Multi-Channel Filters lend themselves to remote control apparatus employing frequency selection. The unit illustrated is a five channel band pass filter of the interstage type with the inputs in parallel and 5 separate output channels designed to feed into open grids. This circuit arrangement provides a 2:1 stepup ratio, with a band pass attenuation of approximately 30 DB per half octave. The dimensions of this unit in its hermetically sealed case are 2½” x 3” x 6”. Filters of this type can be supplied for any group of band pass frequencies from 200 to 7000 cycles.

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FINAL AMPLIFIER
Putting the finishing touches to a Press Wireless 15-kw transmitter
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JAMES H. MCGRAW, Founder and Honorary Chairman

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Director of Circulation:
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From

To

Signed

A. H. M.

SEPTEMBER • 1944
The characteristic you demand in a capacitor is long life. And in this all-important matter the record of Tobe Capacitors is an enviable one, with almost complete absence of "returns."

Lasting stamina is built into Tobe Capacitors through every step in their manufacture and is cross-checked by frequent, rigid inspections. Electrical ratings are always on the conservative side. Research is continuous in the search for an even better way, an even higher standard.

Type OD Capacitor (illustrated below) is manufactured in the careful Tobe way. Mineral oil impregnated and filled, in a streamlined drawn container, hermetically sealed. Designed for operation under a wide temperature range. Why not place your capacitor problems before Tobe engineers? Inquiries receive prompt, intelligent service.

**SPECIFICATIONS—TYPE OD**

**CAPACITOR**

**RATINGS:**

<table>
<thead>
<tr>
<th>Volts</th>
<th>Single Units</th>
<th>Dual Units</th>
<th>Triple Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>.05, 0.1, .25 Mfd.</td>
<td>.05, .1</td>
<td>.05, .1</td>
</tr>
<tr>
<td>1,000</td>
<td>.05, .1 Mfd.</td>
<td>.05, .1</td>
<td>.05</td>
</tr>
</tbody>
</table>

**STANDARD CAPACITANCE TOLERANCE:** plus or minus 20% **

**TEST VOLTAGE:** twice DC rating

**GROUND TEST:** 2,500 Volts DC

**OPERATING TEMPERATURE:** -55°F to 185°F

**SHUNT RESISTANCE:**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.05 to 0.1 Mfd.</td>
<td>-20,000 Megohms</td>
</tr>
<tr>
<td>.25 Mfd.</td>
<td>-12,000 Megohms</td>
</tr>
</tbody>
</table>

**POWER FACTOR:** 1,000 cycles - .002 to .005

**CONTAINER SIZE:**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width 9/16&quot;, length 1-11/16&quot;, height 1-17/32&quot;</td>
</tr>
</tbody>
</table>

**MOUNTING HOLE CENTERS:** 2-1/8"
Not afraid of GHOSTS

Phoenix
REG. U. S. PAT. OFF.
TRACING CLOTH

It's moisture-proofing that makes PHOENIX Tracing Cloth resist damp hands and arms. It will even stand up to ten minutes immersion in water. That's why it's proof against moisture ghosts — the ghosts that haunt prints made from tracing cloths that show perspiration stains.

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EST. 1867

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ON INDUSTRIAL ELECTRONIC TUBES

Looking ahead to continued development of electronic equipment in industry, postwar, we now have a plan to make Westinghouse Electronic Tubes quickly and easily available. Stocks of the most widely used tubes are now available through Westinghouse Electronic Tube Distributors and Westinghouse District Warehouses. As rapidly as possible additional types will be added to local stocks to make a complete line of Quality Controlled Westinghouse Electronic Tubes available to everyone.
EVERY FRONT, IN EVERY BATTLE, IN EVERY WAR INDUSTRY

WOULD GIVE THEIR

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To meet the enormous demands for Westinghouse Electronic Tubes—from the armed forces as well as war industry, we’ve increased floor space 20 times, trained 28 new workers for each one formerly employed, multiplied output 30 times! And now we’re not only meeting time and quality musts on all Government contracts—we’re also continuing to supply the heavy demands of war industry. Your nearest Westinghouse Office or Distributor will be glad to receive your inquiries for Westinghouse Tubes. Westinghouse Electric & Manufacturing Company, Bloomfield, N. J.

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yet 100%
MOISTUREPROOF

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4. Very high leakage Resistance.
5. Fine Power-Factor.
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   From 150 volts to 600 volts.
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8. Types P4, P5 for 95% humidity operation.

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3. Greater Range
4. Greater Sensitivity
5. Reduction of Human Error

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Sherron Electronics

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Brooklyn 6, N. Y.
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If you'd like to know more about what Corning knows about electronic glassware, we have a suggestion. Write today for a new booklet, "There Will Be More Glass Parts in Postwar Electronic Products". Please address the Electronic Sales Dept., E-9 Bulb and Tubing Division, Corning Glass Works, Corning, New York.
71.8%

SMALLER!

A NEW COMPACT, SHOCK-PROOF
IMPULSE-INITIATED TIMER

71.8% smaller than previous conventional units used for similar applications, Struthers-Dunn Type PSEH-1 impulse-initiated timer has the added advantages of rugged shock-proof construction, easily-accessible contacts, and dust-proof cover. Made in both AC and DC types, it operates the contacts at the end of a delay interval after power has been applied, or after receipt of a momentary impulse from a push-button, limit switch, or other source. The adjustable timing range is 20-to-1. The mechanism is immediately recycling. A double-pole, double-throw auxiliary relay is built in to provide a variety of circuit arrangements common to, or isolated from the control circuit. It can be supplied for AC operation on 110 V. 60 cycles or 25 cycles; 220 V. 60 cycles or 25 cycles; or for DC operation at any specified voltage from 6 to 120 volts. Size of a typical PSEH-1 Timer is 3½" x 3¾" x 3¾".

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Area of practical triode application before the G-E disk-seal, parallel-plane design.

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This new tube is one of the most important developments in electronic-tube history—ranking with such other G-E electronic firsts as the screen-grid tube, the high-vacuum tube, the mercury-vapor rectifier, and the thyratron.

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**GATRON IS THE GENERIC NAME ASSIGNED TO THIS DESIGN**

It will, for the first time, enable engineers to take advantage of high frequency channels that could not previously be used to advantage.

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2. **WITHSTANDS EXTREME VIBRATION**
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3. **WIDE RANGE OF APPLICATION**
   The basic unit is adapted to operate wafer switches, switches in separate compartments, or special built-up switch application.

4. **COMPACT & RUGGED DESIGN**
   The basic unit measures 2½"x1½"x1¼". The relay structure is made of finest magnetic metal accurately machined and properly annealed. The coil is wound to exacting specifications and treated to withstand severe humidity and salt spray conditions. Each part proportioned in size for its specific function...a powerful, rugged, space saving device.

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Control of all stages of production is the watchword at Consolidated Radio Products Company. That is why Consolidated's products can be depended on for quality, high efficiency, consistent performance and long life. International acceptance is the result of such high standards of production.
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- Winding strip is wound on a linen bakelite card which has been carefully sanded before winding.
- Windings are made of either Nichrome or Advance wire, depending upon the resistance of the card to be wound.
- The card, wrapped around a moulded phenolic base, is held in position by heavily plated brass nuts and bolts.
- The wiper, incorporating five contacts, is made of plated bronze, carefully buffed where electrical contact is made with the winding.
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MYCALEX 400 meets government specifications for L-4 characteristics, by virtue of its pronounced low-loss factor of 0.013 at 1 megacycle, and its surface resistivity of 300,000 megohms. Its power factor is 0.0018 at 1 megacycle, in accordance with American War Standard C-75.1-1943 (Jan. 1-10). Its dielectric constant is unchanged from 50 kilocycles to 10 megacycles. MYCALEX 400 can be machined with greater precision . . . drilled, tapped, milled, sawed, turned and threaded.

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"OWNERS OF 'MYCALEX' PATENTS"

CLIFTON, NEW JERSEY

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NEW YORK 20, N. Y.
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Doolittle Radio, Inc.
Builders of Precision Radio Communications Equipment
7421 South Loomis Boulevard, Chicago 36, Illinois
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In some cases there will be no need to look further than our standard line of Pyranol* capacitors for built-in applications.

The line includes more than 350 ratings in space-saving shapes and sizes. Many of the ratings are available in three shapes—oval, cylindrical, rectangular—to make your design problems easier; and they can be mounted in any position.

BE SURE TO GET your copies of our time-saving catalogs on d-c (GEA-2621A) and a-c (GEA-2027B) types. Ask your G-E representative for them by number, or write to General Electric, Schenectady, New York.

