converted to a rapidly oscillating motor by means of a commutating switch and return spring. Provisions are made to operate Ledex Circuit Selector Switches from any standard power source.

Precision manufacture to exacting specifications and individual operating tests are your assurance of dependable, long-life service under severe operating conditions.

WRITE FOR COMPLETE DESCRIPTIVE LITERATURE WHICH PROVIDES DETAILED INFORMATION.

G. H. LELAND, INC.
118 Webster Street, Dayton 2, Ohio.

Gentlemen, Send me descriptive literature on the Ledex Circuit Selector Switch. It may be applicable to our . . .

Product:

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Wherever industrial electronic equipment is sectionalized, Amphenol AN connectors serve with efficiency and economy to provide quick connection and easy disconnect for servicing or movement.

They save money by permitting associated wiring for one or many circuits to be prefabricated, thus electronic devices may be tested at the factory and instantly connected for use on arrival. This greatly simplifies installation and servicing procedures.

Available in five major shell designs, each of which accommodates over 200 styles of contact inserts, Amphenol AN connectors handle voltages up to 22,000, amperages up to 200. Types with pressure-proof, explosion-proof or moisture-proof housings also are available as are standard elements for thermocouples.

The complete new Amphenol "AN" catalog is just off the press. A note on your letterhead will bring a copy immediately.

American Phenolic Corporation
1830 South 54th Avenue, Chicago 50, Illinois
Coaxial Cables and Connectors - Industrial Connectors, Fittings and Conduit - Antennas - Radio Components - Plastics for Electronics

Amphenol Non-Rotating, Aligned Contacts

A typical example of outstanding Amphenol design:
All Amphenol solder pockets face in one direction—easy to set in a fixture—easy to solder—will not twist or turn—ideal for low-cost, efficient production. Only one of a dozen important features.

NEW PRODUCTS
(continued from p 130)

into a 50-ohm load. The attenuator is calibrated in c-w or peak pulse power or voltage into a 50-ohm load. Pulse rate is 40 to 4,000 cycles. Details of performance are available.

Dual-Channel Recorder
Amplifier Corp. of America, 398-7 Broadway, New York 13, N. Y.
Model 910-T Twin-Trax magnetic tape recorder gives four continuous hours of recording and playback at 7+ inches per second. Two sound tracks are recorded on a single tape, one in one direction and the other in the reverse. Frequency response is essentially flat from 40 to 10,000 cps.

Vacuum Indicator
The Televac Model I vacuum indicating meter has a scale calibrated directly in the range from 1 to 1,000 microns. A voltage stabilizer mounted within the portable meter case eliminates errors...
due to line voltage fluctuations. Readings are obtained merely by the operation of an on-off toggle switch, no previous current adjustments or calibration being required.

**Signal Generator**

THE ROLLIN Co., 2070 N. Fair Oaks Ave., Pasadena 3, Calif. Model 30 power-type standard signal generator has 6 watts nominal r-f output and 50-ohm impedance with a 160-db range of attenuation and c-w, a-m or pulse operation. It can be tuned from 40 to 400 mc and has a spiral dial scale equivalent to 4 feet in length.

**Coil-Winding Machine**

ASSOCIATED PRODUCTION Co., 2655 W. 19th St., Chicago 8, Ill., announces new improvements in a coil-winding machine that permits almost micrometer adjustment of guide roller travel through positive electric limit switches. The machine winds coils of all types in 16 gage to 42 gage wire. Maximum arbor space is 36 inches.

**Mobile Dynamotor**

GOTHARD MFG. Co., 2110 Clear Lake Ave., Springfield, Ill. Model GP-26 dynamotor was designed chiefly for mobile transmitters but is suited to...
We undertake the Design, Development and Manufacture of any type of Optical—Mechanical—Electrical Instrument. Including Cameras for special purposes.

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COOLER OPERATION
KOTRON
STRIP-TYPE
SELENIUM RECTIFIERS
PATS. PEND.

100 MA. UNIT
- Max. A. C. line input 130 volts rms
- Max. inst. peak current 1000 Ma.
- Max. inverse peak voltage 360
- Average operating temp. 105°F
- Dimensions: 4-1/16" x 1-1/16" x 5/32"
- Other Sizes: 75 Ma. and 200 Ma.

Kotron's metallic rectifying elements are mounted in one plane. Plates cannot contribute heat to each other. Result—Cooler Operation, longer life...increased circuit efficiency. Wafer-thin Kotron saves space, mounts easier.

Write for Complete Technical Data, Prices and Delivery

STANDARD ARCTURUS CORPORATION
54 CLARK STREET · NEWARK 4, NEW JERSEY • Humboldt 2-2400

DC 44 Silicone Grease
for reliable permanent lubrication

Actual performance is the only true measure of a lubricant's quality. That is why more and more manufacturers are specifying Dow Corning Silicone Greases for their lubrication problems. Their tests show that longer lubrication life, greater oxidation resistance, elimination of gumming, and indifference to temperature extremes are all characteristic of the silicone greases.

Motorola Inc. of Chicago had a lubrication problem in their auto radio push-button tuner. The tuning is accomplished by a solenoid and plunger with a dash-pot action between the two for smoother operation. A thin film of the lubricant selected had to be permanent and maintain its consistency over the operating temperature range from —20°F to 160°F, to give the dash-pot action.

Their engineers tested many lubricants but the only one to allow satisfactory operation and still lubricate after 75,000 cycles was DC 44 Silicone Grease. It maintains the right consistency to give smooth action and permanent lubrication. Even in thin films this silicone grease does not run out or form gum.

We recommend DC 44 Silicone Grease for permanently lubricated anti-friction bearings, and for high temperature applications up to 350°F. DC 41 Silicone Grease is recommended for temperatures up to 450°F. DC 33 Silicone Grease is both a low and a high temperature grease and is recommended for use from —95°F to 300°F.

If you want permanent lubrication or have high temperature or low temperature problems it will pay you to investigate Dow Corning Silicone lubricants. Write for data sheet N 7-5 or call our nearest sales office.

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Dallas • Atlanta
In Canada: Fiberglas Canada, Ltd., Toronto
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LOW CORNING
FIRST IN SILICONES

September, 1948 — ELECTRONICS
many marine and aircraft applications. It is available in a range of capacities, with power output ranging up to 80 watts continuous and 150 watts intermittent duty. The unit weighs 84 pounds.

Sealing Unit

TRACERLAB INC., 55 Oliver St., Boston 10, Mass., is now manufacturing the SC-1A Autoscaler with a high voltage supply continuously variable from 500 to 2,200 volts. A time delay circuit is included. Scaling circuit and precision timer are actuated by a pushbutton. Overall resolving time of the input amplifier and scaling circuit is about 5 microseconds. Pulse height sensitivity is approximately 250 millivolts.

Pin Straightener

HYTRON RADIO & ELECTRONICS CORP., Salem, Mass. A new miniature 9-pin straightener is now

A special purpose microphone of many uses

Small, lightweight and inconspicuous, the Turner Model L40 can be worn in the lapel, held in the palm of the hand, or concealed. Highest quality moisture sealed crystal produces high signal level. Engineered by Turner to give crisp, clear speech reproduction. Widely used for sales demonstrations, public address, call systems, sound re-inforcing, and recording systems. Also used in dictographic and detective work. Comfortable to wear. Alligator clip secures unit to clothing. Finished in satin chrome. Complete with 20 ft. of attached flexible cable.

Model 3H-L40

- The Turner "third hand" and L40 microphone. A special combination for mobile sound work and call systems where operator must have both hands free. Ideal for sales demonstrators. The 3H slips over the head. Holds microphone close to mouth! Adjusts to any position. Also available with microphone switch at extra cost.

Ask your dealer

THE TURNER COMPANY
905 17th Street N. E., Cedar Rapids, Iowa

Microphones BY TURNER

containing a NEW FLUX
that is more active, stable and efficient than any rosin flux—yet NON-CORROSIVE • NON-CONDUCTIVE

ACTIVITY
"Resin-Five" will solder zinc, brass, nickel silver, nickel plate, copper and ferrous alloys.

STABILITY
Under the most extreme soldering temperatures the Flux still does the soldering job.

MOBILITY
The unusual activity and stability of "Resin-Five" give it complete mobility.

KESTER "RESIN-FIVE"

The most important development in Cored Solder within the last ten years. "Resin-Five" has virtually no odor even at extreme temperatures. Available in 5 core sizes; varying percentages of flux content. Diameters ranging from .010" to .250". All practical alloys.

NEW PRODUCTS (continued)
available. It is built of aluminum and stainless steel. Designed primarily for radio servicemen, it should find utility in any laboratory.

Filter Selector
AEROVOX CORP., New Bedford, Mass. Choice of proper interference filter is simplified by the analyzer that can be varied to simulate all types of stock filters manufactured by the company.

Knob setting designations are calibrated in terms of these types. Optimum arrangement can then be made after it is determined by means of the analyzer.

Sensitive Relay
ALLIED CONTROL CO., Inc., Dept. S, 2 East End Ave., New York 23, N. Y. Type BK relay, designed for high sensitivity, has a d-c coil rating up to 32 volts at 24 milliwatts and an a-c coil rating of 220 volts.

September, 1948 — ELECTRONICS
NEW PRODUCTS (continued)

at 0.240 volt-ampere. Contact rating is 1 amp at 48 v d-c. It is supplied in single or double pole, normally open or normally closed contact arrangements, also double throw.

Two-Pole Relay

EBERT ENGINEERING AND MFG. Co., 185-09 Jamaica Ave., Hollis 7, L. I., N. Y., announces a 2-pole normally-open or normally-closed mercury relay for loads up to 25 amps breaking both sides of the line, also motor loads up to 3 h-p at 230 volts a-c. Overall dimensions are 5 in. long, 3 in. wide and 2 in. high.

High-Frequency Triodes

AMPEREX ELECTRONIC CORP., 79 Washington St., Brooklyn, N. Y., announce the 492 and 492-R h-f water-cooled and air-cooled triode amplifier and oscillator tubes having a 5-kw plate dissipation. The grid of each is mounted to a ring seal by an unperforated section of copper cone which forms a shield between filament and anode, and makes the tube suitable for grounded-grid h-f circuits.

Intrusion Alarm

EL-TRONICS, INC., 2647 North Howard St., Philadelphia 33, Pa. Model
Faster, Simpler
Audio Analysis with Model AP-1

Panoramic Sonic Analyzer

Reduce time, complexity and cost of making audio measurements with the unusual advantages offered by the Panoramic Sonic Analyzer. By resolving a complex audio wave into a spectrograph showing the frequency distribution and voltage amplitude of the components, Model AP-1...

- Eliminates slow point-by-point frequency checks
- Provides a quick overall view of the audio spectrum
- Enables determination of changes in waveform content while parameters are varied
- Furnishes simple presentations for production line testing.

Panoramic Sonic Spectrograph at 750 cps square wave.

Use Model AP-1 for analyzing...

- Harmonics
- Intermodulation
- Vibration
- Noise
- Acoustics
- Materials

Features...
- Continuous scanning from 40-20,000 cps in one second
- Wide input voltage range
- Linear and log voltage scale
- Closely logarithmic frequency scale
- Built-in voltage and frequency calibrator
- Simple operation.

WRITE for detailed specs, price and delivery.

New Literature Available

Panoramic Sonic Analyzer

Write for Catalog No. 84

Beach-Russ Company
52 Church St., New York 7, N. Y.
HS-5 alarm detects intrusion by change in antenna capacitance upon approach of a person. It also detects fire by means of a heat detector that operates at about 160 F. Slow capacitance changes owing to changing meteorological conditions will not affect the device.

**Midget Thyratron**

**GENERAL ELECTRIC Co., Schenectady, N.Y.** Type GL-5663 midget thyratron designed to maintain low control grid and shield grid currents is inert-gas filled. Peak forward and inverse voltage ratings are 500 volts. Average anode current is 20 ma.

**Symbol Tracer**

**RAPIDESIGN, INC., P.O. Box 592, Glendale, Calif.** announces the new

**PICKERING reproducers** have always been built to the highest standards of the critical listener willing to pay a premium for excellence in record reproduction.

The growing demand for Pickering quality and the resulting increase in production have made possible substantial price reductions.

Revised manufacturing techniques have enabled us to actually improve quality and lower prices at the same time.

We take great pleasure in giving our customers the benefit of lower production costs.

**Model S-120M**

- with .0027" Sapphire Stylus
- Former List Price—$25.00
- Now $16.50

**Model D-120M**

- with .0025" Diamond Stylus
- Former List Price—$60.00
- Now $41.50

**NEW...**

To the line of Pickering Cartridge Reproducers is the Model D-140S for the new long playing, MICROGROOVE type disc recordings. The D-140S has a diamond stylus of .001" radius, tracks with a pressure of 5 grams and, like all Pickering Cartridges, incorporates all of the known requirements for perfect tracking, minimum record and stylus wear, and distortion-free reproduction.

**Model D-140S with .001" Diamond Stylus** $60.00 List

Oceanside, Long Island, N.Y.
NEW PRODUCTS
(continued)
No. 31 Electroneer template for design and drafting personnel in the industrial electronic, television, radio, and electrical engineering fields. A cellulose nitrate sheet of 0.04-inch thickness, it measures 4½ x 6½ inches.

High-Gain T-V Antennas
THE WORKSHOP ASSOCIATES, INC., 66 Needham St., Newton Highlands 61, Mass., has developed eight different high-gain antenna arrays for television and f-m. Each is mounted on a single mast and designed for reception of all channels operating in a particular area. Elements are constructed of half-inch aluminum tubing. More arrays can be added to the installation as additional stations go on the air.

Low-Current Power Supply
BETA ELECTRONICS Co., 1762 Third Ave., New York 29, N. Y. Model 251 regulated low-current power supply is used for currents below 10 milliamperes at voltages up to 500 volts d-c. Output voltage is continuously variable, up to 500, either positive or negative with...
NEW PRODUCTS (continued)

respect to ground; and it will change less than 0.5 percent at any setting for line voltage variations from 95 to 105 volts.

Calorimeters
R. A. WHITEMAN, 630 N. Wisner Ave., Park Ridge, Ill. The types IHC-20 (illustrated) and IHC-50 calorimeters measure and check the power output of induction heating units. They permit measurements from low values to 20 kw and 50 kw respectively. Each is available in either magnetic or nonmagnetic steel.

Light-Beam Wattmeter
GENERAL ELECTRIC Co., Schenectady 5, N. Y., has developed a new portable light-beam wattmeter giving readings in the low wattage, low power factor ranges for frequencies of 25 to 3,000 cycles. It can be used as an instrument calibrator and in laboratory production testing.

Actuator
PHILLIPS CONTROL CORP., 612 N. Michigan Ave., Chicago 11, Ill. The 61A actuator features a frame of

An Electrical Relay, whatever its style or type, responds to a changing condition in one electrical circuit to cause a change in another electrical circuit. Wherever electrical energy is used as a controlling agent, SIGNAL ENGINEERING Relays can be applied in a wide variety of uses. Perhaps you have an electronic circuit where a change in voltage or current requires the switching of several other circuits. The SENSITIVE MULTIPLE CONTACT PLUG-TYPE RELAY, illustrated at right, is designed to meet just such a condition and offers up to 6 pole, double throw, with a 20 point plug. A.C. or D.C. Ask for Bulletin 50-6.

OR
A keying circuit or pulsing circuit where rapid response and low current drain are required characteristics. The SERIES 10 AND SERIES 20 RELAYS are fast, sensitive, shockproof and are adaptable to many contact arrangements. Bulletin KR1-6.

OR
The need for a small, rugged, POWER RELAY, double pole, double throw, without pigtail, for operation of bells, horns, lamps, small motors, etc. Write for Catalog 6-6.

OR
An application requiring a high frequency COAXIAL CABLE RELAY, with correctly designed, low loss circuit, available with A.C. or D.C. actuating coils. Bulletin CR1-6.

ELECTRONICS — September, 1948
What counts, sales-wise, is what your customer sees. What gets the attention for Premier Metal Products, quality-wise, is their sharpness and clarity...close tolerances...rich colors and baked-in finishes. Let us tell you how these qualities can add important sales-appeal to your products.

Etched & Lithographed on:
- Aluminum
- Brass
- Bronze
- Monel
- Nickel Silver
- Stainless Steel

WRITE FOR BULLETIN

PREMIER METAL ETCHING COMPANY
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Quality Products for Over 35 Years

Dependable!

Railway Express is part of the modern miracle of transportation which makes the people of your community neighbors with those of other cities and towns from coast to coast. Neighbors...who depend on each other, near and far, for the essentials and luxuries which contribute to our way of life.

The men and women of Railway Express are your neighbors, too, wherever you may live. They work with you and for you to provide a complete shipping service for every one of your business and personal needs. You'll find them dependable neighbors, always ready to serve you with speed, efficiency and courtesy.

It's good business to say, "Ship it RAILWAY EXPRESS!"

RAILWAY EXPRESS

...Maintains 23,000 offices (there's one near your factory, office or home);
...Uses 10,000 passenger trains daily;
...Has 18,000 motor vehicles in its pick-up and delivery services;
...Offers extra-fast Air Express with direct service to 1,078 cities and towns.
bonded silicon steel laminations and a T-shaped laminated plunger adaptable for both push and pull operations. It is available for continuous duty on 115 volts, 60 cycles, with a maximum stroke of one inch. Approximate pull is 2 pounds at 1⁄4 inch, 4.2 pounds at 1-inch stroke.

**Geiger Counter**

**OMAHA SCIENTIFIC SUPPLY CORP.,**

3623 Lake St., Omaha 4, Nebraska.

The 31-pound TX-6 Geiger counter consists of a probe, amplifier, and headphones. Gamma rays from uranium ore produce clicks in the phones. The instrument is sensitive enough to detect radiation in a radium dial watch.

**Photorelays**

**PHOTOBELL Co.,** 116 Nassau St.,

New York 7, N. Y. Type ES-1 electric eye relay operates from 115 volts 60 cycles, and comprises a photoelectric tube, amplifier, relay and sensitivity adjustment all mounted on a 2½ x 5-inch steel chassis. Type ES-2 is similar but includes a light projector built into
**NEW PRODUCTS**

**THE NEW THYROMETER**

Integrating type scaler with ratemeter

Designed for precision measurement of radioactive samples in the research and medical laboratory.

Some of the special features include:

1. Both scaler and ratemeter can be operated as a unit or the ratemeter can be operated as a separate unit.
2. All operating controls are mounted on the sloping panel.
3. The unit employs a three decade logarithmic type ratemeter.
4. A strip chart recorder may be used to indicate the output of the ratemeter circuit.
5. A range switch provides selection of counting ranges of one, two or three decades (100 - 1000 - 10,000 counts per second) for the recorder.
6. The scaling circuit measures the time required to accumulate a predetermined count with a total selection of five ranges up to 163,840 counts.
7. Available for use with a choice of G-M tubes, sample stage, probes and preamplifiers.
8. The unit may be mounted on an undercarriage as illustrated for utility and accessibility.
9. The ratemeter may also be furnished as a separate unit.

Write for particulars on this or other radiation measuring instruments and components.

**THE VICTOREEN INSTRUMENT CO.**

5806 HOUGH AVE., CLEVELAND, OHIO

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**Heat-Transfer Unit**

**EASTERN INDUSTRIES, INC., 236 Elm St., New Haven 6, Conn. Model No. 5-H.T.U.**

is a new heavy duty heat-transfer unit for cooling the magnetron power tube in an induction-heated oven. The unit will dissipate 3,000 watts within a temperature rise of 40°F above ambient.

**Engine Synchronizer**

**SQUARE D CO., KOLLSMAN INSTRUMENT DIVISION, 80-08 45th Ave., Elmhurst, N. Y.**

A new 28-ounce synchronous differential contains two synchronous motors and a mechanical differential. Used in synchronizing engines, it serves as an...
Exacting users prefer JOHNSON wafer sockets because they are insulated with grade L4 steatite or better, top and sides are glazed, the underside is impregnated against moisture. Contacts are brass with steel springs, cadmium plated and are mounted against phenolic washers in molded recesses to prevent movement. Rivets are countersunk and mounting holes bossed to permit sub-panel mounting. Locating grooves facilitate tube insertion.

Illustrated above is the 122-225, a 5 pin socket which can be used with such tubes as the 807.

Additional Types
122-224, 4 pin, for tubes such as the 812 or 740.
122-226, 6 pin, for tubes such as the T21.
122-227, 7 pin medium, for tubes such as the RK34.
122-217, 7 pin small, for tubes such as the 6A7.
122-228, octal, for tubes such as the 6L6 and 815.

Also available are Giant wafer sockets for transmitting tubes, of 5 or 7 pin bases, sockets incorporating a base shield, and Super Jumbo 4 pin base sockets.

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WAFER SOCKETS
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Precision provides the strength, the insulation, the dependability by the most thorough specialized engineering, exactly to your specifications.

Spiral winding of the tube-heavy heat-treated compression—swaged tube ends securely locked—impregnation of the complete assembly are factors of Precision’s exceptional service. Lightest of all coil bases. Permit larger gauge, or more wire of same gauge in winding area.

Let us make up samples for your requirements
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Engineers and Designers who insist on dependable components have adopted Vickers Selenium Rectifiers into their circuits. They are specifying Vickers products, and are submitting their rectifier problems to us. Our greatly expanded plant facilities, plus the recognized dependability of Vickers products, make it possible for us to offer the most complete line of Selenium Rectifiers and self-generating Photoelectric Cells.

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CANADA: Powertronic Equipment Ltd., 494 King St., E. Toronto 2, Canada

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www.americanradiohistory.com
intermediary regulating device of engine control equipment. It may also be used as a torque-producing half-speed synchroscope. The unit operates from a three-phase source over a frequency range of 15 to 60 cycles with an input voltage of 0.007 times the frequency in cycles per minute.

Control Tester

FLIGHT RESEARCH ENGINEERING CORP., P.O. Box 1-F, Richmond 1, Va. The Servo Analyzer is used as an aid in developing and testing servos and automatic control systems employing 400 cycle error measuring devices such as Selsyns or E type pickoffs. Frequency response and transfer function may be obtained over an input range of from 1 to 60 cps.

Miniature Capacitors

SOLAR MFG. CORP., 1445 Hudson Blvd., North Bergen, N. J. Type TST capacitors are 3/16 inch in diameter and 1 inch long, sealed against humidity effects. Details are given in a new catalog bulletin.

High-Speed Counters

POTTER INSTRUMENT CO., INC., 136-56 Roosevelt Ave., Flushing, N. Y., has developed a new system for measuring frequencies from 0 to 1.6 mc with accuracies
of one part in ten million or greater. Basic units of the system are two high-speed electronic counters, a crystal oscillator and an electronic switch. The instrument shown, a Doppler frequency chronograph, measures unknown frequencies of 50 to 200 kc using the new system.

Industrial Scope

GENERAL ELECTRIC Co., Syracuse, N. Y. Industrial oscilloscope type YNA-4 is intended primarily for servicing such equipments as resistance welders, motor control circuits, and photoelectric circuits. A three-inch tube is employed with pushpull d-c amplifiers. Horizontal sweeps range from 10 cps to 20 kc.

Low-Voltage Soldering Iron

JET THERMAL DEVICE Co., 2873-86th St., Brooklyn, New York. The Slim Jim soldering iron can be used on automobile storage battery or socket

Announcing

Six new volumes in the Massachusetts Institute of Technology RADIATION LABORATORY SERIES

MICROWAVE TRANSMISSION CIRCUITS
Vol. 9. Edited by GEORGE L. RAGAN, General Electric Research Laboratory, Schenectady, N. Y. 716 pages, illustrated, $8.50

This volume brings you a practical treatment of the problems of power transmission at microwave frequencies. Actual designs and performance data, as well as principles and techniques, are given for transmission along coaxial line and waveguides. Use of the circle diagram, matching techniques, and methods for extending the frequency range for good operation are carefully analyzed.

MICROWAVE MAGNETRONS
Vol. 6. Edited by GEORGE B. COLLINS, Chairman, Department of Physics, University of Rochester. 806 pages, 533 illustrations, $9.00

Covers completely the theory, design and operation of magnetrons in the frequency range from 1000 to 20,000 Mc/sec, and in the many modifications that extend the usefulness of these tubes. The circuit theory and electronics of this kind of oscillator are discussed with special attention to the subjects of starting phenomena, electronic tuning, and stabilization of frequency. Practical problems of magnetron design are dealt with in full.

ELECTRONIC INSTRUMENTS
Vol. 21. Edited by IVAN A. GREENWOOD, Jr., General Precision Laboratory, J. VANCE HOLDHAM, JR., Laboratory for Electronics, Inc., and DUNCAN MACRAE, Jr., Harvard University. 721 pages, 466 illustrations, $9.00

This book brings you the theoretical background and practical details of electronic analogue computers, instrument servomechanisms, voltage and current regulators, and pulse test equipment. It includes the practical design of accurately stabilized power supplies and the problems of design and construction of prototype equipment. Numerous practical applications and examples are presented, including special servosystems and radar test oscilloscope designs.

CATHODE RAY TUBE DISPLAYS
Vol. 22. By J. THEORDORE SOLLER, Professor of Physics, Amherst College, M. A. STARR, Department of Physics, University of Portland, and GEORGE E. VALLEY, Jr., Assistant Professor of Physics, M.I.T. 746 pages, illustrated, $10.00

Here is practical aid in the design of instruments employing cathode ray tubes—a thorough discussion of their basic characteristics, principles of operation, and methods of application. This book explains the design and construction of beam deflection and focusing devices, optical projection and measuring apparatus, and auxiliary mechanical equipment. A complete treatment of cathode ray tube screens is included.

RADAR SCANNERS AND RADOMES
Vol. 26. Edited by W. M. CADY, Head, Physics Section, U. S. Naval Ordnance Test Station, Pasadena Area, M. B. KARELITZ, General Precision Laboratory, Inc., and L. A. TURNER, Dept. of Physics, State University of Iowa. 513 pages, illustrated, $7.00.

A comprehensive discussion of the engineering and design features of radar scanners, or antenna mounts, and radomes, the plastic enclosures for antennas. The book includes a thorough development of land-based, shipborne and airborne antennas, antenna mounts, and stabilization. Part I provides a thorough electrical treatment of radomes, including design, materials, installation and testing.

PRINCIPLES OF MICROWAVE CIRCUITS
Vol. 8. Edited by C. C. MONTGOMERY, Associate Professor of Physics, Yale University, R. H. DICKE, Associate Professor of Physics, Princeton University, and E. M. PURCELL, Associate Professor of Physics, Harvard University. 486 pages, illustrated, $5.00

This volume brings you first a description of guided electromagnetic waves, starting from Maxwell’s equations. The concept of impedance is generalized to apply to waveguide circuits. Following a review of low-frequency network theory, general network theorems which apply both to low and to high-frequency circuits are developed. The properties of waveguide circuit elements are fully discussed. These general properties are applied to the discussion of microwave devices.

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NEW PRODUCTS (continued)

power. It is designed for heavy duty but weighs only 33 ounces including tip and cord. The unit will operate on a-c or d-c.

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The type 24 split-armature relay can be adjusted to operate at 0.005 watt from 0.01 to 115 volts d-c or a-c. Several contact combinations are available.

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ELECTRO-VOICE, INC., Buchanan, Mich. Models 650 and 645 high-fidelity, high-output dynamic broadcast microphones are designed for both f-m and a-m. Each is equipped with a newly developed shock mount and a switch which permits instant
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New James Knights Co. Catalog On Request

AN ENGINEER wanted three crystals on approximately 90 kc in one hermetically sealed holder. The James Knights Co. made delivery in 72 hours, our Type H18.

Fractional Motor

BACH ELECTRICAL CORP., Bridgeport, Conn., announces a new fractional 110-volt 60-cycle a-c motor. It is Fiberglas insulated and has cast-aluminum rotors. Further information is available from the company.

Control Panel

EWART AND KOCH, 15 Brattle St., Cambridge 38, Mass. The switch and receptacle unit illustrated is equipped with eight feet of rubber cord with fused plug. A neon pilot lamp shows when the unit is plugged in.

Plane Radio

RADIO CORP. OF AMERICA, Camden, N. J. A new compact, plane-radio transceiver is now available. The One-Sixteen weighs only nine pounds and fits into the instrument panel. A single selector switch tunes in any broadcast program or any frequency from 200 to 400 kc. A special

NEW PRODUCTS (continued)

selection of either 50 or 250 ohms impedance balanced to ground. Further information is available in a recent bulletin.

HERE'S A NEW MATERIAL that can cut costs and ease production problems wherever ultra-high-frequency insulation is required. It's G-E #1422...a new development in plastics.

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marker indicates standard tower frequency of 278 kc.

Radio Instruction

Radio Corp. of America, Camden, N.J. The Dynamic Demonstrator is an f-m and a-m six-tube radio receiver with its circuits and components laid out on a panel 45 x 33 inches for purposes of study. It is designed to simplify the teaching of radio theory, operation and maintenance. The unit will operate on a-m from a signal generator as well as an antenna. The f-m i-f will operate from a sweep generator.

Audio Units

Fairchild Camera & Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N.Y. Audio units from microphone preamplifier to rack frame are available in numerous combinations that are flexible to the current needs of the amplifier system. Basic component is Unit 620 power amplifier with a frequency response from 20 to 20,000 cycles.

Appliance Tester

The Hickok Electrical Instrument Co., 10357 Dupont Ave., Cleveland 8, Ohio. Model 900B volt-ampere wattmeter is designed for testing all a-c appliances from clocks to 220-volt electric ranges. The unit incorporates a current

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(transformer for additional ranges of 5,000 and 10,000 watts, and 65 and 130 amperes.)

Literature

Fabrics Bulletin. The Duplan Corp., Industrial Division, 512 Seventh Ave., New York, N. Y. Many technical facts for a large number of standard weaves of Fiberglas and Nylon fabrics are given in a recent bulletin. A wide range of industrial applications is illustrated and described, together with details of their properties.

Connector Catalog. Cannon Electric Development Co., Humboldt St. and Ave. 33, Los Angeles 31, Calif. The C-47 edition of Cannon Plugs contains 32 pages in 3 colors, covering the thirteen major type series of multi-contact electric connectors. Prices are given on all except the AN, K, and DPD series.

Motor Catalogs. Gleason-Avery Inc., Auburn, N. Y. Two new catalog sheets have been recently released. The first deals with both synchronous and nonsynchronous instrument and timing motors. The second covers the series 500 gear motors. Both are well illustrated and give complete specifications.

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For further information on this and other G-E thermocells, quartz crystals and germanium diodes write today to: General Electric Company, Electrotube Park, Syracuse, New York.

ELECTRONICS — September, 1948
booklet shows the chief features of the Univac (Universal Automatic Computer), which is the central component of an electronic system by which many types of information can be processed with speed and economy. Operation includes the use of a newly developed magnetic tape recording system.

Microwave Test Equipment. Polytechnic Research and Development Co., Inc., 66 Court St., Brooklyn 2, N. Y. New sheets are now available for the company's catalog of test equipment. Included are waveguide terminations, variable flaps attenuators, slide screw tuners, and directional couplers.

All-Channel Antenna. The Workshop Associates, Inc., 66 Needham St., Newton Highlands 61, Mass. A catalog sheet and assembly instructions are available for the new indoor television and f-m antenna that is constructed of corrugated board covered with aluminum foil. The antenna is designed to be mounted in an attic.