*Pyranol is the G-E trade mark for capacitors and for askarel, the synthetic, noninflammable liquid used in treating G-E capacitors.

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A governor automatically compensates for voltage variations of ± 20%.

While the motor normally operates at 450 rpm, the governor is adjustable, allowing a change in speed from 360 to 540 rpm.

The motor shaft drives a gear train which provides an output shaft speed of 5 rpm. This gear train can be modified to meet other speed requirements.

Interchangeable cams permit the use of any desired timing characteristic for two or more separate circuits.

Write for illustrated technical bulletin.

WALLACE & TIERNAN PRODUCTS, INC.
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NAME
ADDRESS
CITY ZONE STATE
This is a cross-section of the Machlett Dynamax X-ray tube. The ball bearings support the anode, which rotates at 3000 r.p.m., and reaches a temperature of 1000°F. The entire structure is in a vacuum of about 10⁻⁶ mm. of mercury, or a billionth of an atmosphere.

Conventional lubricants cannot be used, because they would destroy the vacuum and the tube. Machlett's scientific studies showed that a very thin film of certain metals can act as lubricant. Pure silver was found most advantageous. An almost molecular-thin film of it is deposited upon the balls in a vacuum, by a unique method.

So successful was this technique that Machlett, five years ago, guaranteed its Dynamax rotating anode tube for 10,000 exposures. Today it outlasts conventional stationary anode tubes. Some amazing records have been made with it, the best to date being 272,610 exposures, at the Army Examining and Induction Station, Pittsburgh, Pa.

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THE ANSWER
Add A to B, and you have the answer Hytron is able to give the Services when they demand special purpose and transmitting tubes in staggering quantities and at economical prices.

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RECEIVING TUBE TECHNIQUE
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THE ANSWER
Add A to B, and you have the answer Hytron is able to give the Services when they demand special purpose and transmitting tubes in staggering quantities and at economical prices.

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HY65 Typical of Hytron's instant-heating beam tetrodes for mobile communications, the HY65 combines high-speed techniques with a thoriated tungsten filament and special r.f. design features which gave the Services a rugged, power-conserving, all-purpose beam tetrode. (Cf. JAN-1A spec.)

2C26 Hytron solved a problem for the Services by designing a tube capable of performance and high ratings never before achieved in soft glass. Produced at receiving tube speed and priced at less than a fourth of the cost of tubes replaced, the little 2C26 delivers 2 KW of useful r.f. power under intermittent operating conditions.

WHAT ABOUT POST-WAR? Hytron design, development, and production facilities now serving our fighting men, will be yours to command. The A plus B of Hytron's know-how will supply answers to your special tube problems.

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ELECTRONIC AND RADIO TUBES
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Here, in one sensibly organized book, is the specific information you need on oscillator crystal units. Here is the first complete assembly of factual data on crystal unit design, construction, and application. It is yours, without obligation and without cost. Keep this new Crystal Products Company manual in your files. Use it as a workable tool in planning circuits and assemblies for precise radio frequency control.

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- Cut-Away Drawings
- Technical Specifications
- Functional Data

This is not a treatise on the development of the Piezo-Electric properties of Quartz Crystals; it is a series of specific descriptions of approved Crystal Units that are now accepted and used in all types of practical electronic equipment, and that are available for present and future applications.
Crystal Units are classified according to their fields of use. These include:

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- Filter
- Test
- Amateur
- Aircraft
- Police-Marine
- Multiple Units

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ENGINEERING

Versatility

achieves variety in Transmitter design

TEMCO is a closely knit organization of versatile engineers, designers and technicians — working as a team — producing in single or volume quantities, transmitters of finer mechanical construction and electrical design in ever-broadening fields of applications.

Vision and versatility of TEMCO engineers meet the challenge of diversified assignments ... alertly keeping pace with rapid advancements in radio research.

That is why entirely different groups of instruments are constantly emerging from our organization, all possessing the excellent qualities with which TEMCO-built communication equipment is endowed.

Your problem may be “off the beaten path” — all the more reason why TEMCO can serve you better in arriving at a speedy solution. Let us show you what we have accomplished for others. Write for a copy of the TEMCO catalog.

TRANSMITTER EQUIPMENT MFG. CO., INC.
345 Hudson Street, New York 14, N. Y.

TEMCO

RADIO COMMUNICATION EQUIPMENT
Newly Developed Silicone Products

Now Available in Commercial Quantities

Dow Corning Fluids possess unique characteristics that warrant their close study by technicians in varied industries—especially those engaged in the current war effort. These water-white permanent liquids are furnished in two series, covering a wide range of viscosities.

Dow Corning Silicone Products Include:

RESINS—High temperature insulating varnishes for use with heat stable electrical insulating materials.

GREASES—For lubrication of valves in high temperature or corrosive chemical services. Plugcock Grease—for metal valves. Stopcock Grease—for glass and ceramic valves.

Summary of Characteristics

- Remarkably low viscosity change from sub-zero to high temperatures.
- Exceptionally inert to metals, rubber and plastics.
- Unusually resistant to chemicals and high temperatures.
- Effective water repellent.
- Lubricant for glass, ceramics, plastics.

Dow Corning Corporation
Box 592, Midland, Michigan
This issue is No. 1, Volume 1—others will follow if you request them. Contents are authoritative—but non-technical—designed to inform the layman on a subject which is becoming of increasing importance.

Send for your copy on your letterhead—we are glad to send it as our contribution to a greater Air-America.

You should know——

What is the "bottle-neck" in post-war expansion of civil aviation . . . . . . . . . . . . . . . . . . . See page 8

Why CAA is installing Ultra High Frequency radio ranges. See page 8

What anti-collision devices are being developed . . See page 9

What electronic aircraft detectors are . . . . See page 9

What can civil aviation learn from the A.A.C.S. . See page 2

What goes into an instrument landing system . . See page 11

What is approach control. See page 11

These questions and dozens of others of vital import to all those interested in the development of radio in aviation for increased safety of human life and property are discussed in the pages of "HIGHWAYS OF THE AIR"
Chemical Resistance

“Chemical Warfare” is not confined to the battlefield. Under conditions imposed by modern industrial applications, Plastics, along with other materials, are subjected to constant chemical “attack” as they perform their allotted tasks in military and essential civilian uses.

“Catalin” Cast Resin in the “Chemical Resistant” grade is especially formulated to withstand the effects of most acids, alkalies and lubricants. In addition to this desirable quality, it has a low percentage of water-absorption and the other physical, mechanical and machining characteristics usually associated with all Catalin Cast Resins.

“Loalin”—Catalin’s polystyrene molding compound—offers excellent resistance to all acids, alkalies and alcohols, being soluble only in esters and the aromatic hydrocarbons. Its water-absorption is 0.00% (24 hours immersion at 25°C) and its reaction to mineral, animal or vegetable oils ranges from excellent to poor, depending upon the particular oil.

Our chemists and engineers have made exhaustive tests of both Catalin and Loalin under various conditions and covering chemical, electrical, thermal, mechanical, physical and “working” properties. The results of their inquiries and the experience and testimony of fabricators, molders and users in many fields are available to your own technical staff for immediate application or for guidance in “blueprinting” the products of tomorrow.
The new HK-257B Gammatron provides 235 watts output with ZERO DRIVING POWER

OPERATING DATA
As an RF Power Amplifier, Class C, Unmodulated

<table>
<thead>
<tr>
<th>Power Output (Maximum)</th>
<th>Typical Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>235 Watts</td>
<td>0 Watts</td>
</tr>
<tr>
<td>Driving Power</td>
<td>0 Watts</td>
</tr>
<tr>
<td>DC Plate Volts</td>
<td>4000</td>
</tr>
<tr>
<td>DC Plate Current</td>
<td>150</td>
</tr>
<tr>
<td>DC Suppressor Voltage</td>
<td>750</td>
</tr>
<tr>
<td>DC Suppressor Current</td>
<td>30</td>
</tr>
<tr>
<td>DC Screen Voltage</td>
<td>500</td>
</tr>
<tr>
<td>DC Screen Current</td>
<td>25</td>
</tr>
<tr>
<td>DC Control Grid Voltage</td>
<td>170</td>
</tr>
<tr>
<td>DC Control Grid Current</td>
<td>75</td>
</tr>
<tr>
<td>Plate Dissipation</td>
<td>65</td>
</tr>
</tbody>
</table>

Because grid current is zero in the above circuit, the HK-257B is being operated at zero driving power. Some power is being fed into the circuit developing the grid driving voltage in order to supply normal loss. This loss in the resonant grid circuit is on the order of 1.0 watts in most practical circuits.