Transmitting Tubes. Sylvania Electric Products, Inc., Emporium, Pa. Characteristics on more than a score of types with rated plate dissipation ranging from 20 to 175 watts are given in a six-page bulletin.

Motor Control. J. B. Lewis & Co., 3324 Main St., Hartford 5, Conn. Bulletin 105 points out the features of a new wide range, adjustable speed, motor control employing two electronic tubes.

A-M and F-M Tuner. Browning Laboratories, Inc., Winchester, Mass., has issued catalog sheet 8415 describing the characteristics of an a-m and f-m tuning unit with f-m sensitivity of 10 microvolts for 30 db noise reduction. Curves of its performance are also available.

Crystal Pickup. Electro-Voice, Inc., Buchanan, Mich. The Series 12 Torque Drive crystal pickup cartridge was developed to provide light weight coupling of crystal to record groove. Fourteen outstanding...
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**NEW PRODUCTS**

(continued)

**Standards Index.** American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. The recently issued 240-page index to ASTM standards as of December 1947 will be furnished without charge on written request. Items are listed under appropriate key words according to particular subjects.

**Electronic Glassware.** T. C. Wheaton Co., Millville, N. J. A complete line of electronic glassware, particularly glass-to-steel hermetic terminals in various shapes and sizes, is covered in a recent bulletin.

**Industrial and Laboratory Devices.** Airmec Laboratories Ltd., 19 Charterhouse St., London, E. C. 1, England. Descriptive leaflets are available on the d-c ionization voltage tester type 732, the d-c oscilloscope type 723, and the electromechanical counter type 737.

**Oscillography Equipment.** Allen B. DuMont Laboratories, Inc., 1000 Main Ave., Clifton, N. J., has issued an informative pamphlet covering c-r tubes, oscillographs, allied equipment, and accessories. It may be obtained by request on business letterhead.

**Laboratory Catalog.** Fisher Scientific Co., 717 Forbes St., Pittsburgh, Pa. and Elmer & Amend, 635 Greenwich St., New York 14, N. Y. A 40-page profusely illustrated book pictures 288 laboratory innovations and describes more than 300 equipment items that have been developed to aid laboratory work.

**Chemical Products.** General Electric Co., 1 Plastics Ave., Pittsfield, Mass. An 18-page illustrated booklet CDP-576 describes briefly a wide range of chemical products such as plastics, resins and insulating materials, metallurgical products and compounds. A technical bulletin is available on each product described.

**Tube Data.** Radio Corp. of America, Harrison, N. J. A four-page technical bulletin gives complete data on the 6BA7 and 12BA7 pentagrid converters which are in-
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in quantities suitable to Volume Production...it may pay you to call upon the Design Engineers of United-Carr and its subsidiaries. They have helped many manufacturers.

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Meets basic needs by providing for VHF Transmission, LF Range Reception and Rotatable Loop Navigation.

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Combines the advantages of the Type 11A and the Type 17, offering 2-way VHF, together with LF Range Reception and Rotatable Loop Navigation.

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Sensitivity
20000 ohms/volt AC-DC

Ranges
AC-DC Volts: 0-3, 15, 75, 150, 300, 750, 1500, 7500

DC Current: 0-150, 1/5 MA, 1/30 MA, 1/5 MA, 1/15 A

Ohms: 0-5000, 50,000, 50,000000

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Features:
- Measure from a low of 10 microamperes to a high of 15 amperes—from 0.2 volts to 7500 volts—from 1 ohm to 50 million—from minus 10 to plus 73 DB.

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ELECTRONICS — September, 1948
Gothard DC-AC ROTARY CONVERTERS

Gothard Rotary Converters are designed to deliver outputs of 90% Power Factor. Standard output voltages vary 8 to 15% from no load to full load. No starting equipment is required up to 500 VA. Input voltages from 6 to 230 V DC. Output 110 to 1000 VA at 60 cycles, 90 to 800 VA at 50 cycles.

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2114 Clear Lake Avenue Springfield, Illinois
EXPORT DIVISION: 25 Warren St., New York 7, N. Y.

NEW PRODUCTS (continued)

cent leaflet pictures and technically describes the model RH. 24 Redifon industrial radio heater with an output of over 350 watts. The unit is specifically designed for dielectric heating applications and features a single oscillator valve of the latest repairable silica-envelope type.

Paper Tubulars. Cornell-Dubilier Electric Corp., South Plainfield, N. J. Descriptive bulletin NB116 covers the Grey Tiger paper tubulars which are Vikane impregnated and feature outstanding performance over a temperature range of \(-55^\circ\text{C}\) to \(+100^\circ\text{C}\). These capacitors are primarily designed for use in automobile radios and other high-temperature applications.

Recording Catalog. Gorrell & Gorrell, Haworth, N. J. Bulletin G-100 is a condensed catalog briefly outlining features, functions and general construction of several types of instruments for timing, control, and graphic recording. Complete details and typical applications are given in individual bulletins.


Internal Defect Locator. Sperry Products, Inc., 1505 Willow Ave., Hoboken, N. J. Operation and application of the new portable, lightweight type SR05 supersonic reflectoscope is described in bulletin 3001. This nondestructive testing instrument is used for locating internal defects in metals and other materials.

Precision Equipment. R.T.S. Electronics Ltd., King St., Exeter, England. The model EA11 single-channel cro, model EA20 resistance-capacitance bridge and EA36 signal tracer are fully treated in a 12-page, board-covered booklet.

Fractional H-P Motors. Alliance Mfg. Co., Alliance, Ohio. Various types and sizes of electric motors rated from less than 1/400th h-p to 1/20th h-p are described and illustrated in a four-page folder. Applications are given.

Sigma's specialty is the supplying of relays to meet unusually exacting requirements. Such success as we enjoy is due as much to willingness to study applications in detail as to basically good relay designs.

You are urged to take advantage of this in submitting your problem, by stating particulars of purpose and function, permitting us to see the relay as part of a complete system.

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Write for Bulletin F-68

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The type RI14MS sinusoidal potentiometer is illustrated. It is wound to a total resistance of 35,400 ohms and provides two voltages proportional to the sine and cosine of the shaft angle. It will generate a sine wave true within ±.6%. Overall dimensions are 4½" diameter x 4 11/32 long plus shaft extension ½" diameter x 1½" long.

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Write for Catalog
NEWS OF THE INDUSTRY
(continued from p 134)

programs are currently being broadcast in Leningrad twice a week, and are expected to be increased to four times a week soon. The Leningrad center also plans to have in operation by autumn a portable television transmitter.

During the past two years, the Moscow Radio Club organized two cycles of 15 lectures each dealing with the principles of television and how to build a television receiver. Under the aegis of the club's television section, 400 amateurs made their own television receivers and are now viewing regular programs broadcast by the Moscow Tele-Center.

Rural Industrial Radio

A SPECIAL INDUSTRIAL radio service was recently proposed by the FCC to make radio-communication available to persons engaged in commercial or industrial operations which are predominantly rural in nature. Under this category would be included farming, ranching, irrigation, mining and construction activities.

Also covered by the proposed special service would be those engaged in commercial and industrial operations involving hazard to life and property where use of radio would decrease such hazards, those engaged in operations reacting directly upon public welfare or safety, and maintenance and repair services directly involving public health or well-being.

URSI-IRE Meeting

A SECOND joint meeting of the American Section, International Scientific Radio Union, and the Institute of Radio Engineers will be held in Washington on Thursday, Friday, and Saturday, October 7, 8, and 9, 1948.

The program will, as usual, be devoted to the more fundamental and scientific aspects of radio and electronics. The program of titles and abstracts will be available in booklet form for distribution before the meeting. Anyone wishing to submit papers for presentation at this meeting should send in title and a 100-word abstract before
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NEWS OF THE INDUSTRY (continued)

August 20 to Dr. Newbern Smith, Secretary, American Section, URSI, National Bureau of Standards, Washington 25, D. C.

San Francisco Audio Society

ON JUNE 22 in San Francisco's NBC Building the first organizing meeting for formation of a San Francisco Section of the Audio Engineering Society was held. About thirty audio specialists attended and established by acclamation a temporary chairman, L. R. Ganic of Audiophone, Oakland, Calif. There was also a talk and demonstration of the Ampex tape recorder by Myron Stolaroff.

Television Reallocation

HEARINGS WERE HELD in Washington, D. C. recently at which the FCC proposed a nation-wide reallocation of the twelve television channels. A 10 x 16ft. map of the U. S., on which interference conditions are graphically portrayed, was prepared by Allen B. DuMont Laboratories, Inc., for the occasion.

Dr. Thomas T. Goldsmith (right), head of DuMont research division and an assistant, Robert Wakeman, with map of U. S. showing FCC's proposed allocation.

The DuMont proposal includes first the correcting of some serious spacings in the proposed FCC allocation plan and secondly the addition of a few further channels beyond the present twelve.

Channel Numbers to Stay

WAYNE COY, chairman of the FCC, recently announced that the Commission is not considering a renum-
VERSATILITY...PLUS

The Tektronix Type 511 is a portable wide band oscilloscope providing facilities formerly available only in very expensive, cumbersome instruments.

Sweep Characteristics
Continuously variable .1 second to 1 microsecond (10 cm. deflection).
Direct reading sweep speed dial.
Choice of triggered, recurrent or single sweeps at all speeds.
Triggers on time waves to 10 mc. or pulses over .05 microsecond.
Any 20% of sweep may be expanded 5 times.
DC coupled PP amplifier for external sweep input.

Miscellaneous
Calibrating voltage 0-1, 0-10, 0-100 volts, 60 cycles.
CRT SCP1A, SCP7A or SCP11A operating at 3 kv.
Direct connection to all plates from side panel.
Total weight 65 pounds, self contained.

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The theory and application of electronics in industry

Industrial Electronics Reference Book

By Electronics Engineers of the Westinghouse Electric Corp.

This book was compiled to answer the need for complete and clear information on the application and design of industrial electronic equipment. Written by a group of engineers, each an expert in his particular branch of electronics, the Industrial Electronics Reference Book contains the most recent information on the subject. The material is directed at the practicing engineer. Its aim is to give him a better understanding of the scope and limitations of electronic apparatus as it is applied to industrial processes.

Contents Include:

Physical Background of Industrial Electronics; Electron Emission; Control of Free Electrons; Electrical Conduction in Gases; Vacuum Tubes; Gas Tubes; Photoelectric Devices; Industrial X-Ray Tubes; Cathode-Ray Tubes; Ultraviolet Radiators; Circuit Elements; Tuned Circuits and Filters; Transformers; Vacuum Tubes as Circuit Elements; Electronic Motor Control; Industrial Photoelectric Control; Care and Maintenance of Electronic Apparatus.

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NEWS OF THE INDUSTRY (continued)

boring of the present 12 television channels. In a letter to the executive vice-president of the RMA he stated that neither the report and order deleting Channel No. 1, nor the proposed rule revising the allocation of television channels contemplates changing the numbering of the remaining 12 television channels.

Army Tests Transistors

A RECENT Bell Laboratories development, the transistor (see p 68, this issue), gives promise of having great military value for communications equipment. Exhaustive tests are being undertaken by the Signal Corps to gather complete data on the device's characteristics and its reaction to shock, vibration and extremes of climate.

The transistor, a new crystal triode, is important to the army because, having no filament, it requires no heating current to amplify voltages. In portable communications equipment, such as the walkie-talkie and the handy-talkie, a large part of the weight and bulk consists of batteries for heating tube filaments. Transistors would greatly reduce the ground soldier's load.

Signal Corps engineers caution that there is little conclusive data on the new crystal triode's performance. They believe it will be useful where low power is involved but expect to continue to rely on the vacuum tube for high-power equipment.

Utilities Radio Committee

AT A RECENT meeting attended by twenty-two power utilities representatives from all over the country, the National Committee for Utilities Radio was organized in Chicago. It will be a successor committee to the group formerly known as Committee 4 of Panel 13, RTPB.

The first item of business which the new organization undertook was the formulation of comments to be forwarded to the FCC on their new proposal for the reallocation of frequencies in the various bands and on the proposed new rules under which the licensees represented by this committee are to operate. Empha-
WHEREVER power drives or remote control are required, you can depend upon us to produce the Flexible Shafts that will meet the exact specifications. We have years of experience in manufacturing flexible shafting for all types of industry. If we do not have what you require in stock, we can make shafts to your specifications. Our engineers will be glad to work out your problems without obligation.

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Our research and development now permit us to offer manufacturers genuine diamond needles hitherto unobtainable.

Radius and angle are positive gem finish, insuring gem contact in record groove, and assuring a minimum of record wear.

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Our diamond needles may be inserted in any spring or similar assembly with a minimum of mass.

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MicroMatch
Model MM252
Model MM272

New Direct Reading Wattmeter—MicroMatch models MM252 and MM272 —can be used in laboratory or field to monitor continuously RF power or standing wave ratio at levels up to 500 watts, and may be used to measure momentary power levels up to 1000 watts. Price, either model $60.00

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Micro-Match models available for operation at 500 kc to 250 Mc, and power levels of 2 to 50,000 watts.

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NEWS OF THE INDUSTRY

(continued)

manufacture all Hallicrafters communication designs.

RADIO SONIC CORP., formerly Tuck Electronic Corp., has moved its research laboratory and factory to 186 Union Ave., New Rochelle, N. Y.

AMERICAN BROADCASTING COMPANY recently installed an RCA 80-ft antenna for WJZ-TV atop the Hotel Pierre, New York City.

GENERAL ELECTRIC Co., Syracuse, N. Y., designed and installed a 24-watt f-m transmitter for Syracuse University. Preliminary FCC approval of such noncommercial, low-cost f-m broadcasting has been given.

HOWARD W. SAMS & Co., Inc., Indianapolis, Ind., publishers of the Photofact Folders, in began set No. 38 a presentation of television principles for radio service technicians. The entire series will be included in consecutive sets.

THE PERMANENTE METALS CORP. will reactivate its plant at Permanente, Calif., to handle the facilities of an entire German aluminum foil mill purchased from the Foreign Liquidation Commission.

FIELDEN ELECTRONICS INC., of Huntington Station, N. Y., was recently incorporated and is closely associated with Fielden (Electronics) Ltd., of Manchester, England, manufacturers of the Drimeter, a device for giving continuous indication of moisture content for the textile industry.

PERSONNEL

M. J. KELLY, executive vice-president of Bell Telephone Laboratories, has been named chairman of the newly constituted Committee on Navigation which will work closely with the Air Navigation Development Board.

FRIEDA B. HENNOCK recently became the FCC's first woman commissioner.

CLARENCE A. LOVELL was co-recipient of the 1948 Potta Medal of the Franklin Institute for combined

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1 The G-E Focus Coil requires less current permitting the use of lower-priced power supplies.

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WRITE FOR BULLETIN 4505
It gives essential data about S.S. White Resistors, including construction, characteristics, dimensions, etc. Copy with price list on request.
Photo courtesy of Photovolt Corp., New York, N. Y.

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NEWS OF THE INDUSTRY

(continued)

contributions to the theoretical and practical design of the electrical gun director.

DAVID B. PARKINSON was co-recipient with Dr. C. A. Lovell of the 1948 Potts Medal of the Franklin Institute.


J. A. Rajchman  W. H. Cherry

WILLIAM H. CHERRY, co-author of the above-mentioned paper, was the co-recipient of the Levy Medal. He has been engaged in research for RCA since 1941 and is at present working in the RCA television group.

WILLIAM BALDERSTON, formerly executive vice-president, has been elected president of Philco Corporation. Between 1944 and 1946 he directed the company's reconversion to civilian production.

PAUL H. WENDEL, formerly associate editor of Radio News and business manager of Radio Maintenance, has joined the Photofact staff of Howard W. Sams & Co., Inc., Indianapolis, Ind.