Now Heintz and Kaufman engineers offer an improved version of the famous HK-257 Gammatron—the tube that produces 235 watts of RF power with zero drive, that operates at high efficiency up to 150 megacycles, and that requires no neutralization.

The special design of the HK-257B permits high screen and plate voltage ratings, which in turn allow high power output with zero drive.

A transmitter designed around this remarkable Gammatron requires a minimum number of stages, few tuning controls, minimum driver equipment, and enables instant channel switching as no neutralization adjustment is needed.

The improved HK-257B is more rigid mechanically, has maximum protection against filament bombardment, and withstands severe momentary overloading without injury.

HEINTZ AND KAUFMAN LTD.
SOUTHERN SAN FRANCISCO • CALIFORNIA
Gammatron Tubes

WRITE TODAY FOR COMPLETE DATA
Put the Screws on the Enemy...BUY BONDS!

**STOP waste of time**
There's no fumbling or dropping, with American Phillips Screws. And no wobbling starts, for the recessed screwhead fits firmly onto the 4-winged driver, like a fixed bayonet onto a gun. Power drivers can be used, increasing assembly-speed often as much as 50%.

**STOP rejections**
"Controlled Accuracy" means that American Phillips Screws and driver align themselves automatically into one straight-line unit that can't drive crooked and spoil work. Nor can the driver ever twist out and slash across the work-surface.

**STOP scrapping of screws**
American Phillips Screws can't be burred or broken like slotted-screwheads. And American Phillips Screws don't have to be backed out and thrown away. Nor do they have to be scrapped for defects of head, thread, or point...thanks to American's individual inspection.

*AMERICAN SCREW CO.*

his is a special-purpose electronic part. It is a plug-receptacle assembly for use with rack-panel type of counting. Twenty-four silver-plated phosphor-bronze contacts are provided, each male and female contact full floating between steatite plates. Heavy side pins and matching holes in the frame assure perfect alignment.

We don't know that your product has any need for a part as this. We do know, however, that this part is most exactly suited to its special requirement, just as are hundreds upon hundreds of other parts which have been created through Lapp engineering and Lapp production facilities directed to the solution of specific problems.

With a broad basic knowledge of ceramics—their capabilities and their limitations—Lapp has been able to simplify and to improve many types of electronic equipment through engineering and production of sub-assemblies that make most efficient use of porcelain or steatite and associated metal parts.

There may be a way you can improve performance, cut costs and cut production time through use of Lapp-designed and Lapp-built sub-assemblies. We'd like to discuss your specific requirements with you.

Lapp Insulator Co., Inc., LeRoy, N. Y.
GET THIS TIMELY, NEW
Dry Electrolytic Capacitor CATALOG

Every day finds dry electrolytic capacitors establishing new standards of performance in applications formerly reserved for other types. Small, light and inexpensive, dry electrolytics have been steadily improved to a point where they meet the most exacting specifications. These include salt air, reduced pressure, low and high temperature extremes, transients, r-f impedance, sealing, "shelf life," and many more. In addition, Sprague Dry Electrolytics are available in unlimited combinations of capacity and voltage ratings, with special electrical characteristics, and in containers for every mechanical requirement. You will find this big new catalog a handy guide to dozens of standard and countless special purpose types.

(Formally Sprague Specialties Co.)

SPRAGUE CAPACITORS · KOOLOHM RESISTORS

September 1944 — ELECTRONIC
CHAIN television is here! With the recent dedication of the new Philco Relay Transmitter at Mt. Rose, N. J., the first Television Network, linking Philadelphia, New York and Schenectady, is in actual operation today. Now Philadelphians enjoy clear reception of programs from New York through their local Philco television station. Thus the first step has been taken through which millions will eventually witness events that take place thousands of miles away... by television.

HOW PHILCO RESEARCH SPEEDS THE ADVANCE OF TELEVISION

This first television network is an example of how Philco research is working to establish transmission principles which can extend chain television broadcasting from coast to coast. At the same time, Philco research is improving the clarity, sharpness and detail of the television picture... so that future television sets will have the greatest possible sales appeal. Thus in two ways... by helping to broaden the market for television, and by designing a more saleable product for that market... Philco leads toward the goal of television as tomorrow’s “billion dollar industry.”

Radio Hall of Fame Orchestra and Chorus.
Tune in Sundays, 6 P.M., E. W. T., Blue Network.

BACK THE ATTACK—BUY WAR BONDS

PHILCO
THE OVERWHELMING LEADER IN RADIO FOR 12 STRAIGHT YEARS
Right... the First Time

Fuse panels like these are in line with our most specialized kind of work... the combining of metal parts in bakelite assemblies. These are not standard parts, however. They were all made to the particular specifications of a new customer. From a small first order these panels have since developed into numerous and larger orders from the same source.

Many, perhaps most, of our new jobs at Ucinite come from companies which have production bottlenecks to break and not too much time to make sure that it is done. We get a great kick out of being able to turn emergency customers into regular customers... by getting things right the first time.

The UCINITE CO.
Newtonville 60, Mass.
Division of United-Carr Fastener Corp.

Specialists in RADIO & ELECTRONICS
LAMINATED BAKELITE ASSEMBLIES
CERAMIC SOCKETS • BANANA PINS & JACKS • PLUGS • CONNECTORS • ETC.
'200.00 in prizes every month
$100.00 first prize, $50.00 second prize, $25.00 third prize, $15.00 fourth prize, $10.00 fifth prize, plus $1.00 for every letter received.

Rules for the Contest
Hallicrafters will give $200.00 for the best letters received during each of the six months of September, October, November, December, 1944, January, and February, 1945. (Deadline: Your letter must be received by midnight, the last day of each month.)

For every serious letter received, Hallicrafters will send $1.00 so even if you do not win a big prize your time will not be in vain. Your letter will become the property of Hallicrafters and they will have the right to reproduce it in a Hallicrafters advertisement. Write as many letters as you wish. V-mail letters will do.

Open to servicemen around the world. Wherever you are, whenever you see this ad, drop us a line. Monthly winners will be notified immediately upon judging.

There's gold here! Write today to get your share. Tell us your story in your own way. You can't lose and you can win as high as $100.00.
PERFECTION
assured by quality control

You can be sure your wiring harnesses are okay—if Whitaker produces them

Skilled technicians, utilizing specially designed testing equipment, check every assembly produced by Whitaker. Hundreds of individual tests are made on some assemblies—and when passed by our experts, you can be sure the job is okay.


WHITAKER

Cables, Wiring Harnesses and Assemblies for Automotive, Aircraft, Marine and Radio Equipment
FOR SERVICES WELL RENDERED, I THANK THE MEN AND WOMEN WORKERS OF THE ELECTRO-VOICE MANUFACTURING COMPANY WHO HAVE BEEN AWARDED THE "E" BY THE ARMY AND NAVY OF THE UNITED STATES.

Albert Kahn

PRESIDENT, ELECTRO-VOICE MANUFACTURING CO., INC.
The 80 practical specialists who work in this magnificent building at Bayonne, N. J., have every facility—chemical, physical, metallurgical—to aid them in bringing nearer their goal—extending to the utmost the effective means of electrical transmission and distribution. Built in 1941, the structure has already grown to 60,000 sq. ft. of floor space—is planned for further expansion as needed.
THE FIRST GREAT LABORATORY DEVOTED EXCLUSIVELY TO RESEARCH ON ELECTRICAL WIRES AND CABLES

...thus "basic research in a particular industry devolves naturally upon the leading manufacturer." General Cable has been alert to its responsibility. In this great Laboratory are maturing the insulation discoveries and product developments which will loom large in days ahead.

GENERAL CABLE CORPORATION

Manufacturers of Bare and Insulated Wires and Cables for Every Electrical Purpose
The right answer is important to you!

All of the above methods are done in our plant thus assuring the best and most economical production of your plastics requirements.

Send your Tough plastics problems to~

**Brilhart LTD.**

434 Middleneck Road • Great Neck, N.Y. • Phone: Great Neck 4054
Inversion from the frantic pace of wartime production to tranquil ways of a world at peace will be another gigantic job. But it's one that must be done and done quickly when the time comes. For we must be ready for peace... we must have jobs waiting for those boys who have been there doing the biggest job of all for us!

That's one of the reasons why the WPB recently encouraged such planning and released materials for the development of new products.

This future-minded organization... is still 100% engaged in war work. But it is already planning and perfecting Electronic control devices which may readily play an important part in your conversion plans.

*BUY MORE THAN BEFORE... BONDS*

**Maguire Industries, Inc.**

**Electronics division**

Maguire Industries, Inc., Greenwich • Stamford • Bridgeport • New Milford • New York

Electronics will add to the comforts and conveniences of the home of the future, in the country as well as the city. Keep your eye on the Magic Eye. It's going places.
Precision operation of a wide variety of factory testing, production and laboratory electrical equipment requires uniform, stabilized AC input voltage. A Raytheon Voltage Stabilizer, incorporated in the product, permanently eliminates fluctuating voltages by assuring constant output voltage of 115 volts ± 1/2%. They are available in three designs to meet practically every installation requirement. Bulletin DL48-537 gives the complete story. Write for your copy.

**NOTE THESE PERFORMANCE FEATURES**

**CONSTANT AC OUTPUT VOLTAGE**
Raytheon Voltage Stabilizers control fluctuating input voltages and hold constant output voltage to ± 1/2%.

**WIDE AC INPUT VOLTAGE LIMITS**
Raytheon Voltage Stabilizers will stabilize input voltages varying from 95 to 130 volts.

**QUICK RESPONSE**
Raytheon Voltage Stabilizers stabilize the varying input voltage within 2 cycles. Variations cannot be observed on an ordinary volt meter.

**ENTIRELY AUTOMATIC**
Raytheon Voltage Stabilizers are entirely automatic in operation. They require no adjustments or maintenance. Simply connect the stabilizer to the AC input and the output to the electrical device and the unit will take care of itself, stabilizing the varying voltage to ± 1/2%.

**NO MOVING PARTS**
Raytheon Voltage Stabilizers have no moving parts . . . Nothing to wear out thus assuring long life.

**PARALLEL OPERATION**
Standard Raytheon Stabilizers of identical rating can be connected in parallel for higher output rating.

**THREE DESIGNS**
Standard Raytheon Voltage Stabilizers are available in three designs . . . cased, uncased and endbell . . . to meet practically every installation requirement.
Qualities

OF A PERFECT RECORDING BLANK

PURITY OF COATING: There must be no surface or concealed dirt, grit, mottling, lint, streaks, whorls, "orange peel" scratches, oiliness, ripples, wrinkles or unpleasant odor.

PROPERTIES OF COATING: It should be absolutely smooth, of uniform density and thickness, without pits which pop and click; soft enough to cut; hard enough to retain good tonal values; and it must not deteriorate with age. GROOVES should be glossy, which means playbacks without surface noise. THREAD must curl in one piece and be static free. PLAYBACK, whether at once, next month, or next year, must be 100%.

PROCESSING must give fine results whether silvered or sputtered.

THESE ARE THE QUALITIES CRITICAL USERS FIND IN audiodiscs

they speak for themselves
JOIN METALS FASTER, BETTER

with High Frequency Induction Heating

Many production metal-joining operations now performed by welding or brazing can be done with remarkable savings of time and cost by modern Lepel High Frequency Induction Heating. The most intricate jobs can be so simplified that they can be accomplished in a matter of seconds by

1. Assembling pre-fluxed parts (in jigs if necessary) with the brazing alloy pre-formed in the form of rings, strips or irregular shapes.
2. Heating the joint or seam by means of a "load coil" for the exact time necessary to ensure thorough penetration by the molten alloy. Brazing alloys of any melting point from the lowest to the highest can be used.

An entire joint of any shape — or several joints — can be heated at one time. Heating frequently can be performed on a moving belt in conjunction with other operations to provide continuous-flow production.

As the heat is generated within the metal itself, the brazing alloy penetrates throughout the joint, producing maximum strength and soundness. At the same time, accurate manual or automatic control of time and temperature cycles prevents excessive heating, minimizing discoloration and practically eliminating scale. Thus little, if any, cleaning up or refinishing is necessary.

A Lepel field service engineer will be pleased to call to give you further information and aid in working out details of the applications of this modern method to your joining operations.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
PIONEERS IN INDUCTION HEATING
39 W. 60th STREET
NEW YORK 23, N.Y.

September 1944 — ELECTRONIC
Pride is something that comes from the heart. It cannot be seen—except as a symbol. Such as these service pins worn by our skilled craftsmen.

C-D's men and women are outstanding technicians in their special field—capacitors. Many of our men have been working on C-D capacitors almost as long as modern capacitors have been in existence... for C-D pioneered in capacitors and has manufactured them exclusively for 3½ years.

Some of our men designed and made capacitors for wireless equipment used in World War I. They proudly wear their symbols of long service. Others wear their 5-year pins, their 10-year pins, their 20-year pins as a mark of their skill, accumulated knowledge and experience in capacitors.

Our men and women are constantly striving for improvements... and out of their inquiring minds come new developments to meet the changing needs of capacitor users. These are the people who build dependability into C-D capacitors—that make them top quality always. Cornell-Dubilier Electric Corporation, South Plainfield, N. J.

CORNELL-DUBILIER CAPACITORS WORLD'S LARGEST MANUFACTURER OF CAPACITORS

MICA * DYKANOL * PAPER * WET AND DRY ELECTROLYTICS

1910-1944
Its tough, flexible insulation enables you to produce tighter coils in less time

- When you're using Formex magnet wire, you can literally "go the limit" in speed of coil winding and in tension. Its insulation film is so flexible that it can be wound around its own diameter without cracking.

- It is so tough that it has thirty times the abrasion resistance of conventional enameled wire; so tough that, even in the ultrafine sizes, the tension limit is determined by the strength of the copper conductor, not by the insulation.

Formex wire is smoother and more flexible than either enameled or fabric-covered wire. It pulls into place readily without forcing or jamming.

Because of this extra strength and flexibility, you can wind coils tighter and faster—and these same qualities will insure more coils passing final inspection.

For more information on Formex magnet wire, get in touch with the nearest G-E apparatus office. General Electric Company, Schenectady 5, N. Y.

A NEW NAME ON THE ELECTRONICS POST-WAR HORIZON

The period after the war may well become known as the “Electronic Era”. In the development of the many ingenious post-war products, there will be a need for specialized engineering of precise and intricate high frequency components. This is our field. Our organization, with years of experience designing and making such products is at present devoting its manufacturing facilities 100% to war work. These unusual facilities will soon be available for the peacetime needs of our industry, and our engineering “know-how” is at your service now to help you with your post-war planning.

Mec-Rad

MANUFACTURERS OF MECHANICAL-ELECTRICAL COMPONENTS FOR RADIONICS

DIVISION-BLACK INDUSTRIES

1400 EAST 222ND STREET  CLEVELAND 17, OHIO
If you are worried about copper wire corrosion, there's good news in recent tests made by a well-known laboratory. They placed cellulose acetate butyrate film in contact with copper wires in electrical use, under maximum water absorption conditions. No evidence of corrosion was found on either the wire or the film. (Copy of report on request.)

Lexel insulating tape is cellulose acetate butyrate. These tests confirm our own laboratory findings and the long experience of Lexel users. They prove not only its noncorrosive qualities, but also its low moisture absorption characteristics.

Lexel has other advantages, too. Small bulk and weight save space in tight places. The conductor is always center-sealed by heat in a continuous helical tube. Lexel has high dielectric strength and insulation resistance.

Test Lexel insulation tape for instruments, controls, lead-in and hook-up wires and other low-tension applications. We'll send you samples and names of manufacturers that can supply Lexel insulated wire and cable.

CUSTOM-MADE INSULATION

As a regular service, Dobeckmun engineers also develop laminated insulation products, custom-made to special purpose specifications, such as slot cell and phase insulation for motors, insulation for shipboard cables and other uses. If your requirements are unusual, call on us.

"LEXEL" is a registered trade-mark of The Dobeckmun Company.
MORE THAN an engineering laboratory developing extraordinary new instruments and devices... more than a test service for the armed forces and many of our largest industries... Waugh Laboratories is a source of test instruments... the one place where an engineer or industrial laboratory may obtain the particular instrument required for specific tests or as permanent equipment.

Given your problem, Waugh will gladly recommend an instrument or combination of instruments that seem most likely to offer a solution, and no matter how specialized, will endeavor to provide these instruments on order.

In addition to this procurement service, Waugh offers laboratory and field service in vibration, stress and strain determination and analysis, and also an instrument rental service.

Write us concerning your problem.
Every Manufacturing Customer Will Benefit

Industrial users of WILCO Products will find the increased facilities, the new products and techniques developed by WILCO for war service of great advantage to their own postwar products.

As the Hourglass indicates . . . with the coming of peace, many WILCO products now making for precision performance in airplanes, ships, tanks, guns and instruments of the Army and Navy will play an equally important role in meeting civilian needs for hundreds of useful and reliable products.