DAN DROMMERHAUSEN, senior engineer with Hoffman Radio Corp., Los Angeles, has become manager of the service department.

STUART BALLANTINE (deceased) was recently awarded posthumously the Armstrong Medal for outstanding contributions to the art. One of his many works was development, on a purely mathematical basis, of...
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"Where Professional Radiomen Study"

ELECTRONICS — September, 1948
the theory of the vertical antenna and its low-angle radiation.

DONALD K. DE NEUP is chief engineer of the Rural Radio Network's sixth f-m station, WVBN, at Turin, N. Y. Like the other five (WFNF, WVFQ, WVCV, WVBTE, and WVCN), it is operating on a radio relay network basis. WGHF in New York City is an affiliate.

EVERETT S. LEE, chief engineer of G-E's General Engineering and Consulting Laboratory at Schenectady, has been elected president of the AIEE for 1948-49.

ALBERT J. FRIEDMAN, formerly associated with the Federal Telephone and Radio Corp. of Nutley, N. J. and the Island Electronics Co. of Freeport, N. Y., has been appointed chief antenna development engineer at J. F. D. Mfg. Co., Inc., Brooklyn, N. Y.

PAUL THOMPSON has been named chief electronic engineer of the Turner Company, Cedar Rapids, Iowa, manufacturers of microphones and electronic equipment.

LEO L. HELTERLINE, JR. has been promoted from chief engineer to general manager of Sorensen and Co., Inc., Stamford, Conn. He was formerly associated with General Motors and Sylvania Electric Products Co.

WILLIAM A. BROWNE, former engineering buyer for radar development at Sylvania's Electronics Division, was recently appointed merchandising supervisor for the Radio Division of Sylvania Electric Products, Inc.

R. L. CAMPBELL has established a consulting television engineering laboratory in Boston, Mass.

For the best look west of the Rockies when others failed, Peerless engineers successfully solved a TOUGH PROBLEM

Illustrated above is a modulation transformer, extremely difficult to design and manufacture. Other manufacturers failed to meet the customer's requirements. Peerless surprised the customer by more than meeting requirements. Designed to meet C.A.A. specifications and specifically, the following electrical characteristics:

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DISTORTION – The audio distortion in the transformer is less than 2% for all specified frequencies and impedances and all power levels up to 250 watts.

INSERTION LOSS – The insertion loss is less than 21/2% at 1,000 cps for all specified loads.

REACTANCE – The reactive value of the input impedance is less than 100% of the resistive value for any audio frequency from 90 cps to 200 cps; less than 50% from 200 cps to 1000 cps; and less than 15% from 1000 cps to 12,000 cps. These ratios obtain for all specified loads at any power level up to 250 watts.

PHASE SHIFT – The phase shift of this unit is less than 5% between 9,000 cps and 11,000 cps for all rated impedances.

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GENERAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Delay</th>
<th>0 sec. to 8 min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contacts</td>
<td>15V, normally open or closed</td>
</tr>
<tr>
<td>Contact Rating</td>
<td>3,000 volts</td>
</tr>
<tr>
<td>Weight</td>
<td>2 oz. to 0.14 lb.</td>
</tr>
<tr>
<td>Heater</td>
<td>2 volts, 115 volts max.</td>
</tr>
</tbody>
</table>

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ELECTRONICS — September, 1948
NEW BOOKS

Vibration and Sound
By Philip M. Morse, Director, Brook- 
haven National Laboratory. McGraw- 
Hill Book Co., Inc., New York, N. Y.  

This is a revision of the original 
book brought out in 1936. The 
author has continued the objective 
of the first edition, namely, a 
thorough treatment of the theory 
of vibration and sound for students 
in physics and communication en-
gineering. In attaining these aims 
the author has provided an adequate 
and complete treatment of the 
mathematical foundations of con-
tentional sound theory which forms 
the basis for the solution of the 
specific problems. Accordingly, the 
first part of the book is concerned 
with a complete mathematical treat-
ment, with most of the detailed 
steps included. In the latter portion 
of the book, the treatment is not 
as complete and therefore, requires 
some effort to fill in the interme-
date steps.

The subject matter is confined for 
the most part to types of vibrations 
that can be handled mathematically. 
It is not, however, a book on mathe-
matics with sound as an excuse. 
Mathematics is used as a tool. 
Sufficient explanation is given for 
the most part to keep the physical 
concepts and significance of the 
formulas clear.

The use of diagrams to illustrate 
modes of vibrations of strings, bars, 
membranes, and plates is one of the 
outstanding and useful features of 
the book. In the case of membranes 
and plates, the figures are presented 
in perspective to show the shapes 
for the lower modes of vibration. 
Illustrations of this kind are useful 
because they give at a glance infor-
mation which cannot be readily 
gleaned from the mathematics.

Some of the subjects not usu-
ally considered in detail in books on 
sound are as follows: the perturba-
tion theory of strings with variable 
density, effect of motion of the end 
supports of a string, vibration of 
membranes and plates, radiation re-
sistance of radiators of various 
shapes, scattering of sound from 
obstacles, and room acoustics.

The transient response of vibra-
iting systems is one of the important

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and unregulated units available. 
ELECTRONIC MICROAMMETERS: 0.01 
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decade ranges. Cannot be damaged by 
overload. 
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megohms to below 100,000 ohms. Good 
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NEW BOOKS (continued)

characteristics which depicts the performance of a vibrating system. It is fortunate that one of the additions in the revision is the application of the operational calculus and the Laplace transform to the study of transients.

The treatment of room acoustics is outstanding. The following subjects are considered: room resonance, the characteristic frequencies or modes, rooms of various shapes, steady-state response and boundary coefficients.

The book includes a useful set of tables of trigonometric, hyperbolic, Bessel and Legendre functions and absorption coefficients, and plates or graphs of hyperbolic tangent transformation, standing-wave-ratio vs acoustic impedance, and absorption coefficient vs acoustic impedance. The glossary of symbols used in the book is very useful.

The bibliography on contemporary books is not complete or up to date. For example, there are at least six new and pertinent books which have been published since the old edition was issued which are not listed.

A large collection of problems of a practical nature, at the end of each chapter, gives the student a working knowledge of problems in vibrating systems and sound.

The book is a valuable addition to the literature in acoustics, particularly to the serious student and investigator.—HARRY F. OLSON, RCA Laboratories.

Microwave Magnetrons


The book opens with an introduction which is evidently intended, in a concise manner, to acquaint the reader with the fundamentals of the field of microwave magnetrons. This takes the reader through subject matter which is in the main repeated in greater detail in the five main parts of the book. Though the introduction is well written, the extent to which it touches upon material to follow renders its value in the book somewhat questionable. Beyond the introduction the de-
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**BATTLEFRONTS OF INDUSTRY**

By David O. Woodbury,

Wells-known author of books and articles on science.

This is the dramatic story of Westinghouse Electric’s contribution to the war effort — a story in many ways typical of American industry as a whole. Since very little has been told about industry’s part in winning the war, this history of its “battlefronts” is doubly interesting.

The author stresses the ingenuity of scientists and engineers in meeting and overcoming technical problems. He explains how the application of mass production techniques made possible the speedy completion of assignments considered impossible in peacetime. Battlefronts of Industry also emphasizes the important role of scientific research and its contributions to victory.

Contents include:

A Challenge for Genius; As a Good Citizen; Toward a Shooting War; Ordnance in a Big Way; High Pressure in Steam; To Shoot Straight; War Story of a Factory; Hitting on all Twelve; Research; Research Helps War Industry; X-Rays and War; Lights to Fight; Ordnance Round-up; Vital Measurements; “The Impossible Takes a Little Longer”; The Turbine Forge Ahead; Uranium; Battle of the Isotopes; An End and a Beginning.

June 1948
342 pages
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Detailed treatment of the subject matter is presented in five main parts.

In the four chapters of Part 1, a quite complete analysis is made of resonant systems as developed for cavity magnetrons. The last of these chapters deals with the problem of coupling the load to the tube cavity.

The four chapters comprising Part 2 present an analysis of the operation of microwave magnetrons to the extent that this was developed during the wartime activity. In this part, one is impressed by the need of additional research in this field, and the apparent complexity of an analytic treatment of the problem. The chapter entitled, "The Space Charge as a Circuit Element", is particularly interesting and instructive. This is followed with a discussion of transient behavior which necessarily deals to a considerable extent with mode selection. The concluding chapter of this part deals with noise in the magnetron.

Part 3 consists of four chapters on design which generously present various devices for arriving at quantities needed to make up a tube design. Interesting block diagrams are provided to set forth interrelations among design parameters. The laws are given of scaling a known tube design to arrive at values for a new tube. For application of these laws, performance charts of a number of existing types of tubes are included. This is followed by appropriate data for r-f portions of the tube, the cathode, and the magnetic structure.

Part 4 deals with mechanical and electronic tuning, and frequency stabilization. Part 5 contains practical information relating to tube construction. It is gratifying that the book is rounded out with this section, which is of great importance to anyone setting out to build magnetrons. After a chapter on measurements and test equipment, there is a closing chapter of data on typical magnetrons.

Upon studying this book, one is impressed with its uniqueness, scope, and general excellence. For a worker in the field of microwave magnetrons it is unquestionably an essential.—H. W. ANDERSON, Electronics Laboratory, General Electric Co., Syracuse, N. Y.
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.

More Hartley Law

Dear Sirs:

In reply to the letter of Mr. L. A. Zadeh in your May issue, it is, of course, true that Hartley, in his original paper, fully realized that the capacity of a channel to carry information per unit time was proportional to the product of the bandwidth of the channel and the logarithm of the number of quantum levels. It is also true, as Hartley pointed out, that the capacity of the system is limited by the distortion (random and nonrandom) introduced by the transmission circuit. It is not, however, true, in the absence of distortion of the random variety, that the capacity of a channel to carry information per unit time is limited, as was shown in the original Hartley article. It is in the recognition of this last point, which eluded Hartley in his otherwise striking analysis, that the new theories represent a revision of the Hartley law.

In his 1928 paper Hartley showed that the capacity of a channel to transmit information was limited by a quantity which he called intersymbol interference; namely, interference produced by the fact that any filter with finite cut-off frequency contains energy storage elements. Energy stored in these elements results in the appearance of signals at the output of the filter long after the input signal has become zero. The spurious output signals, according to Hartley, become mixed with subsequent signals. According to this viewpoint, one must wait until the intersymbol interference has decayed to a suitable value before measuring the amplitude of any new incoming signals.

It has now been shown, by all the workers in the field mentioned in
AN 8" DIA-CONE SPEAKER WITH THE HIGHEST EFFICIENCY NOW AVAILABLE TO INDUSTRY

The acknowledged design leadership of Altec Lansing in the field of high quality sound reproduction has now produced an 8" speaker of extreme high efficiency, light weight, and quality performance. It incorporates the famous Dia-cone principle of high frequency reproduction from a separate metal diaphragm. It is particularly applicable for portable sound reproduction uses, such as 16 MM sound projectors, wire recorders, and announcing and music systems in mobile units, such as airplanes and buses. It is ideally suited for television, and table model FM receivers where quality reproduction is essential and space occupied by the speaker is important.

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SPEIFICATIONS:
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- Voice Coil Impedance: 8 ohms
- Required Amplifier Output Impedance: 4-8 ohms
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- Speaker Depth: 3 3/4"
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(continued)

BACKTALK

Mr. Zadeh's letter, that this intersymbol interference need not exist. In other words, in the absence of random noise or harmonic distortion, and, in fact, sometimes even in the presence of the latter, information may be transmitted at an arbitrarily high rate over a system of any bandwidth desired. Systems have been constructed, on paper at least, capable of performing this operation. The statements, to the effect that the "new" law, indicated the possibility of transmitting speech on a bandwidth of only a few hundred cycles, are therefore completely correct and do not involve a method of frequency compression similar to that described by Dr. Gabor in the November issue of the Journal of IEE (London). These schemes having to do with the "new" law concern themselves purely with the elimination of the intersymbol interference found by Hartley to be the major factor limiting the rate of transmission of information in communication systems as we know them today.

Since this intersymbol interference may readily be eliminated from any communication system, it is necessary to probe further into the problems of the transmission of information to discover what does limit the rate at which information may be transmitted. We must then go to the terms which from Hartley's viewpoint were second order, namely noise and distortion. It is in this recognition of the nonexistence of the Hartley limit and the probing into the second order effects of the revised theories hold their utility. It is perfectly correct that the equations involved in the "new" law can readily be obtained directly from Hartley's law by a process such as that given by Mr. Zadeh in his letter after one recognizes the unessential nature of the Hartley limit. This process, however, glosses over certain of the effects of wide-band modulation which should be included in any derivation of an adequate law for the rate of transmission of information and have been so included by all of the later workers in the field.

It should also be pointed out that in the derivation of the "new" law, no tacit assumption that the bandwidth of the transmission channel is at least as large as that of the
message need be made, and, in fact no such tacit assumption has been made by those whose theories have received recent attention. Such a restriction may be placed, if desired, and if this is done, a special form of the law will be obtained. This restriction is neither desired nor necessary in any general statement of theory. It is to be hoped that a complete statement of the derivation of the revised Hartley law may be published within a reasonable time so that this whole matter may be cleared up.

W. G. TULLER
Melpar, Inc.
Alexandria, Virginia

Acronyms

Dear SIRS:
We read the article “Surveying with Pulsed-Light Radar” in the July issue with a great deal of interest.

How about using the acronyms “infrar”, “lidar” and “ultrar” for infrared, light-wave and ultraviolet-type pulsed radars?

Ted Powell
Engineering Dept.
Amplifier Corp. of America
New York, N. Y.

Radiosonde Measurements

Dear SIRS:
In connection with my article “Radiosonde Potential Gradient Measurements” (p 184 Jan. 1948) I wish to point out that the article is based on a portion of my M.Sc. Honours thesis. The work described was done at the Physics Department, Auckland University College, New Zealand, under the supervision and following the suggestions of Dr. K. Kreielsheimer and Prof. P. W. Burbidge. Doubtless as a consequence of the (present) address from which I corresponded with your staff, the published affiliation is misleading.

R. E. Belin
Wellington, New Zealand

Note: On April 8, 1948, Mr. Belin wrote pointing out the misleading impression created by the affiliation published under his byline. Publication of the above letter has been delayed during correspondence with Mr. Belin and Dr. Kreielsheimer. Public announcement of radiosonde potential gradient measurements was first made jointly by Dr. Kreielsheimer and Mr. Belin (Nature, p...
Light Meter

Dear SIRS:

In the article, Light Meter for Electric Flash Lamps, that appeared in the June 1948 issue, there is an error in the drawing on page 78. The negative lead of the 45-volt battery should connect to the lower side of capacitor C instead of one side of the filament.

Harold E. Egderton
Massachusetts Institute of Technology
Cambridge, Massachusetts

Square-Wave Response

Dear SIRS:

In the reference sheet "Square-Wave Response" (ELECTRONICS, p 130, Aug. 1947) a waveform is shown identifying the voltages used in the equations on which the nomogram is based. The formula seems to apply to a pulse, but could be made applicable to a square wave if voltages were measured with reference to a mean-value axis.

W. F. Thomson
Wembley, England

Dear Mr. Thomson:

I am sorry that an errata has not been made stating that $E$ is the peak value at the beginning of the cycle (not the peak-to-peak value) and that $e$ is the peak value $t$ seconds later. With these definitions, the nomogram is applicable to rectangular waves of any duty cycle. The waveform certainly should have been more representative. You may also have noticed that $R$ in the circuit diagram should have been $R_x$ and that an additional defining relation: $R = R_x + R_s$ where $R_x$ is the load resistor of the first plate, should have been added.

I am grateful to you for bringing these errors to our attention. The printer was unable to send the nomograph with the waveform, circuit diagram, and equations to me for approval before publication.