The demand of all branches of the service for Thermostatic Bimetals and Electrical Contacts has motivated many WILCO developments of great potential value to postwar industry. New products added to an already extensive line; increased facilities for refining and fabricating precious metals; greatly extended rolling mill facilities—these new additions and improvements, now devoted principally to the war effort, will prove equally helpful to manufacturing customers in meeting their peacetime production and marketing problems.

WILCO PRODUCTS ARE:


- Thermmetals—Electrical Contacts Precious Metal Bimetallic Products

The H. A. Wilson Company
105 Chestnut Street, Newark 5, New Jersey

Branches: Detroit • Chicago

September 1944 — ELECTRONIC
This newly designed Picker Series "50" Low Voltage X-Ray Unit is a tool of many uses in many fields... light metals, plastics, textiles, fibres, plywood... to name only a few. It provides accurate controls on spot welds, routinely and non-destructively, through periodic radiographic checks of operation procedures (as in example "A"). A typical example of its utility in the field of plastics is evident in the radiograph "B" above, where density variations would indicate the need for revisions in manufacturing technique.

Don't imagine that such X-Ray check-and-control operations require large space and cumbersome installations. On the contrary, this new Picker Series "50" X-Ray Unit, designed for just such work, is clean-lined, simple, compact and efficient... capable of all kinds of low voltage long wavelength radiography from 5 KVP to 50 KVP. There is definitely a place for this machine in your plant. Your local Picker representative will be glad to discuss with you its amazing utility and manifold applications. Or send for Picker Bulletin 1444 which gives complete details.

**Picker 50 KV Industrial X-Ray Unit**

- Special line-focus tube, water-cooled, end-grounded
- Low absorption beryllium window
- Continuous operation throughout entire range
- Safe electrically; safe against primary as well as secondary radiation

Picker X-Ray Corporation • New York, N. Y.
Waite Mfg Division • Cleveland, Ohio

PIONEERING IN THE HIGH-VOLTAGE ELECTRICAL FIELD

SINCE 1879
The performance of a high power transmitting tube depends largely on the purity of the component metals used. That's why Taylor "Custom-Built" heavy duty tubes rely on Callite for thoriated tungsten filament wire, tungsten filament springs and tungsten welds.

Callite Thoriated Tungsten Filaments contain the right proportions of tungsten and thorium to give the required electronic emission plus the strength to withstand rough handling and higher overloads. Callite's careful processing of tube components is backed by long experience in tungsten metallurgy. You, too, can rely on us as a dependable source of supply. Callite Tungsten Corporation, 544—39th St., Union City, N. J. Branch Offices: Chicago, Cleveland.

Taylor Tube Type B 838, manufactured by Taylor Tubes, Inc. of Chicago, with Callite components.

R  FOR R-DAY (Reconversion)
Discuss your post-war plans with our engineers. Our accumulated knowledge and experience is worth having—Now. We can help you on the design and selection of materials.
Throughout the world, the name of Chicago Telephone Supply Company means leadership in precision mass production of variable resistors, both wire wound and carbon types.
E-E Electronic Tubes!

New principles, new methods, startling results! Voices and images hurled across the miles! Pin-point navigation, electron-optics, electronic heating and control—all these and more, speeding and bettering production and communications! The vacuum tube is a super-bazooka blasting and clearing the path of civilization.

E-E power Rectifiers and Amplifiers are leaders in the vanguard of this advance. Included in this diversified line are High Vacuum, Mercury Vapor and Grid Control Rectifiers, Oscillators, Modulators and Amplifiers—all ruggedly designed for heavy duty applications, and rigidly controlled throughout production.

Complete technical information is contained in the descriptive E-E Data Book—why not write today for your copy.

ELECTRONIC ENTERPRISES, INC.

GENERAL OFFICES: 65-67 SEVENTH AVENUE, NEWARK, 4, N. J.
EXPORT DIVISION: 25 WARREN STREET, NEW YORK, 7, NEW YORK
CABLE ADDRESS: SIMONTRICE NEW YORK

September 1944 — ELECTRON
ILLUSTRATED are several examples of metal-glass hermetic seals produced by Stupakoff for various types of equipment.

The metal, KOVAR,* a cobalt, nickel, iron alloy, has made possible a hermetically sealed terminal without the use of cements or gaskets. The seal between Kovar and glass is a chemical bond in which the oxide of Kovar is dissolved into the glass during a heating process. The result—a permanently vacuum and pressure tight seal—effective under the most extreme climatic conditions.

Stupakoff also supplies Kovar as rod, sheet, wire, tubing, eyelets, cups and other forms for those equipped to do their own glass working. Kovar-glass seals answer most hermetic sealing problems. Write today for technical data Bulletin KA-12 listing currently available Kovar-glass terminals and Bulletin KA-11A for standard Kovar shapes and sizes.

DO MORE THAN BEFORE—BUY EXTRA WAR BONDS

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

*Trademark 337952 REGISTERED IN U.S. PATENT OFFICE

TRONICS — September 1944
Farnsworth engineers

AT YOUR SERVICE

WRITE FOR A COPY OF
"The Story of Electronic Television"
—a new brochure for which you'll have many uses.

FARNSWORTH
Television · Radio · Phonographs

You can call on a wide range of experience in the Farnsworth engineering staff. This outstanding organization includes specialists in television ... FM and AM reception and transmission ... Radar ... phonograph reproduction ... acoustics ... record-changers.

War keeps these men busy today. Tomorrow they will be the background for Farnsworth radio, phonograph and television equipment ... drawing upon a rich experience of more than 19 years in electronic research and development ... guarantee of leadership.

... And they will welcome your questions regarding all phases of radio and television transmission and reception. You'll find Farnsworth engineers leading in more and more fields ... Farnsworth experience and Farnsworth equipment belong in your plans for the future.
It is a well known theorem in geometry that "a whole is greater than any of its parts and is equal to the sum of all of them". This is certainly true of electronic equipment where overall performance is entirely dependent on each component part doing faithfully the job expected of it. Mica capacitors are frequently assigned a tough job—one in which ability to "stand up and take it", under the most severe operating conditions, is of paramount importance.

Sangamo Type H capacitors were designed for just this kind of service. Manufactured in accordance with the strict requirements of the American War Standard Specifications—case sizes CM45 and CM50—these capacitors are performing faithfully in many types of electronic equipment now in service in all corners of the world.

SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS
RETAINING all of the inherent advantages of the ceramic case Erie Insulated Ceramicons, this new improved type, with a one piece molded phenolic case offers even better protection against humidity. It also insures more intimate contact between the silver electrode and the molded dielectric, eliminating the possibility of air gaps.

In all other respects the molded type Erie Ceramicons are the same as Ceramicons with ceramic insulation. Overall dimensions are unchanged. They cover the same standard range of temperature coefficients, from $+100 \text{ P/M/ } ^{\circ}C$ to $-750 \text{ P/M/ } ^{\circ}C$.

At present both types are available, but all production will be standardized on the molded type in the near future.

Samples have been submitted to the Army-Navy Electronics Standard Agency at Redbank, N. J., for approval against JAN-C-20. Orders are now being accepted for both the molded insulated and ceramic insulated styles against JAN-C-20. Write for cross reference sheet showing styles of Erie Ceramicons and corresponding JAN-C-20 designations.

Do More Than Before—Buy EXTRA War Bonds

Electronics Division
ERIE RESISTOR CORP., ERIE, PA.
LONDON, ENGLAND • • TORONTO, CANADA
Lumarith* protects the finest wiring from the Black Hand of Corrosion

The unusual corrosion-resistance of Lumarith insulating film is best shown by its application to coils of extremely fine copper wires where the tendency to corrode increases rapidly as the diameter of the wire decreases.

Even when used with wires as fine as #40 AWG, Lumarith gives protection due to the absence of electro-chemical decomposition—that built-in hazard of insulations containing an excess of water-soluble chemical salts. Lumarith is entirely different chemically from paper, cotton and regenerated cellulose.

Lumarith also provides an effective barrier to high humidity and moisture conditions, particularly important to the insulation of small relay coils operating at high voltages. Lumarith has a high softening point (146°–177° C depending on formulation).

Corrosion-resisting wrappers of Lumarith film and Lumarith molding powders in solutions for dipping, are high in dielectric and physical strength, low in moisture absorption. Films come in a special mat finish which increases visibility and decreases slippage in winding operations.

Have you a copy of "Lumarith for the Electrical Industry"? It’s well worth having on file. Celanese Celluloid Corporation, a division of the Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

Lumarith

A Celanese* Plastic

These are special nuts, critical items of war production. They were made originally by milling from round bar stock. Production could not come near to meeting the demand. "National" developed the cold header method, upsetting the collar from a hex bar of smaller diameter. This obviates the necessity of milling the hex from the round bar.