A. J. Baracket
Allen B. DuMont Labs., Inc.
Clifton, N. J.

September, 1948 — ELECTRONICS
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147-57 41st AVENUE Telephone INdependence 3-1919 FLUSHING, N.Y.
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<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF Repeater</td>
<td>115 volts, 60 cycle</td>
<td>$30.00 each net</td>
</tr>
<tr>
<td>IF Special Repeater</td>
<td>115 volts, 400 cycle</td>
<td>$15.00 each net</td>
</tr>
<tr>
<td>Generator</td>
<td>115 volts, 60 cycle</td>
<td>$15.00 each net</td>
</tr>
<tr>
<td>Control Transformer</td>
<td>115 volts, 60 cycle</td>
<td>$22.50 each net</td>
</tr>
<tr>
<td>PIONEER AUTOSYNs</td>
<td>26 volts, 400 cycle</td>
<td>$4.00 each net</td>
</tr>
<tr>
<td>PRECISION AUTOSYNs</td>
<td>new with calibration curve</td>
<td>Call or Write</td>
</tr>
<tr>
<td>GENERAL ELECTRIC D. C. SELSYNS</td>
<td>24 volts</td>
<td>$3.00 each net</td>
</tr>
<tr>
<td>8 DJJ-PCY Indicator</td>
<td>24 volts</td>
<td>$6.00 each net</td>
</tr>
<tr>
<td>8 DJJ-PCY Indicator</td>
<td>24 volts</td>
<td>$6.00 each net</td>
</tr>
<tr>
<td>PIONEER TORQUE UNITS</td>
<td>12627-1-A</td>
<td>$65.00 each net</td>
</tr>
<tr>
<td>12627-1-A</td>
<td>Price $65.00 each net</td>
<td></td>
</tr>
<tr>
<td>PIONEER TORQUE UNIT AMPLIFIERS</td>
<td>12073-1-A</td>
<td>$17.50 each net</td>
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<tr>
<td>RATE GENERATORS</td>
<td>J36A, Eastern Air Devices, 10 to 5000 R. P. M., 0.02 V. per R. P. M.</td>
<td>$8.50 each net</td>
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<tr>
<td>PM2, Electric Indicator Company</td>
<td>$175 V. per R. P. M.</td>
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<tr>
<td>PM2, Electric Indicator Company</td>
<td>two-phase, 22 V. per phase at 1800 R. P. M.</td>
<td>$14.00 each net</td>
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<tr>
<td>B-68, Electric Indicator Company</td>
<td>Drag Cup, 110 volts, 60 cycle, one phase</td>
<td>$14.00 each net</td>
</tr>
<tr>
<td>INVERTERS</td>
<td>12117-4, Pioneer</td>
<td>$12.00 each net</td>
</tr>
<tr>
<td>12117-4, Pioneer</td>
<td>Input 12 volts D. C. Output 26 volts, 400 cycle</td>
<td>$12.00 each net</td>
</tr>
<tr>
<td>12123-1-A, Pioneer</td>
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<td>153F, Holtzer Cabot</td>
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<tr>
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**ELECTRONICS — September, 1948**

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1. PANORAMIC ADAPTOR: For use with any receiver with If. frequency of 405-505 kc, 4.75 to 5.75 mc., and 29-31 mc.
2. OSCILLOSCOPE: Visually checks received signals, monitors transmitter output, percentage modulation, carrier wave-shapes, etc.
3. SYNCHROMETER: External outputs provide synchroscope indication.
4. RECEIVER: Three inputs provide facilities for use with converters to cover wide range of frequencies to 10.000 mc.

FEATURES:
- 3" scope tube
- 21 tubes
- Variable sweep 35-40,000 cy
- Transformer built in for 110 V. 60 cycle operation.
- 2 I.F. stages—double conversion
- 2 Video stages in push pull to vertical plates
- Peptide output audio monitor
- Multi-Vibrator horizontal sweep (radar type)
- Horizontal sweep amplifiers P.P. to horizontal plates

Surplus equipment tested and guaranteed in perfect operating condition. We have sold hundreds of these units to leading schools, laboratories, amateur operators all over the world.

$129.50

SOUND POWERED CHEST SETS
No batteries required. Ideal for television installers, or any antenna measurement work. Leaves hands free to make adjustments. Set consists of microphone and headset as illustrated.

Brand New $19.50

PARABOLOIDS
Ideal for microwave experimental work. Span Magnesium dishes
Reinforced Perimeter 17½" Diameter x 4" Deep
Two sets mounting brackets on rear. Open center hole 1½" x 1½"
Per Pair, Brand New... $8.75

All prices quoted subject to change, 20% deposit on C.O.D.'s to fab. Tuckahoe, N. Y.
About 20 miles north of N.Y.C.

5 WEAVERLY PLACE

ELECTRONICRAFT INC.
PHONE—TUCKAHOE 3-0044
TUCKAHOE 7, NEW YORK

W. E. TYPE D-168479 MERCURY CONTACT RELAY

For applications in all types of high speed switching devices. Long service life, with operating speeds. Present and voltage handling capacity. Uniform and constant operation. Actuators and contacts are exposed under adverse atmospheric conditions. Hermetically-sealed mercury contacts in gas-filled glass envelopes. Free from moisture, dust, corrosion and atmospheric pressures.


$4.75

MOTOR GENERATORS
K.V.A. output 1,250 R.P.M. 3600 K.W. output 1.
Cont. Duty Ph. Single P.F. 60 Cycles 60
Volts input 115 D.C. Volts output 120 A.C.
Amps. input 14 Aamps. output 10.4
Length 26"; width 12½"; height 19½".
Compound accumulative A.C. and D.C. fields, Centrifugal starter. Splashproof covered. Frequency adjustable to load, plus or minus five cycles.

PRICE $125.00

Identical Machine, but 230 volts
D. C. Input $125.00

Set of Replacement Spare Parts for Either Machine $29.50

DYNAMOTORS—500 Watts
Navy Type CAJO-211444

BRAND NEW $95.90

SCHNYSCH
(Seligs, Autosyns, etc.)

Navy Ordnance types: 5B, 5G, 5F, 5T, 5DC, 5SS, 5SDG, etc.
Army Ordnance types: 2JSF, 2JSIL, 2JF, 2JF, CAL. 18300, 2JF, CAL. 18300, etc.

Also Pioneer Precision Autosyns AY101D, brand new in original containers.

G. E. AMPLIDYNES
Type 5AMU117, NEW $42.50
Type 5AMU11D10, NEW $49.50

G. E. SERVO AMPLIFIERS
Type 2CVIC, NEW $19.50

PARABOLOIDS
Ideal for microwave experimental work. Span Magnesium dishes
Reinforced Perimeter 17½" Diameter x 4" Deep
Two sets mounting brackets on rear. Open center hole 1½" x 1½"
Per Pair, Brand New... $8.75

All prices quoted subject to change, 20% deposit on C.O.D.'s to fab. Tuckahoe, N. Y.
About 20 miles north of N.Y.C.

5 WEAVERLY PLACE

ELECTRONICRAFT INC.
PHONE—TUCKAHOE 3-0044
TUCKAHOE 7, NEW YORK

September, 1948 — ELECTRONICS

www.americanradiohistory.com
VOLTAGE REGULATOR

Mr. Haythorn: "American" Type "88-

2 neon lamp Input: -50 to 120 vac 50-c y. Output

TRANSTAT VOLTAGE REGULATOR: Tension: 135 KVA 0.15 amp. Inset 125 vac 20 vac 100 y.

ITF Circuit Breaker: 15 amp. 1/2 sec. 700 vac 600 vac 120 vac 20 vac 100 y.

PLATE TRANSFORMER: Pot 117 vac 10 vac 20 vac 100 y. Input: 117 vac 1 amp 10 vac 100 y.

Plate Transformer: Pot 200 vac 12 vac 20 vac 100 y. Input 120 vac 20 vac 100 y.

FILE TRANSFORMER: Pot 20 vac 15 vac 20 vac 100 y. Input 120 vac 20 vac 100 y.

TRANSFORMER: 185 vac 5 amp 120 vac 600 vac 20 vac 100 y.

FILTER TRANSFORMER: 10 amp 40 amp 400 vac 600 vac 100 y.

VOLTAGE REGULATOR TRANSFORMER: Ruthven UX 361.1 amp 20 vac 100 y.

004-1 Pot: 0.125 amp 60 vac 12 vac 20 vac 100 y.

552-50 amp 400 vac 600 vac 100 y.

MICROWAVE PLUMBING

10 CM WAVEGUIDE SWITCHING UNIT, 100 ft. of 2.5" waveguide, 100 ft. of 3/4" waveguide, 100 ft. of 1/2" waveguide.

90 cm CAVITY UNIT, 90 cm cavity unit. 90 cm cavity unit. 90 cm cavity unit.

18 cm CAVITY UNIT, 18 cm cavity unit. 18 cm cavity unit. 18 cm cavity unit.

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### TUBES! GUARANTEED!

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<tr>
<td>RG 6/12</td>
<td>75 Ohms</td>
<td>5.90</td>
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</tbody>
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### TUBES PLUS!

- **General Electric Noise Filter**
  - 10 tubes, .95 each
  - .95 box

- **Crane**
  - 5 tubes, .95 each
  - .95 box

- **Radio Tubular**
  - 5 tubes, .95 each
  - .95 box

- **Automatic 115 Volt**
  - 20 tubes, .95 each
  - .95 box

- **Automatic 230 Volt**
  - 20 tubes, .95 each
  - .95 box

### AUDIOVALVE FOR rien\n
- **Coil Type**
  - 15 tubes, .95 each
  - .95 box

### AMERTRAN TRANSTAT VOLTAGE REGULATORS

- **Model 72144**
  - Fixed winding 115 Volts, 40 cycles
  - 18 becoming 120 Volts
  - Price $5.95

- **Model 72144**
  - Fixed winding 115 Volts, 40 cycles
  - 18 becoming 120 Volts
  - Price $5.95

### RADIO NOISE FILTERS

- **General Electric Noise Filter**
  - 10 tubes, .95 each
  - .95 box

- **Crane**
  - 5 tubes, .95 each
  - .95 box

- **Radio Tubular**
  - 5 tubes, .95 each
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- **Automatic 115 Volt**
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- **Model 72144**
  - Fixed winding 115 Volts, 40 cycles
  - Price $5.95

- **Model 72144**
  - Fixed winding 115 Volts, 40 cycles
  - Price $5.95

### LAST MINUTE SPECIALS

- **JONES PLUGS & SOCKETS**
  - Alignment

- **FREE SHIPPING**
  - Price $2.00

- **FREE SHIPPING**
  - Price $2.00

### EDLIE ELECTRONICS INC.

131 LIBERTY STREET
Telephone: WORTH 4-1169
NEW YORK 6, N.Y.

September, 1948 — ELECTRONICS
50 MICRO AMP METER

This is the exact meter utilized in the General Electric model YMW—1A Lab Type Unimeter

- 50 microamp movement ± 2%
- 3000 ohms resistance ± 2%
- Knife edge pointer
- Uncrowded Multi-Range Scale
- A 4 x 1/2 sticky Backlit Case
- 50 microamp scale available at 25c additional
- A Peak scoop at only $0.75 ea.

METER SPECIALS

1½" GE 0.1 MA Basis...
2" GE 0.05 amp. D.C....
2" GE 0.1 amp. RF (internal thermal)...
2" GE 0.3 ma (amp scale)...
2" GE 0.12 ma (0-100 scale)...
3" GE 0.4 ma (0-100 scale)...
Green 0.3 VDC (1000 ohms per volt)...
Weston 150-0.150 microamps...
Westinghouse 0.25 amp AC...
3" VOLTCRAFT 0-4 D-0...
Westinghouse 0.50 amp AC...
Westinghouse 250-1.000 volt AC...
Westinghouse 0-50 mA DC...
Westinghouse 0-500 volt DC...
Westinghouse 0-150 volt DC...
Westinghouse 0-150 volt AC...
Westinghouse 0.50 volt AC...
WE 0-50 microamps...

VERSATILE POTENTIAL

These transformers have many uses—milliammeter, isolation, standards, etc.
All have 2 separate primary for 110/220 volt 25-60 cycle operation. Primaries can be used in series or parallel.
1 Type: 500-115 volts 500 miliamps plus or minus 5%. Perfect for meters,
1 Type: 110 volts 3 miliamps 5%. Perfect for meters,
1 Type: 220 volts 1 miliamp 5%. Perfect for meters,
1 Type: 120 volt 8 miliamps 5%. Perfect for meters,
1 Type: 240 volt 4 miliamps 5%. Perfect for meters.

STEPDOWN TRANSFORMER

220/110 volt, 110 volt, 60 cycle, 1 amp input. Fully enclosed, 5/4 x 4 x 4 x 4.5/8. 60 cycle. Perfect for meters.

AMERTRAN 3 KVA PLATE

600/700-230 volt 60 cycle, 3 phase. Excellent for meters. 500,000 megohms plus or minus 1%

AMERTRAN PLATE 3000 VOLS

C.T. at 1 Amp Pri 110/200 V 60 Cycles. 8 x 8 x 20 x 15. 250,000 megohms plus or minus 1%

SOLA CONSTANT VOLTAGE TRANSFORMER

Pri. 95-130 volt, 60 cycle, 15 amp. 225,000 volts. 335 VA, 2.9 Amps

U. F. COAX. CONNECTORS

UG12U—B31—UG21—B31P—B31P

T.P.D. ANTENNA RELAY

110 V. 60 cycle coil Steatite insulation. Only $1.25 each

ELECTROLYTIC CAPACITORS

25 Mfd, 25 volt D.C. Tubular. 25c
50 Mfd, 5 volt D.C. Tubular...
8 Mfd, 450 Volt D.C. Tubular...
11 Mfd, 600 Volt D.C. Tubular...
1000 Mfd, 25 Volt D.C. Tubular...
2000 Mfd, 25 Volt D.C. Tubular...

MISCELLANEOUS SPECIALS

2-11 mm, Butterfly with ball bearings...
3.5 mm, 0.030 Amp. D.C. Tubular...
8 Mfd, 450 Volt D.C. Tubular...
1000 Mfd, 25 Volt D.C. Tubular...

Phone Cortlandt 7-6443

PEAK ELECTRONICS CO
188 Washington St., New York 7, N. Y.

DEPARTMENT EA
SEND FOR BULLETIN
**IMMEDIATE DELIVERY**

**Kollsman 775-01 Selsyn**
Ideal for Ham use as transmitter or receiver. 6.12 volt 60 cycles. 70 volts 400 cycles. Stock #SA-37.
Price $3.75

**DYNAMOTORS**
D-W101: 27 v. DC input @ 1.5 amps. DC output 281 v. 160 in. Stock #SA-182.
Price $8.50 ea.

**MICROWAVE ANTENNA**
AS-217A/AMP 158 19 cm dipole and 15 inch Parabola housed in weatherproof aluminum dome 14 1/2 diam. 21 v.
Price $9.50 ea.

**Rate Generators**

**Westinghouse FL BLOWER**
115 v. 600 cy. 1/2 cfm. Includes capacitor. Stock #SA-144. Price $8.75 each.

**Sweep Generator Capacitor**

**Servo Motor**
Price $1.75 ea. net.

**Phase Shift Capacitor**
-101-D and #SA-131-D

**Selsyn Special**
W.E. KS-350-1.2
Size 5, 15 v. 400 cycles. Use on reduced 60 cycles. Stock #SA-182.
Price $4.25 each.

**Magneseysns**
Pioneer CL-3
6 power Magneseysns. Use as transmitter or receiver. 26 v. 400 cycle. Stock #SA-6.
Price $3.75 each.

**Microwave Generators**
Price $8.75 ea.

**400 Cycle Inverters**
Pioneer 12016-2-A. 16121-A.
Price $10.50 each.

**800 Cycle Inverter**
Navy Type CRV-33, DEL. SA51211-27 v. DC input. 175 v. 800 cy. output. Wt. 25 lbs. Stock #SA-192. Price $30.50 each.

**LP-21-LM Compass Loops**

**Original Cartons**

**110 RPM Motor**
G.E. SBA1014 27 v. 600 amp. | oz. torque. 1 3/4 diam. x 3 1/2 ig. 3/8 shaft extension. Stock #SA-94.
Price $6.50 each.

**Note**
All merchandise is new and guaranteed to meet manufacturer's specifications.

Write for complete listing, or call ARmory 4-3366

4 Godwin Ave.

*September, 1948 — ELECTRONICS*
RCA Frequency Meter Type 306-A

**Consisting of 2 Power Supplies TX-1401A**
- **Audio Mixer (TX-101A)**
- **High Frequency Oscillator (TX-141A)**
- **Duplex Oscillator (TX-111A)**

Complete unit in heavy steel cabinet. 20" x 28" x 25". Wrought enamel finish. Front panel 3/4" black Bakelite. Drawn on top and rear of cabinet for easy accessibility. Connections to each unit made quickly with cords and connectors.

Well Regulated Power Supplies. Supply No. 1 uses:

- DP Toggle switch in bank of chassis for either "High" or "Low" voltage. Supply No. 2, for low power consumption, uses same tubes except 9V-50.

**RCA Frequency Meter Type 306-A**

Can be used to great advantage in experimental applications when the frequency in cycles per second is concentrated to 10 Hz, also used to check frequency of unknown sources of voltage, as a check on calibration of best frequency oscillators or other generators.

**Features**
- Direct reading—0 to 50,000 cycles.
- Regulated Power Supply.
- Ten ranges, 0.1 meter scale.
- Output drives recording meter direct.
- Accuracy unaffected by input wave shape.
- Limiting circuit makes reading independent of input voltage over wide range.

**Specifications**
- Frequency Range... 100 to 10,000 cycles or 1000 cycles.
- Input Voltage..... 1 to 500 volts rms.
- Input Impedance... 2,000 ohms.
- Recorder Output..... 0.5 ma. 1000 ohms max.
- Accuracy........... ±0.5%
- Power Supply.. 150-250 volts, 15-60 cycles.
- Power Consumption... 70 watts.
- Height 8 3/4"; width 15"; depth 13 1/2"; weight 41 lbs.

**Milliammeters**

- **Weston**
  - Model 264
  - and Jewett Model 52
- **Meters**
  - Weston: 0-300 0-10 A
  - Jewett: 0-50 0-300 Mils.
- **Frequency and Voltage Indicators**
  - Weston: 0-100 0-1000 Mils.
  - Jewett: 0-100 0-1000 Mils.
- **Accuracy**
  - Weston: ±2%
  - Jewett: ±5%

**Prices**
- **Used**
  - Weston... $40
  - Jewett... $25
- **New**
  - Weston... $45
  - Jewett... $30

**AN ELECTRO VALUE...$75**

**Heavy Transformers**

- Duty Primary: 55 V. Secondary: 10 V. @ 25 Aps.
- 120 KVA, Dimensions: 31 " x 9.75" x 4.25".
- Two transformers can be used in series to operate on 110 V. 
  Volt, giving maximum 110 V. 100 Aps.

**BRAND NEW INDIVIDUALLY Cased...$125 each**

**G. E. Distribution Transformers**

- SPOKANE—Oil Filled
  - Type 1500 KVA, 9-50 cycles per second.
  - 60 Hz 3800 Volts Continuous Duty.
  - 2500 KVA, 9-50 cycles per second.
  - 3800 Volts Continuous Duty.

**BRAND NEW INDIVIDUALLY Cased...$36 each**

All prices F.O.B. Boston. Orders accepted from rated concerns on open accounts. Net 30 days.

Write for price list, and complete catalog on company letterhead.
### SURPLUS BARGAINS!

**D. C. AMPERS & MILLS**
- 1/2" 2GE. DWV1... $2.95
- 5/8" 2GE. DWV1... $3.75
- 3/4" 2GE. DWV1... $4.50
- 1" 2GE. DWV1... $5.25
- 1 1/4" 2GE. DWV1... $6.00
- 1 1/2" 2GE. DWV1... $6.75
- 2" 2GE. DWV1... $7.50

**AC VOLTS**
- 0.15 V, 2" Westing HN-31... 2.75
- 0.29 V, 2" Westing 682A... 2.95
- 0.49 V, 2" Westing 686... 2.95
- 0.165 V, 2" D. C. Def... 4.75
- (Black scale—flush metal)

**AC—VOLT AMMETER SET**
Whe Ra 278.7 Ohms 600 V AC.

**FREQUENCY METER RANGE**
150-450 Cycles, Weston 617 Aircraft, Complete $4.05

### Selenium Rectifiers
**NEW... FRESH STOCK NOT OVER 6 MONTHS OLD**
- Full Wave Bridge... Single Phase... Resistive/Inductive Load Conservatively Rated—Continuous Duty

**SELENIUM RECTIFIERS**
**GOV'T SURPLUS NEW APPROXIMATE RATING**
- Type Max RMS Max DC Output
- 3B-1 24 18V 8.3 A
- 3B-2 24 18V 8.3 A
- 3B-3 24 18V 8.3 A
- 3B-4 24 18V 8.3 A
- 3B-5 24 18V 8.3 A
- 3B-6 24 18V 8.3 A
- 3B-7 24 18V 8.3 A
- 3B-8 24 18V 8.3 A
- 3B-9 24 18V 8.3 A
- 3B-10 24 18V 8.3 A

### Rectifier Transformers
**PRI—105/110/115/120 V., 50-60 Cycles—Open Frame Construction**
- 18 V, 4 A... $1.85
- 15 V, 4 A... $1.50
- 20 V, 5 A... $1.85
- 20 V, 5 A... $1.50
- 25 V, 5 A... $2.25
- 30 V, 5 A... $2.25
- 40 V, 5 A... $3.25
- 50 V, 5 A... $3.25

### Heady Duty Stepdown Transformers
**Input:** 115 V, (with 8 taps in primary).
**Output:** from 10 to 10.5 V, (in steps). Capacity 750 KVA—amps: 10%.
**Size:** 15" x 15" x 9". Approx. Weight: 30 lbs. Title. Price: $65.00.

### Running Time Meter
Industrial Timer Corp., $45 RD, Total Hours, 4 Cardinal Digit, 1 Decimal Digit, 100-150 V 60 Cycles.

### A Real Buy at $18.00
(same type as PRI, KVAC, Input: 115-125 V. 15.25 A. Price: $65.00.)

**ALL PRICES INDICATED ARE FOB. OUR WAREHOUSE, NEW YORK, N.Y.**

---

Shipment Transportation Charges Collect Will Be Made Via Railway Express Unless Separate Postage Is Included, or Other Instructions Issued. We Will Refund Excess Postage In Stamps.

Powertron Electrical Equipment Co.
117 Lafayette Street
Phone: Worthy 4-8610
New York 13, N.Y.
### Oil Filled Capacitors

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<th>Value</th>
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<td>2500</td>
<td>1200</td>
<td>2.52</td>
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<tr>
<td>2 mf</td>
<td>10,000</td>
<td>43.95</td>
<td>2 mf</td>
<td>2500</td>
<td>1000</td>
<td>1.88</td>
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<td>3 mf</td>
<td>7500</td>
<td>35.95</td>
<td>3 mf</td>
<td>2500</td>
<td>600</td>
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<td>4 mf</td>
<td>6250</td>
<td>31.95</td>
<td>4 mf</td>
<td>2500</td>
<td>470</td>
<td>1.31</td>
<td>1.88</td>
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<td>6 mf</td>
<td>5000</td>
<td>26.95</td>
<td>6 mf</td>
<td>2500</td>
<td>300</td>
<td>1.18</td>
<td>1.88</td>
</tr>
<tr>
<td>8 mf</td>
<td>4000</td>
<td>22.95</td>
<td>8 mf</td>
<td>2500</td>
<td>200</td>
<td>0.94</td>
<td>1.88</td>
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<tr>
<td>10 mf</td>
<td>3000</td>
<td>16.95</td>
<td>10 mf</td>
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<td>200</td>
<td>0.84</td>
<td>1.88</td>
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<td>12 mf</td>
<td>2500</td>
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<td>2500</td>
<td>160</td>
<td>0.69</td>
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<td>15 mf</td>
<td>2000</td>
<td>10.95</td>
<td>15 mf</td>
<td>2500</td>
<td>150</td>
<td>0.55</td>
<td>1.88</td>
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<tr>
<td>20 mf</td>
<td>1600</td>
<td>8.20</td>
<td>20 mf</td>
<td>2500</td>
<td>120</td>
<td>0.55</td>
<td>1.88</td>
</tr>
</tbody>
</table>

**ORDER Your Coaxial Cable NOW at these never again PRICES!**

RG 8/U—NEW-UNUSED 52 OHM

- **Very low DB loss**
  - 500-2500 feet: $19.90 per M
  - 1,000-2,500 feet: $39.90 per M
  - 5,000-10,000 feet: $79.90 per M
  - Over 20,000 feet: $27.90 per M

**No charge for reels.**

---

### Transformers & Chokes

- **GENERAL RADIO FREQUENCY METER**
  - Reg. price: $695.00
  - Reliance net: $295.00
  - **Postage**
    - 100 B's: $5.00
    - 200 B's: $4.00

- **Universal Joint Aluminum**
  - 14.4" long: 1/2" O.D., 1/4" I.D.
  - Price: 35¢

- **POSTAGE STAMP MICAS**
  - Price: $1.00 MF, .50 MF
  - **Price Schedule**
    - $1.00 MF to .001 MF: $5.00
    - .001 MF to 93° M: $1.00
    - 93° M to .002: $1.00
    - .002 MF to 93°: $1.00
    - 93° to .004: $1.50
    - .004 to 93°: $2.50

- **SELSYN Differential**
  - **Price**: $2.25
  - **Special Silver Mica**: $1.00

- **GENERAL SEARCHLIGHT SECTION**

- **ELECTRONICS**
  - All RELIANCE
  - PHILA., PA.

- **SEARCHLIGHT SPECIALS**

- **PRECISION RESISTORS**
  - 1% or better
  - Any Order For
  - 100 pieces 2% Off
  - 1000 pieces 5% Off

- **PRESSURE FITTINGS**
  - **1072 A IFF X'MITTER in MAPLE CHEST**
  - 150 to 200 Mso
  - Power Supply: 0-5000 v.d.c.
  - **Price**: $22.50

---

### Specials

- **Selsyns**
  - **Price**: $7.25 per pair
  - **Model**: #C78248

- **Selsyn Differential**
  - **Price**: $2.25
  - **Model**: #C78249

- **RELIANCE Merchandizing Company**
  - All Orders F.O.B.
  - **Minimum Order**: $3.00
Build YOUR OWN TEST EQUIPMENT

NEW 1948 HEATHKIT
5" OSCILLOSCOPE KIT

A necessity for the newer servicing technique in FM and television at a price you can afford. The Heathkit is complete, beautiful two color panel, all metal parts punched, formed and plated and every part supplied. A pleasant evening's work and you have the most interesting piece of laboratory equipment available.

Check the features — large 5" 5817 tube, compensated vertical and horizontal amplifiers using 6577's, 15 cycle to 30 M cycle sweep generator using 884 gas triode, 510V 60 cycle power transformer gives 1100 volts negative and 350 volts positive.

Convenient size 8½" x 13" high, 17" deep, weight only 26 pounds.

All controls on front panel with test voltage and ext. syn post. Complete with all tubes and detailed instructions. Shipping weight 35 pounds.

Order today while surplus tubes make the price possible.

$39.50
Nothing
ELSE TO BUY

HEATHKIT SINE AND SQUARE WAVE AUDIO GENERATOR KIT

The ideal companion instrument to the Heathkit Oscilloscope. An Audio Generator with less than 1% interstrident, high calibration accuracy, covering 20 to 20,000 cycles. Circuit is highly stable resistance capacity tuned circuit. Five tubes are used, a 6577 and 6K6 in the oscillator circuit, a 6577 square wave clipper, a 6577 as a cathode follower output and 5Y3 as transformer power supply rectifier.

The square wave is of excellent shape between 100 and 5,000 cycles giving adequate range for all audio, FM and television amplifier testing. Either sine or square waves available instantly at any toggle switch. Approximately 25V of sine AC available at 50,000 ohm output impedance. Output — ±1 db from 20 to 20,000 cycles. Nothing else to buy. All metal parts are punched, formed and cadmium plated. Complete with tubes, all parts, detailed blueprints and instructions.

$34.50
Shipping Wt., 13 lbs.

HEATHKIT SIGNAL TRACER KIT

Reduces service time and greatly increases profits of any service shop. Uses crystal diode to follow signal from antenna to speaker. Locates faults immediately. Internal amplifier available for speaker testing and internal speaker available for amplifier testing. Connection for VTVM on panel allows visual tracing and gain measurements. Also tests phonograph pickups, microphones, PA systems, etc. Frequency range to 200 Mc. Complete ready to assemble. 110V 60 cycle transformer operated. Supplied with 3 tubes, diode probe, 2 color panel, all other parts. Easy to assemble, detailed blueprints and instructions.

Small portable 9" x 6" x 4½". Wt. 6 pounds. Ideal for taking on service calls. Complete your service shop with this instrument.

$19.50
Nothing
ELSE TO BUY

HEATHKIT SIGNAL GENERATOR KIT

Every shop needs a good signal generator. The Heathkit fulfills every servicing need. Fundamentals, from 150 Kc. to 30 megacycles with strong harmonics over 100 megacycles covering the new television and FM bands. 110V 60 cycle transformer operated power supply.

400 cycle audio available for 30% modulation or audio testing. Uses 6577 as RF oscillator and audio amplifier. Complete kit has every part necessary and detailed blueprints and instructions enable the builder to assemble it in a few hours. Large easy to read calibration. Convenient size 9" x 6" x 4½". Weight 4½ pounds.

$24.50
Nothing
ELSE TO BUY

THE NEW HEARTHKIT VACUUM TUBE VOLTMETER KIT

The most essential tool a radio man can have, now within the reach of his pocketbook. The Heathkit VTVM is equal in quality to instruments selling for $75.00 or more. Features 500 microamp meter, transformer power supply, 1% glass enclosed diode resistors, ceramic selector switches, 11 megohm input resistance, linear AC and DC scale, electronic AC reading RMS Circuit uses 6577 in balanced bridge circuit, a 6N6 as AC rectifier and 6 X 5 as transformer power supply rectifier. Included is means of calibrating without standards. Average assembly time less than four pleasant hours and you have the most useful test instrument you will ever own. Ranges 0-3, 30, 100, 300, 1000 volts AC and DC. Ohmmeter has ranges of scale times 1, 100, 1000, 10M and 1 megohm, giving range 1 ohm to 1000 megohms. Weight 8 lbs.

$19.50
Nothing
ELSE TO BUY

HEATHKIT CONDENSER CHECKER KIT

A condenser checker anyone can afford to own. Measures capacity and leakage from 0.0001 to 100 MFD on calibrated scales with test voltage up to 500 volts. No need for tables or multipliers. Reads resistance 500 ohms to 2 megohms. 110V 60 cycle transformer operated complete with rectifier and magic eye indicator tubes.

Easy quick assembly with clear detailed blueprints and instructions. Small convenient size 9" x 6" x 4½". Weight 4 pounds. This is one of the handiest instruments in any service shop.