On one of these items alone, our process released 500 milling machines and effected a saving in material of about one-third. A serious production bottleneck was broken.

Have you seen our booklet "Saving Critical Man Power, Material, Machines"? It may suggest how you can have a production headache relieved. Write for it today.
It was a great day for radio communication when National Union engineers developed the technique of gold plating certain tube parts. For by this ingenious means they measurably extended the life of power tubes.

The object, here, was not to make power tubes structurally stronger—or even more durable. Already these tubes were sound enough mechanically to do a bang-up job. What the N. U. process of gold plating did, was to make the electrons behave. N. U. engineers demonstrated that by gold-plating the grid wire, they automatically eliminated a very disturbing factor in power tube performance, known as grid emission. The source of this undesirable primary emission was imprisoned within the gold. No longer could it interfere with the planned and controlled electron flow within the tube. Result—power tubes of a higher performance level and longer life.

Thanks to the greatly expanded electronic research program at National Union Laboratories, many such improved tubes with wide application in America’s homes and industries will be available at the war’s end. Count on National Union.

NATIONAL UNION RADIO CORPORATION, NEWARK, N. J.
Factories: Newark and Maplewood, N. J.; Lansdale and Robesonia, Pa.
The Pan American World Airways routes shown below are those in existence on December 7th, 1941. Present routes cannot be shown.
PAN AMERICAN WORLD AIRWAYS continues to perform a vital wartime service by speeding men and materials to every U.S. front and outpost... and AAC Precision Radio Products play an important part in this service.

As the giant Clippers spread their wings across the world, AAC Products help to maintain communications along the lifelines of this vast system which flies to every continent on the globe. These products are in use at operations bases, both here and overseas.

This is just one example of how the engineering and production skill of Aircraft Accessories Corporation serves the world's great airlines—as well as various branches of the armed forces. As one of America's largest producers of transmitters and other precision radio equipment, AAC offers the services of its Engineering Department in designing special equipment for you, without obligation.

In war as in peace the PAA Clippers serve humanity. Here 1810 pounds of medical supplies go aboard at LaGuardia Field.

ACCESSORIES CORPORATION

New York, N.Y. Burbank, Calif. Cable Address: AACPRO
The purpose of the electron tube is simply to harness electrons to useful work. What shape the electron tube takes in glass depends upon the type of work to be done. As the result of fulfilling many important wartime electronic assignments, Sylvania now makes a wide variety of electron tubes and now has the experience to design even more. A few of them are shown here. There are many more, some of which are still on the restricted list. For information, write Sylvania Electric Products Inc., 500 Fifth Avenue, New York 18, N. Y.

one standard—the highest anywhere known

SYLVANIA
ELECTRIC PRODUCTS INC.
500 FIFTH AVENUE, NEW YORK 18, N. Y.
HOW Pan American Airways Packs 2,100 Hours Into a Day

The minute the giant transatlantic Pan American Clippers get back to their base, they get an exhaustive going over.

It's thorough. And it's fast.

A swarm of mechanics, working in eight-hour shifts, get the job done in 60 hours—2,100 man-hours a day.

That helps this swift turn-around by the Elastic Stop Nuts. These nuts have been on every Pan American clipper since 1928. They are on rotors, mounts, wings and countless structural parts.

Particularly timesaving are the Anchor Nuts which permit smooth end mounting. Hundreds of these fasten the covers for inspection openings. These Anchor Nuts* are an Esna development and are used millions in all kinds of airplanes.

The Elastic Stop Nuts lock tight and fast without any auxiliary devices. There's no time wasted in fussing to get them off and back on again.

They lock because of the elastic collar in the top. This collar squeezes between the bolt threads. It's impressed tight. The nut can't turn. It can't wiggle. It can't shake lose. And you can take it off and put it on again many times and it still locks.

Every fastened product can be better because of these nuts—can be safer, tighter, quieter, and longer lasting.

So if you have a fastening problem now, or see one ahead, let us show you how these red-collared Esna Nuts can help. Our engineers are ready to consult with you and recommend the appropriate nut.

*ESNA Anchor Nuts allow ready access to inspection openings, yet refasten tight and strong to carry stressed skin loads.

ESNA

TRADE MARK OF ELASTIC STOP NUT CORPORATION OF AMERICA

ELASTIC STOP NUTS

Lock fast to make things last

UNION, NEW JERSEY AND LINCOLN, NEBRASKA
This **NEW** Sturdy, Smaller Transtat AC Voltage Regulator
OFFERS INCREASED DESIGN POSSIBILITIES!

The new TH 2½A Transtat A. C. Voltage Regulator is half the size and less than half the weight of the smallest previous TH Transtat. When used as a dual unit, a further space saving is made possible by base-to-base mounting. In attaining this extreme compactness, AmerTran also introduced several mechanical innovations: the unique die cast brush arm with its generous heat dissipating surface; smooth commutator with solid insulation between segments; the operating shaft that can be quickly changed for table, panel or gang mounting; the Phenolic Thermosetting Plastic Base with its terminal barriers and other features.

Yet the TH-2½A Transtat's conservative rating is a working rating—output voltages are full load voltages. Exciting current is only 0.06 amperes. Control throughout working range never exceeds 0.4 volt increments. And like its larger brothers, it cannot disturb power factor, distort wave form or interfere with radio reception. Investigate its possibilities in your apparatus today.

Write for Bulletin 171-01

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AMERICAN TRANSFORMER COMPANY, 178 Emmet St., Newark 5, N. J.
DON'T LOOK FOR A JACK-OF-ALL-TRADES IN ELECTRONIC HEATING MACHINES

ELECTRONIC HEATING is rapidly outmoding many industrial heating processes because of its numerous advantages, recognized and acknowledged by all leading industries.

It is, however, important to realize that the maximum time- and money-saving advantages of the process can only be realized by using it correctly in every application. Each heating process requires a definite FREQUENCY and POWER combination.

To use any combination of frequency and power other than the one ideally adjusted to the process implies a waste of power and the use of a "misfit" size machine.

No electronic heater has ever been built that can provide a large enough variety of frequency and power combinations to permit economical application to more than one type of heating operation.

For 23 years we have pioneered and specialized in electronic heating. As recognized experts we urge all first-time users to consult our engineers and to investigate the many advantages of our complete variety of units before buying. Write to us for detailed information.

Manufacturers of Vacuum Tube and Spark Gap Converters Since 1921
Meeting the severe operating conditions encountered in military, aircraft, police, broadcast, P-A and other equipment...

**HYVOL “BATHTUB” Capacitors**

- These drawn-container units are designed for applications requiring compact, extra-quality capacitors. AeroVox Type 30 capacitors are specified for equipment that must undergo severe-service operating conditions, more particularly in military, aircraft, police, broadcast, public-address, and other classes of communications equipment, as well as in electronic assemblies operating hour after hour. These “bathtubs” are standard capacitors in Government radio and electronic equipment.

  Type 30 is Hyvol impregnated and filled. Type 30M is mineral-oil impregnated and filled. One-piece drawn metal case with soldered bottom plate. Terminals are constructed with the AeroVox-originated “double-rubber” bakelite insulators permanently riveted to the case, making a sturdy, absolutely immersion-proof assembly. Terminals on side, top, bottom or ends to suit mounting and wiring requirements.


- Write for descriptive literature and listings.

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AEROVox Capacitors

AEROVox Corporation, New Bedford, Mass., U.S.A.


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Specify Your Own Deflection Curves for Rubber Mountings and Bearings

--- We Can Engineer

THE GENERAL SILENTBLOC
To Conform Exactly To That Curve

You need not put up with "roughly good" results from vibration-damping materials. Designing with General Silentbloc mountings, bearings and couplings, you can specify the exact performance you want—and get it.

Patented Silentbloc construction permits almost infinite variation in performance characteristics. A rubber ring of predetermined size and modulus is inserted into a metal tube under high pressure. An inner sleeve or shaft is "shot" with extreme force through the axis of the rubber. Performance is determined by the variables—length and diameter of metal sleeves; type, modulus and elongation of rubber ring; distortion of inner and outer diameters of rubber; confinement of rubber by snubbing rings.

The permanent radial compressive force of the rubber forms an indestructible adhesion with the metal. The tensed rubber stays "alive," does not harden.

General designers can engineer Silentbloc fittings to conform to your specified rate of deflection for controlling, isolating or insulating against vibration or noise, absorbing shock loads. Silentbloc bearings are also used to give trouble-free torque action and to correct for misalignment of bearings and shaft supports.

Silentbloc can be made of any metal, any type of rubber, in any size to carry loads of ounces to tons.