$35.00
Nothing
ELSE TO BUY

The HEATH Company
DEPT. E ... BENTON HARBOR, MICHIGAN

September, 1948 — ELECTRONICS
Wells
Radio-Electronic Components
of Guaranteed Quality

10 METER MOBILE ANTENNA
This 8 ft., 3 section mobile antenna is by far the best whip we've seen. The elements are copperplated, spring steel tubing, painted O.D. for protection against the weather. A 4" ceramic insulator reduces losses to a minimum. Long service under extreme vibration conditions is assured by the special molded rubber spring mounting. Positive co-ax connector at base. Mobile Antenna complete—only $5.75 each.

BALLOONS AND KITES
These Army emergency balloons and box kites were made to carry long wire antennas. They are wonderful for field and DX work. Tubular canvas bag containing 2 4-ft. heavy duty balloons (packed in sealed cans), 2 hydrogen generators, an aluminum frame folding box kite, 300 ft. of stranded antenna wire—only $9.95.

MICRO-SWITCHES AND SWITCHETTES
Our Micro-Switch and Switchette stock is one of the nation's largest. Listing 104A contains popular types at extremely attractive prices.

RELAYS
We have over a million relays in our warehouse. Huge quantities of hundreds of types make Wells the foremost source of equipment of this kind. Every relay is brand new and has been inspected, rated, individually boxed, and priced far below the market. Tell us your requirements or write for our Relay Catalog.

WELLS TREMENDOUS STOCK INCLUDES A WIDE SELECTION OF THE FOLLOWING COMPONENTS:
- Transmitting Tubes
- Mica Condensers
- Transmitting Condensers
- Wire & Cable
- Transformers & Chokes
- Terminal Strips
- Wire Wound Resistors
- Volume Controls
- Rheostats
- Dry Disc Rectifiers
- Tube Sockets
- Selector Switches

Manufacturers and Jobbers Write for Latest Complete Electronic Catalog

AMATEURS:
See us in Milwaukee at the ARRL Convention. Write for Amateur Catalog H400C

Wells SALES, INC.
320 N. LA SALLE ST., DEPT. S-L; CHICAGO 10, ILL.

ELECTRONICS—September, 1948
BUFFALO RADIO SUPPLY, ONE OF AMERICA'S LARGEST ELECTRONIC DISTRIBUTORS, IS IN A POSITION TO SUPPLY MOST OF THE REQUIREMENTS OF FOREIGN PURCHASERS, DIRECTLY FROM ITS GIGANTIC STOCKS OR THOSE OF ITS AFFILIATES. EXPORT ORDERS ARE SOLICITED BOTH FROM EXPORTERS AND FROM FOREIGN GOVT. PURCHASING COMMISSIONS HERE AND ABROAD. EXPENSE CAN BE REDUCED AND REQUIREMENTS FILLED WITH A MINIMUM OF DELAY BY CONTACTING BUFFALO RADIO SUPPLY INITIALLY.

BUFFRAK CAR RADIO ANTENNAS

All of our car radio antennas are made of triple plated Admiralty Brass Tubing, complete with low weight antenna lead, and high quality fittings.

SIDE COWL—HR-1, 3 sections extend to 75". Your price—single unit price—$1.50; 10 lot price—$1.45 ea.

SKYSCRAPER—HR-2 has 4 heavy duty sections that extend 92". The super-sail must be seen to be appreciated. Your price—single unit price—$2.45; lots of 12—$2.25 ea.

TRANSFORMER—HR-3 is made to order in all lengths, sections extend to 96". Single unit price—$2.00; 10 lot price—$1.95 ea.

VERNALIE—HR-4, single hole fender or top cow mounting may be adjusted to conform with all body contours, 4 sections extend to 100". Single unit price—$2.50; 10 lot price—$2.40 ea.

THE MONARCH—HR-5, single hole top cow mounting, 3 sections extend to 110". Single unit price—$2.80; 10 lot price—$2.75 ea.

AFTER SEEING OUR ANTENNAS AND COMPARE, YOU WILL NEVER BUY ANY OTHER MAKE!

BUFFALO RADIO SUPPLY, 219-221 Genesee St., Dept. 9-E BUFFALO 3, N. Y.

TELEVISION

CAMEO EQUIPMENT

Available for immediate delivery.

DUNLOP CORRUGATED ORTHICON PICKUP HEADS, with type 504-A ELECTRONIC VIEW FINDERS, complete with all tubes, including 2932 Image Orthicons.

Factory Reconditioned—Perfect Condition (L.b. N.Y.C. Subject to prior sale.

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THE NATIONAL INSTRUMENT COMPANY

FAR ROCKAWAY, NEW YORK

SO-7 RADAR SETS

10-cm Band. 275,000 watts peak pulse watts. Operate on 110v 60 cps AC, 3 KW.

Unused, $1,950.00

F.O.B. Houston

GULF COAST ELECTRONICS

1110 Winburn St., Houston 4

Justin B-1551

September, 1948—ELECTRONICS

www.americanradiohistory.com
GENERAL ELECTRIC 150 WATT TRANSMITTER

Cost the Government $1800.00 • Cost to You—BRAND NEW—$67.50

This is the famous transmitter used in F.M. Army bombers and ground stations, during the war. Its design and construction have been proved in service, under all kinds of conditions, all over the world. The entire frequency range is covered by means of variable inductors, which are included. Each unit includes tuneable power amplifiers, coils and condensers, and antenna tuning circuits—all designed to operate at top efficiency within its particular frequency range. Transmitter and accessories are finished in black bakelite, and the muffinautotransformer, voltage, and RP ammeter are mounted on the front panel. Here are the specifications: FREQUENCY RANGE: 200 to 1000 Kc and 150 to 2500 Kc. With slight modification for which diagrams are furnished, OSCILLATOR: self-excited, thermo-compensated, and hand calibrated. POWER AMPLIFIER: Neutralized case provides low v.t. tube and shield circuitry which matches practically any brand of receiver. MODULATOR: Class "B" uses 211 tubes. POWER SUPPLY: Supplied complete with dynamotor which furnish the output at 110 volts A.C. 50 c.p.s. This transmitter is furnished with two 110 volt A.C. 50 c.p.s. transformers and two 110 volt A.C. 50 c.p.s. power supplies. The power supplies will require an external circuit breaker and an external switch, and the dynamotor will require 110 volts A.C. 50 c.p.s. to run. Total shipping weight, 250 lbs. complete with all tubes, Dynamo power supply, all tuning units, antenna tuning unit and the eventual plug. Price, $160.00 to 110.00 effective Oct. 1, 1948.

1949 MODEL MUTUAL CONDUCTANCE TUBE TESTER

No possibility of good tubes reading "Bad" or bad tubes reading "Good" as on dynamotive conductance testers or other vacuum tube testers. Equipment is designed to test each valve in the complete circuit as the dynamotor is designed to test each valve in the complete circuit as the dynamotor is designed to test each valve in the complete circuit, detect shorts or open circuit. Use either of above for $5.00 extra. Card radio accessories. POWER SUPPLY: 110 volt 50 c.p.s.

TERIFIC VALUE—PORTABLE ELECTRIC DRILL

(Sold at less than established factory price so we cannot mention brand name.)

$595 Takes Both Big Bargains

1. ALUMINUM GEAR BOX 18x18 that can take two powerful electric motors, and two matched gear trains, 62 parts in all turning in all directions. Comes with a bearing kit, reverse gear, and a battery, $3.50. 2. SENSATIONAL FASCINATING SILENT SLEEPS. Brand new self-made, makes no noise. Twenty-five different combinations work perfectly on 110 vac. Any rotation of the shell of the motor makes a sound, and all other combinations will rotate to the exact point as any device. Sold in same direction, coming in reverse, the motor and all other combinations work perfectly on 110 vac. Any rotation of the shaft of the motor makes a sound, and all other combinations work in either direction, instead of wires. True is this, but until the shaft of the motor runs freely, no matter how fast or slow it runs, it will do its job. The shaft of the motor is made of brass, and all other combinations are made of brass. Complete with bearings and instructions. Per matched pair $4.50.

SCR-274N COMMAND SET

The greatest radio equipment value in history. A mountain of valuable equipment that includes 3 receivers that use plug-in coils, and consequently can be changed to any frequencies desired without conversion. Also included are two Tuning Control Boxes; 1 Antenna Coupling Box; four 40-Watt Transmitters (easily converted to 110V. operation); two 40-Watt Transmitters including crystals, and Preamplifier and Modulator; 29 tubes supplied in all. Only a limited quantity available, so get your order in now for this rare item before the aircraft is sold, and in guaranteed electrical condition. A super value at $34.95, including crank type tuning knobs for receivers.
Variable Transformer for precise Voltage Control. Excellent mechanical construction, design, and durability.

**VARIABLE TRANSFORMERS**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Description</th>
<th>Volts</th>
<th>Amps.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>115V, input, 0-135 V. output @ 3.0 amps. 0.4 KVA</td>
<td>3.0</td>
<td>0.4</td>
<td>$12.50</td>
</tr>
<tr>
<td>116</td>
<td>Mounted; 115V input, 0-135 V. output @ 7.5 amps. 1.0 KVA</td>
<td>7.5</td>
<td>1.0</td>
<td>23.00</td>
</tr>
<tr>
<td>116U</td>
<td>Unmounted; 115V, input, 0-135 V. output @ 7.5 amps. 1.0 KVA</td>
<td>7.5</td>
<td>1.0</td>
<td>19.00</td>
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<tr>
<td>116S</td>
<td>115V, input, 0-135 V. output @ 15.0 amps. 2.0 KVA</td>
<td>15.0</td>
<td>2.0</td>
<td>46.00</td>
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<tr>
<td>1226</td>
<td>115V, input, 0-135 V. output @ 45.0 amp. 6.1 KVA</td>
<td>45.0</td>
<td>6.1</td>
<td>118.00</td>
</tr>
</tbody>
</table>

If not rated 25% with order, balance C.O.D. All prices F.O.B. our warehouse New York. We ship to any part of the globe. Write Dept. EL.

---

**SURPLUS LABORATORY EQUIPMENT**

We have in stock, for immediate delivery, the following surplus Laboratory Instruments: Precision Indicators; Oscillographs; Tube Voltmeter; Signal Generators; Signal Transformers; Frequency Counters; Crystal Filters; Crystal Oscillators; Band Pass Filters; Potentiometers; Megohm Meters; Megohm Bridges.

**WIRE WOUND POTENTIOMETER**

100,000 ohm, precision made. New........... Each...$1.95

---

**SCOPE TRANSFORMER**

PRI-115 Volts—60 Cycle

Sec. #1-2100 Volts H.M.S.—2 MA. Each...$4.50
#2—3.5 Volts—1.75A Each...$1.00
#3—4-5 Volts—0.6A. Each...$1.25
#1—3 Volts—0.6A. Each...$1.25

Brand New

Littlefuse—Fuse Holder

Fuses extractor Post. Finger Operated knob. Single, complete with all hardware. New List.$3.50 Each, 3 for $1.00

Dues $1.00

G.E. Switch 218/22C $5 Brand New Individually boxed. Each...$3.00

C.P. Clare Relay—6 P.L.T.—Solenoid 1200 ohms—PA1250—New Boxed. Each...$1.25

New Bulletin alt press—write

**GREENWICH SALES CO.**

59 Cortlandt St.
Tel. Dgby 9-3813 New York 7, N. Y.

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**FOR SALE**

**PARALAX SINGLE COMPUTERS**

Model 2CH105-R

85 NEW—and in original cartons—Shipping weight 85 lbs. Prices on application.

1000 PET17C POWER UNIT—6 or 12 V Input. Shipping weight—35 lbs. each. Lots of 100 or more—$1.25 each. Write for further details.

CRABTREE'S WHOLESALE RADIO

2608 ROSS AVE. DALLAS 1, TEXAS

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**THE NATIONAL INSTRUMENT CO.,**

FAR ROCKAWAY, N. Y.

G. KELLOGG DEHYDRATOR**

An all purpose self-reactivating dehydrating unit. To be used for removing moisture from air. Numerous applications in the fields of Physics, Electronics and Chemistry. Dual insulated tanks with thermostatically controlled heating elements. Complete with 20 lbs. of silica gel, heating elements, shut-off and safety valves. $62.50

**INTERSTATE Appliance Co., Inc.,**

Dept. KD, 600 Broadway. NEW YORK 12, N. Y.
CRYSTAL MIXER ASSEMBLY, 8 band, type N fittings, variable oscillator in-
duction coupling, $200.

THREADED FEED THROUGH CAPACITORS, 50 mfd, 1000 v DC, $100 for $1000.

DISC TYPE FEED THROUGH TUNGSTEN CAPACITORS, 500 mfd, 500 v DC, $100 per.

X BAND SWR, Test Sets, TS-12/AP, new.

X BAND POWER METER, TS 36/AP, new.

X BAND WAVE METER, TS 38/AP, new.

X BAND POWER LOAD, TS-164, new.

TUNING UNITS for AFR-4 and AFR-1 receivers, TS-19, 570-2160 mc and TS-54, 2160-4000 mc, new.

10 cm OSCILLATOR, BC-106-18 with 36 mc pre-IP amplifier 102-10 H, kilva-
tron power supply and 417-A kilva-
tron, 110 v 60 cps, new in transit,

CALIBRATED X BAND fixed attenuator, 10.5-20-50 type, mfd, $19.00.

MICROWAVE TEST CABLE, 12 RG-59U cable with BR-241 connectors 15 feet long, $10.00, 5 per box, $5.00.

LOSSY CABLE, 10 db at 2500 megacycles, type N connectors, $20.00.

TYPE N CONNECTORS, UG-16, 12, 21, 22, 24, 25, 27, 30, 38, 50, 86, 190, 201, 240,

and UHF connectors, 60-239, P, 250 v 85
ap, UG-266, complete with center con-

RCA Adapters, BC-106-A, 150 2/6
gigacycles, individual tuning for the c.f. stages, bandwidth 4 megacycles.

110 volts, 60 cps, 14 tubes, $15.00.

GENERAL RADIO PRECISION WAVE,

METER, type 525A, range 1 k to 10 megacycles, 0.25% accuracy, V. T. V. M.

radiometer, complete with acces-
sories and carrying case, new.

Pulse Transformer, 152-AWP, $1.00.

Pulse Transformer, Utah 8250, $1.00.

Pulse Forming Network, 20 kv, 92 micro-

second, 50 ohms, $75.00.

RADIO COMPASS RECEIVER, Redick

MCX-5A, 120-1500 kc, 15 v, 400, 0.65

watts, 1000 ohms per volt meter.

WESTINGHOUSE XX 23, $1.50.

ELECTRO IMPULSE LABORATORY

66 Mechanic St., Red Bank, N. J.

Red Bank 6-4247

SELENIUM RECTIFIERS

And Specialized Electronic Components

FULL WAVE BRIDGE TYPES

Input Output

Type Price

B1-20 150 MA .50

B2-20 250 MA .50

B3-20 400 MA .50

B6-15 600 MA .50

B1-15 1.5 AMP .50

B2-15 3 AMP .50

B3-15 6 AMP .50

B6-15 12 AMP .50

B1-10 10 AMP .50

B2-10 20 AMP .50

B3-10 40 AMP .50

B6-10 80 AMP .50

B1-7 30 AMP .50

B2-7 60 AMP .50

B3-7 120 AMP .50

B6-7 240 AMP .50

B1-5 50 AMP .50

B2-5 100 AMP .50

B3-5 200 AMP .50

B6-5 400 AMP .50

B1-3 150 AMP .50

B2-3 300 AMP .50

B3-3 600 AMP .50

Three Phase Bridge Types

Input Output

Type Price

BR-15 15 AMP .50

BR-25 25 AMP .50

BR-35 35 AMP .50

BR-50 50 AMP .50

BR-10 10 AMP .50

BR-20 20 AMP .50

BR-30 30 AMP .50

BR-40 40 AMP .50

BR-50 50 AMP .50

BR-60 60 AMP .50

BR-70 70 AMP .50

BR-80 80 AMP .50

BR-90 90 AMP .50

BR-100 100 AMP .50

BR-120 120 AMP .50

* Select Proper Capacitor From List Shown Below, to Obtain Higher D.C. Voltages Than Indicated

RECEIVING BRACKETS

For Types B1 through B6, and Type C1 $ .35 per set.
For Types B6 through B12 $ .50 per set.
For Types B13 1.20 per set.