Silentbloc has been used in many fields—automotive, aviation, electrical, industrial machine, home and farm equipment. It can give your new products higher efficiency, longer life, less maintenance. Write for new booklet giving full information. The General Tire & Rubber Company, Dept. 92, Wabash, Indiana.

THE GENERAL TIRE & RUBBER CO.
Mechanical Goods Division, Wabash, Indiana
Auto-Lite Electrical Wire and Cable

Wide Range of Types
Wide Range of Shapes and Sizes
Wide Range of Insulations

The question faced by every user of electrical wire and cable is: What is the specific job, what are the special qualities needed? The answer can be readily found at Auto-Lite.

Auto-Lite engineers will be glad to help you determine just what size, type and shape of wire you need, what material to use and what insulation.

Auto-Lite research has anticipated the problem, has engineered the solution. The manufacturing facilities in the big Auto-Lite plant are diverse enough to furnish the kind and quantity of electrical wire and cable you need. Address your inquiries to

THE ELECTRIC AUTO-LITE COMPANY
SARNIA, ONT.

Wire Division
PORT HURON, MICH.

TUNE IN "EVERYTHING FOR THE BOYS" STARRING DICK HAYMES—EVERY TUESDAY NIGHT—NBC NETWORK

September 1944 — ELECTRONICS

Precision-Made to fit your wiring job
If in your products you use electrical transmission equipment, there is in these Data Sheets information that you can use to advantage, if not today then on postwar products.

Amphenol equipment is used where the requirements are tough. There are Amphenol products for current of low or high frequency. Wherever you use electricity you need the best of equipment—Amphenol.

Use the coupon to send for the information you want.

AN and 97 CONNECTORS
Where electrical connections must be positive and secure, where they must be made or broken quickly—as on aircraft, tanks or ships—these connectors are used. Made with from one to forty-eight contacts. On the coupon check Section A.

SPECIAL CONNECTORS
These are the special service connectors—explosion proof, moisture proof, thermo-coupling, grounding, instrument, special mounting, etc. Mark the coupon Section A1.

CONDUIT FITTINGS
Conduit couplings—straight, 45° and 90°, coupling nuts, ferrules, clamps, etc. Designed for secure connections. Properly finished to avoid abrasion of wire insulation. On coupon check Section B.

AIRCRAFT ELECTRICAL CONDUIT and CABLE ASSEMBLIES
Flexible metal and plastic conduit, cable assemblies, wiring harnesses, etc. Ample facilities for quantity production. On coupon check Section B1.

SPECIAL TOOLS
Conduit ferrule crimping machines, saw vises for cutting conduit and cable. Special tools for good work on this type of electrical equipment. Mark on the coupon Section C.

U. H. F. CABLES AND CONNECTORS
For ultra high frequency transmission—Amphenol low-loss cables and connectors—a complete line. This includes the full list of RG type cables. On coupon check Section D.

BRITISH CONNECTORS
In quality, type, range of size and application these are similar to Amphenol AN and 97—but built to specifications of the British Air Ministry. Mark the coupon Section E.

RADIO PARTS AND ACCESSORIES
For Radio, FM, Television, Electronic and Sound equipment—connectors, sockets, plugs, etc. Also special tools for wiring. On the coupon check Section F.

SYNTHESES FOR ELECTRONICS AND INDUSTRY
The story of Amphenol’s facilities for making plastic parts or products by compression or injection molding, extrusion or machining. On the coupon check Section G.

AMERICAN PHENOLIC CORPORATION
1830 S. 56th Avenue, Chicago 50, Illinois

Please send me information and Data Sheets as checked below—without obligation.

☐ Section A  ☐ Section B1  ☐ Section E
☐ Section A1 ☐ Section C  ☐ Section F
☐ Section B  ☐ Section D  ☐ Section G

Signed ____________________________

Company __________________________

Address __________________________

City and State ______________________

American Phenolic Corporation 1830 S. 56th Avenue, Chicago 50, Illinois

CTRONICS—September 1944
IN GLASS TUBING TOO
IT'S THE VARNISH THAT COUNTS

TURBO
VARNISHED GLASS TUBING

DIELECTRIC STRENGTH
AT HIGH TEMPERATURE

TURBO Impregnated Fibrous Glass Tubing is the complete solution to insulating problems when abnormally high temperature dictates the choice of glass. The natural advantages of fibrous glass as an insulating material are actually enhanced by the exclusive TURBO process of Varnish Impregnation—a special process that penetrates all the way through to insure perfect insulating qualities.

This unique TURBO process of impregnating fibrous glass produces a tubing of increased dielectric strength, absolutely impervious to moisture. At the same time the inherent flexibility of the glass fibre is retained by using flexibly constituted TURBO Insulating Varnish. Varnished Glass Tubing may be cut to any length—because fraying is a non-existent factor.

WILLIAM BRAND & COMPANY
276 Fourth Ave. New York, N. Y.
325 West Huron Street Chicago, Ill.

ELECTRICAL INSULATION MATERIALS • TURBO OIL TUBING AND SATURATED SLEEPING • VARNISHED CAMBRIC • PAPER AND TAPE • MICA AND MICA PRODUCTS
The electronic engineer has more than a testing and research job. His is a creative job, too. From his fertile mind come the great new ideas for the electronic equipment which is helping to defeat the enemy and which will mean a glorious peacetime era when peace is assured. Most all industries will benefit from the highly specialized technical and scientific knowledge of the electronic engineer and the discoveries he has made.

Raytheon is proud of its part in the immeasurably important role that advanced electronic equipment is playing in winning the war. When peace comes, Raytheon's research and wartime production knowledge will be used to doubly protect the electronic equipment requirements of post-war radio and industrial products manufacturers, and to assure Raytheon's continued leadership in the electronic era.
For a dozen years past the Allen B. DuMont Laboratories have specialized in the development, production and application of cathode-ray tubes.

DuMont was the first to introduce the commercialized cathode-ray tube as a practical tool for research worker, production engineer and technician. Not only have DuMont tubes and oscillographs resulted in savings in time required to investigate the many problems to which they are applicable, but they have also revealed truths in man’s laws of the working forces of nature.

And now, as a further service, DuMont engineers have compiled a manual of pertinent data, together with detailed descriptions of DuMont tubes and associated equipment. This data is in loose-leaf form. The binder permits constant revision to keep pace with the fast-moving cathode-ray technique. Each manual bears a serial number so that the name and address of its recipient may be duly registered. Additional pages are mailed from time to time.

Write on your business stationery for your copy. Our Engineering Department is interested in aiding you with your cathode-ray application problems.
the theaters of war and on the battlefronts, every precaution is taken against failure of communications. The performance of Wilcox radio equipment has proved its reliability under all conditions, in all parts of the world. Today, Wilcox manufacturing is fulfilling military needs and those of the commercial airlines of the nation.

WILCOX ELECTRIC COMPANY
Manufacturers of Radio Equipment
Fourteenth & Chestnut • Kansas City, Mo.
CONSIDER Simplicity of Control

WHEN YOU SELECT A NEW TRANSMITTER

Easy to put on the air, easy to keep on the air... that's what you want in a transmitter, and that's what Westinghouse equipment assures.

Specifically, here are some of the features that make for operating simplicity in Westinghouse Transmitters:

1. One Master Control puts the transmitter on the air and cuts the power off at the end of the broadcast period. It is impossible for power to be applied in the wrong sequence.

2. Individual Tuning and Adjustment Controls are mounted on the front panel, easily accessible.

3. Indicator Lights Flash Circuit Conditions to Operator, indicating instantly which circuit requires attention.

4. Simplified Circuits—require a minimum of tubes... no tricky wiring.

5. "De-ion" Breakers Show Outage Location, providing fuseless protection for the low-voltage power circuits.

Simplicity of Control is only one feature of Westinghouse Transmitters. Others equally important are: Low Operating Cost, Continuity of Operation, High Fidelity Signals, Ease of Maintenance.

PLACE YOUR ORDER NOW FOR YOUR POSTWAR TRANSMITTER

By placing your order today for a Westinghouse transmitter, you assure yourself of the fastest possible delivery following the lifting of wartime manufacturing restrictions. We are scheduling deliveries in the sequence in which orders are received. For details, write Westinghouse Electric & Mfg. Company, Dept 1NB, P. O. Box 868, Pittsburgh 30, Pa.
HERE ARE ELECTRICAL STEEL COILS
made from
HOT ROLLED SHEETS!

You can have the fabricating advantages of coils for all regular requirements when you use ARMCO Electrical Steels.