RECEIVING TRANSFORMERS

All Primary 115VAC 50-60 cycles

Type Price

HY2 0.5 Hy 2 $2.50

HY3 0.5 Hy 3 $2.50

HY5 0.5 Hy 5 $2.50

HY6N5 0.5 Hy 6 $2.00

HY20 0.5 Hy 20 2 $2.00

HY12 0.5 Hy 12 2 $2.00

HY15 0.5 Hy 15 2 $2.00

HY20 0.5 Hy 20 3 $3.00

HY12 0.5 Hy 12 3 $3.00

HY15 0.5 Hy 15 3 $3.00

HY20 0.5 Hy 20 4 $4.00

HY12 0.5 Hy 12 4 $4.00

HY15 0.5 Hy 15 4 $4.00

All Types Types are Tapped to Deliver 25, 50, 50 Volts.

ELECTROLYTIC CAPACITORS

Input Output

Type Voltage Amps. Price

XFD-10 10 10 1.50 $7.50

XFD-20 20 20 1.50 $10.00

XFD-30 30 30 1.50 $12.00

XFD-40 40 40 1.50 $14.00

XFD-50 50 50 1.50 $16.00

XFD-60 60 60 1.50 $18.00

XFD-70 70 70 1.50 $20.00

XFD-80 80 80 1.50 $22.00

XFD-90 90 90 1.50 $24.00

XFD-100 100 100 1.50 $26.00

XFD-110 110 110 1.50 $28.00

Types are Tapped to Deliver 12, 24, 36 Volts.

METERS

O-1 MA, D.C. Weston (266 3/4 R), Bakelite case $2.95

O-15 MA, D.C. Weston (560 5/8 R) $2.95

O-50 A.D.C. Weston (4013 1/4 R) $15.95

O-50 A.D.C. Weston (4013 1/4 R) $15.95

O-60 A.D.C. Weston (4013 1/4 R) $15.95

O-120 A.D.C. Weston (4013 1/4 R) $120.95

O-30 V.D.C. Weston (239 1/4 R) $120.95

MOTORIZER HEATERS

Ideal for both, air-

conditioning, home, halls, etc.

259
$3.95
10 for $35.00
PORTABLE
D. C. AMMETER
HOYT TYPE 515
RANGE 0—15 AMPS

Mirrored scale 3½" long, knife-edge pointer. Molded bakelite case dimensions 4½" x 5½" x 2½". Snaps in place in black wrinkle-finished steel case 5¼" x 6" x 2½". Furnished with 3 ft. color-coded rubber insulated clip leads.

Basic movement—approximately 12.5 ma. Shunt readily replaced permitting conversion to lower range scale.

Individualy packaged in moisture-vapourproof packing.

TV and SCOPE POWER TRANSFORMER—15 V. 117V, 60 cy., Reconditioned—100WY, 100A, 1000 VCT.

100mA, 5V 3A, 2 1/2V 2A, 4 3/4V 1A, 12 6V 1A $7.80

AN/APS-13 1 CM ANTENNA ASSEMBLY, $33.25

HYDRAULIC SERVO CONTROLS—Sports Type F as equivalent. 54c (Transmitter and Receiver) $20.00

Write for Our Bargain Bulletin

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Phone—Cumberland 8-4737

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—Priced Right—

Switches—15,000V, 5 Amp., SPDT Motor Driven 110/1/60 $ 42.50

RA-38 Power Supplies, 15,000V DC, 5 Amp. Output 110/1/60 Input 275.00

RA-38 Power Supplies, 15,000V .035 A. 140.00

RA-34 Power Supplies, 1000V—350 MA-DC 12V, 14A AC, 12V, 2A DC 95.00

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THE FOLLOWING:

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15000 Phone Radio Switches $.10

150000 pole position rotary switches $ .10

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Large quantities of movie condensers in all sizes at low prices

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—RADAR SETS—

MODEL SF1. 10 cm. new, complete with spares. $1,800.00
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Rek-x-Kut 16" Master Pro M-55 — dail speed recorder; Augus head & E.M.M.牌子

Rek-x-Kut 12" dail speed playback

2-Astatic 400 pickups
50 watt R.C.A. power amplifier

Shure 255 microphone

Meter and amplifier mounted in rack Complete, assembled and mounted in custom built cases. Ready for use.

Practically brand new, original cost $870 now only $400.

FS-5092, Electronics

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Photograph 3 times actual size Glass both 1/16" thick Soldering iron removes lamps from base
Mazda G.E. 323 Jr. 19A Used for illuminating Meters, Comptometers and Airplane模型 for Models, Dali Houses, Miniature Trains, etc.
12 Volt. 100 Watt Soldering iron...

NEW RA38 POWER SUPPLY
115V., 60 cycle input adjustable output 0-15-
000V. A.C. or D.C. @ 500 Mils. Complete with
set of New Tubes and remote control, Ship-
ing weight 2100 lbs.

$250.00

TRANSMITTING
TRANTHROPS

 RECTIFIERS

<table>
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3824 4-amp. Recti-
tagons $5.95

TRANSMITTERS

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§500 Mfd. 50v. Dry Electrolytic... .95
2 Mfd. 600V. Tubular D1. .39
10 Mfd. 600V. Oil... .95
2 Mfd. 2500V. Oil... .24
2 Mfd. 1000V. D.C. or .125 Mfd. 1200V. D.C... .75
350V. 28c... .16
100V. 10,000V. £.40... .05
1200V. D.C. Oil... .35
115V, 25/200V. $2.25
001/25000V. $7.25
50 MfF. 32V. Tubular vacuum... .49

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RC 117.—Westinghouse Time Delay Current
Relay, Type SC-2. 2 to 1 amp A.C. or D.C.
8 amp continuous rating. Rating 20-60%
drop out ratio 512:1,-set weight. 3 lbs. Dim.
3 1/2" W x 5 1/2" D x 3 3/4" H.

BOONTON
140-A FREQUENCY GENERATOR
Range 20 CPS to 5 M.C. Output Voltage 1 V/M to
32 Volts. We have one unit for immediate reconditioning. GUARANTEED
THE NATIONAL INSTRUMENT CO.
FAR ROCKAWAY NEW YORK

Industrial Power Supply Equipment

RECONDITIONED GUARANTEED

<table>
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1527 E. Seventh Street

EPCO
Los Angeles 21, California

www.americanradiohistory.com
7,000 NEW STORAGE BATTERIES

PORTABLE TYPE

Plastic and Hard Rubber Containers

waterproof, lead acid type terminals. 6 volts, 15 amp, hrs., 3 cells, 2 volts each, 1½ amp, for 10 hrs., size 4½" width by 4½" length by 5½" height, manufactured by Willard and Gould, packed in wood boxes of 9, 12 and 18 each. At $2.00 each, I.o.b. Allentown, subject to prior sale.

Sample orders upon request

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Western Electric transformer 223A per D-163041 toroidal type core impedance 600 to 1000 $1.95.

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Telephone switchboard cords, 2 conductor tinsil rubber covered ½", long, both ends lugged. 100 $4.00 per 1000 $35.00.

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Record 62½ Minutes on each side of a 165" MemoDisc.

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1—Scott SLRM—New...$125.00 ea.

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2—Lyman CM-20 Com...10.00 ea.

1—Lyman CM-203 Used...2.50 ea.

2—Lyman CM-30 Good...10.00 ea.

1—Leland—½ HP-32 v dc Motor Used...10.00 ea.

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1—PE-73-E DM Unit...2.50 ea.

1—BD-77-C DM Unit...2.50 ea.

2—GE—27 v 60V-530w Ampidyne M/G...2.50 ea.

1—RCA-AVR-20R-Rec...10.00 ea.

2—RCA-AVT-112A-XMR...10.00 ea.

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The finest performing reproducers—barring none
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Meets every requirement
• NO INTER-MODULATION DISTORTION
• Your EARS will easily know the difference!

What is the life of a "Permanent" needle? Write for Complimentary Pamphlet on this important subject.

AUDAX COMPANY
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"Creators of Fine Electro-acoustical Apparatus since 1915"
Daven fixed attenuators are precision built, accurately calibrated networks. These units are extensively used in major broadcasting installations, motion picture sound studios and as laboratory standards of attenuation.

Some suggested uses are:

- **LOSS:** Introduction of a fixed known loss.
  - (a) To reduce level
  - (b) To equalize several incoming lines
  - (c) As laboratory standards of attenuation

- **TRANSFORMATION:** To transform or change from one impedance to another without introducing frequency or reflection errors.

- **ISOLATION:** To isolate one part of a line from another.

- **BRIDGING:** To bridge a program line for monitoring purposes.

- **MULTIPLE CIRCUIT:** To combine several inputs into one output, or to divide one input into several outputs.

The following fixed attenuators are our standard type units. Unless specifically stated, any standard impedance or loss is available upon request. Frequency range, unless listed, is from zero to 50 KC for most values. Upon request, this range can be extended.

**TYPE T-950**
- "T" Network
- Size: 11/16" diameter x 1 1/4" long (overall).
- Mounting: No. 6 screw through center hole.
- Maximum level + 20 DBM

**TYPE H-950**
- Balanced "H" Network
- Maximum level + 20 DBM

**TYPE T-154**
- "T" Network
- Size: 1-13/16" high x 1 1/2" long x 1 1/2" wide (overall).
- Mounting: Four 6/32" screws.
- Maximum level + 25 DBM

**TYPE H-154**
- Balanced "H" Network
- Maximum level - 30 DBM
  (Available up to 20 Watts, upon request)

**TYPE T-153**
- "T" Network
- Size: 3 5/8" high x 1 1/2" long x 1 1/2" wide (overall).
- Mounting: Four 6/32" screws.
- Maximum level - 30 DBM

**TYPE H-153**
- Balanced "H" Network
- Maximum level - 30 DBM

**TYPE T-691**
- "T" Network
- Size: 1 1/4" dia. x 3" long
- Mounting: Octal tube socket.
- Maximum level + 20 DBM

**TYPE H-691**
- Balanced "H" Network
- Maximum level + 20 DBM

**TYPE V-154 - "T" OR "T" NETWORK**
- Video Attenuator.
- Frequency Range: 0 to 10 MC. Loss: 0 to 30 DB per unit. Impedances: 50 to 75 ohms. Furnished with BNC type receptacles. Matching plugs or right angle adaptors for RG cable can also be furnished.

**TYPE RF-155 - "T" OR "T" NETWORK**
- Radio Frequency Attenuator.
- Frequency Range: 0 to 200 MC. Loss: 0 to 20 DB per unit. Impedances 50 to 75 ohms. Total of 80 DB available by connecting in series.

**MULTIPLE NETWORKS**

**TYPE 1030 - "T" NETWORK**
- 0-40 DB in 1 DB steps.
- Size: 1 1/4" diameter x 1 1/4" long.
- Mounting: No. 6 screw through center hole.

**TYPE 1130-8 - "H" NETWORK**
- 1 input, 8 outputs, 18 DB loss.
- Size: 1 1/4" diameter x 1 1/4" long.
- Mounting: No. 6 screw through center hole.

Further information on these units will be supplied upon request.
RCA preferred type tubes . . . for today and tomorrow

RCA Preferred Tubes fulfill the major engineering requirements for future equipment designs. RCA preferred Types are recommended because their general application permits production to be concentrated on fewer types. The longer manufacturing runs reduce costs—lead to improved quality and greater uniformity. These benefits are shared alike by the equipment manufacturer and his customers.

RCA Tube Application Engineers are ready to suggest the best types for your circuits. For further information, write RCA, Commercial Engineering, Session 1840, Harrison, N. J.

### RECEIVING TUBES

#### MINIATURE TYPES

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<th>Triodes</th>
<th>Pentodes</th>
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#### METAL AND OCTAL-GLASS TYPES

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### CATHODE-RAY TUBES AND CAMERA TUBES

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### POWER AMPLIFIERS AND OSCILLATORS

**MAXIMUM INPUT POWER VS FREQUENCY**

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High-Transconductance Types.
* Included for television damper applications only.
M miniature Types. Input values are for push-pull operation.
ICAS Rating—This type is recommended only for applications of a highly intermittent nature.

The fountainhead of modern tube development is RCA.

TUBE DEPARTMENT

RADIO CORPORATION OF AMERICA

HARRISON, N. J.
To Measure the Lowest Values of Current and Voltage Accurately

We Recommend These High-sensitivity Instruments

The high sensitivity, excellent responsiveness, sturdiness, and dependability of our complete line of galvanometers make them ideal for use in:
1. Laboratory measurements of temperature, resistance, etc.
2. Production tests of instruments and materials where rapid readings and minimum fatigue to operators are essential.

These galvanometers are portable and are easily connected into a circuit. Seventy-five ranges are available for immediate shipment. With such a large number of ratings you can be sure to find one that has the characteristics required for your particular application.

D-c Inkless Recorder - Its low power consumption makes it particularly well suited for high-sensitivity measurements. This recorder can be obtained as an ammeter, voltmeter (1000 ohms per volt), microammeter, millivoltmeter, milliammeter (for example, 1 ma - 16 ohms). It is accurate within 2 per cent, sturdy, and portable. Its inkless feature means there's no pen to start, no ink to spill, and rapidly fluctuating loads will not cause "painted" charts.

For a-c measurements, the companion Type CF-1 instrument is available as an ammeter and voltmeter.

For further information on the galvanometers, ask for Bulletin GEA-2136; on the recorders, GEA-3187. The nearest G-E office has copies. General Electric Company, Schenectady, N. Y.
RCA Type 68-B Beat-Frequency Oscillator. For equalizing the frequency-response of your remotelines... for checking frequency-response of your station equipment... for measuring distortion... this laboratory-type oscillator is ideal. Output is substantially constant over entire range, 20-17,000 cycles. Calibration accuracy within 1 cycle below 100 cycles; less than 1% deviation above 100 cycles.

RCA Type 69-B Distortion Meter. With the Type 68-B Oscillator, the 69-B permits rapid determination of distortion, hum in amplifiers, noise, and frequency-response characteristics. Harmonic distortion can be measured at any audio frequency—not just at one "check frequency."

RCA Type 311-AB Frequency Monitor. Meets the new rigid requirements of F.C.C. requiring frequency stability within ±20 cycles. The Crystal Oscillator of the 311-AB is stable to better than 2 parts per million! Double heat-control. Double-range large scale meter is undetected by modulation.

RCA Model 66-A Modulation Monitor. For rapid checking of percentage modulation. Neon peak flash lamp can be set to any predetermined threshold value. Readings can be made on either positive or negative modulation peaks. Measures also program levels, modulated carrier-shift, and average carrier value during modulation. Equipped with easy-reading meters, the 66-A is simple, accurate, foolproof.

RCA Model 308-A Field Intensity Meter. Direct Reading. No calculations. Quick and accurate to use... light and easy to carry on field-intensity surveys. Covers 120 to 18,000 kc. Reads directly signal-strengths from 20 microvolts per meter to 10 volts per meter. Because it avoids time-wasting calculations for each of the hundreds of individual survey-points, the 308-A quickly pays for itself.

Your station’s technical staff can keep your equipment at its peak efficiency only if they have the facts from which to work! That’s why accurate measuring equipment is about the best investment any station can make. It assures maximum coverage... helps get that extra margin of audio quality that pleases advertisers and audiences alike. Make a note now to ask your staff if they have all the measuring equipment they really need!