For those grades where cold rolled practice has not yet been developed, ARMCO has perfected a unique method of butt-welding hot rolled sheets into coils which can be plied as narrow as one inch. This gives you the advantage of continuous platings for all grades of siliccon steels. Weld thicknesses are guaranteed to be within the thickness tolerance of the sheets. Magnetic qualities are not affected by the welds.

This way you can save time, labor and steel by using coils for all standard operations. There are relatively no end-of-strip scrap losses. And besides being easier on dies, coils help step up production by eliminating all "hand-feeding" to presses.

Whether you need coils or sheets, there is a grade of ARMCO Electrical Steel for every requirement. You will get steel of top magnetic quality with low core loss and exceptional permeability; steel that is ductile, flat and clean-surfaced.

Write for data on ARMCO Electrical Steels for specific jobs. We'll be glad to supply you with the information you need. Just address The American Rolling Mill Company, 2601 Curtis Street, Middletown, O.

EXPORT: THE ARMCO INTERNATIONAL CORPORATION

THE AMERICAN ROLLING MILL COMPANY

Electronics — September 1944

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Write for your
BUYERS' GUIDE
self-bound for convenience

Through the courtesy of the publishers of Electronics we are able to distribute to purchasing agents, engineers, etc., bound copies of the 1944 Buyers Guide of Electronic and Allied Equipment . . . requests on Company Letterheads should be addressed to Dept. BG, A. W. Franklin Manufacturing Corp., 175 Varick Street, New York City 14.

If you have not received your copy of the 1944 FRANKLIN catalog... NOW is the time to write for one.

A.W. FRANKLIN MANUFACTURING CORP.
175 VARICK STREET • NEW YORK, 14, N.Y.
PURE, READY-TO-USE ZIRCONIUM METAL POWDER EXPEDITES TUBE PRODUCTION

Of the many advantages of "G" grade Foote Zirconium Metal Powder, one of timely interest to tube manufacturers is its purity.

"G" grade is specially prepared for power and transmitting tubes. It is extremely pure, a typical analysis revealing only .028% acid soluble calcium, .003% iron, and .04% aluminum. Furthermore, "G" grade is not a compound and contains no gases which must be driven off before using. "G" grade may be used just as received with the addition of the usual proper binders.

If you are not familiar with the other advantages of Foote "G" grade, this brief review may be helpful to you:

a. A surface sprayed with "G" grade Zirconium Metal Powder approaches a perfect black body in heat radiation.

b. "G" grade has little or no tendency to mirror the tube wall or insulating parts, therefore it eliminates inter-element leakage and losses, raises the maximum load limit of the tube, decreases shrinkage and increases tube life.

c. It does not easily alloy with the molybdenum plate and thus decrease its efficiency as a getter.

d. With "G" grade the pumping time for certain tubes with carbon or graphite anodes is reduced over 50%.

e. "G" grade is a continuous getter at temperatures less than 400°C. but is most active over 600°C.

For additional information about Foote Zirconium Metal Powder you are urged to write us.

"HOUSE OF TOMORROW"

From our "house of tomorrow"—that is, the various Foote plants and laboratories, pour products used by hundreds of industries, and by our Armed Forces and those of our Allies on for flung battle fronts. Ores and minerals, chemicals and alloys, wrested from the earth, and new processes developed in our laboratories and plants, await your consideration, cooperation or application. Let Foote research and products help you today—for tomorrow.
Precise apparatus performs with maximum efficiency when serviced by precision test equipment. Quality testers manufactured by RCP meet industries' needs for superior equipment because of their consistently reliable performance.

Typical of RCP’s advanced design is the Electronic Limit Bridge Model 670 for precision resistance testing.

The scale is uniformly calibrated from 0 to 10% deviation on either side of center; each division represents 0.5%. Simplified direct readings are in terms of plus/minus deviation from a built-in standard of predetermined resistance. The built-in standard can be any value specified from 8 ohms to 10 megohms. Provision is made for the use of external standards of specified values as well as external and internal standards in combination.

Other RCP electronic and electrical instruments are described in catalog 128. If you have an unusual test problem—for production or laboratory work—our engineers will cooperate in helping you find the most efficient solution.

Other Features of the Model 670 are:
- Component resistors are 0.1% accurate
- 1½” Galvanometer has a sensitivity of 25 microamperes in either direction
- Battery operated
- Automatic cutout switch disconnects batteries when instrument is not in use
- Engraved bakelite case is heavily shielded
- Complete with self-contained battery supply, ready to operate

$150.00
Tasting the International Meter Rods at Paris 1874. The degree of accuracy attained 1/10,000,000 of a quadrant of a terrestrial meridian.

WHO SETS THE Quality Standard FOR TRANSMITTING TUBES

In every art or craft, the work of some acknowledged master sets the standard.

Since 1934 UNITED has won recognition by specializing exclusively in the engineering, design and building of transmitting tubes which are unchallenged for excellence. UNITED tubes excel in every electronic application... including radio communication, physiotherapy, industrial control and electronic heating. In these and other applications, tubes by UNITED continue to win top honors for uniformly dependable performance.

In communication equipment for airlines, commercial broadcasting, police radio stations and other vital civilian services, UNITED transmitting tubes set the standard. Accept nothing less than UNITED quality tubes for your requirements.

Order direct or from your electronic parts jobber.

UNITED ELECTRONICS COMPANY
NEWARK, 2
New Jersey
Transmitting Tubes EXCLUSIVELY Since 1934
NO FRAYED ENDS
NO FRAYED NERVES
WHEN YOU USE BH FIBERGLAS SLEEVING!

Here's an Insulation that Handles Easier, Cuts Cleaner and Saves Time

IF you're exasperated by ordinary sleeving that frays on the ends, works stiffly and doesn't hold up in use . . . then you'll certainly want the lowdown on BH Extra Flexible Fiberglas Sleeving! For this is a really flexible and definitely non-fraying sleeving—built around the excellent insulating qualities of Fiberglas by an exclusive BH process.

Fiberglas, you know, is moisture-resistant, high in dielectric and tensile strength and is shunned by fungus growths and unharmed by most chemicals. "Punishment" tests prove that BH Extra Flexible Fiberglas Sleeving has even more advantages. It is permanently non-fraying and non-stiffening. It won't burn because both yarns and impregnation are non-inflammable. And it lasts indefinitely without cracking or rotting.

Assembly and repair men say BH Extra Flexible Fiberglas Sleeving is a pleasure to handle and a sure bet for long life in the most severe service. So why tolerate a less efficient sleeving any longer? BH is available in all standard colors and all sizes from No. 20 to ½", inclusive. Write for samples today and make your own comparison!
The Stake of the United States in Expanding World Trade

With the war in Europe racing to a climax, and with a sure pattern for the defeat of Japan already outlined, American business is confronted with the need for an immediate decision on long-term economic policy.

What is this country’s foreign trade program to be after the war?

No intelligent appraisal of all the factors any longer can allow us to postpone considering the issue merely because, in the past, foreign trade absorbed barely eight per cent of our production.

Actually, a whole new set of conditions was injected into the picture by the first World War; but we persisted in ignoring these new factors.

Almost overnight, the United States was transformed from the largest debtor nation in the world to the second largest creditor nation. At the same time, we made faster technological progress than any other nation. Thus we created the need for more dollar exchange on the part of the rest of the world and simultaneously made it harder for other nations to earn dollars.

Today, as another, far vaster war is approaching its end, those changed circumstances are magnified. America has new responsibilities—to itself, and to the world.

Our war-inflated industrial capacity cannot be allowed to drop back to prewar levels without causing a domestic crisis which we dare not permit.

And, because so much of the world is geared to the American industrial machine, we can no longer contemplate calmly the repercussions of a largely self-sufficient trade program or of an unplanned foreign trade program. Either would inevitably set the stage for the next world war.

If we are going to prepare ourselves intelligently to cope with this new problem, we must acknowledge certain basic principles.

World trade cannot be rebuilt simply by attempting to restore prewar flows of goods. The war has so completely changed the economic fiber of many countries that it is necessary to develop new trade relationships. The East Indies, for example, may find the demand for their rubber considerably reduced; the United States may, to a large extent, have to cease exporting cotton; Japan will need to find new substitutes for much of its exports of silk; the British will need new markets to replace the income which they formerly derived from their large overseas investments.

We cannot expand markets for our goods, at home or abroad, unless we find ways of buying more supplies from more people at home or abroad, so that they will have more dollars to spend.

And we probably cannot create increasing buying power abroad without first exporting more of our technical skills—our engineers, our production and management men—to build new markets for our own specialties.

What is needed to rebuild the world’s economic system?

1. Most basic of all, of course, are stable governments which command popular support. In the absence of strong governments, currency stability cannot be achieved.

2. Most war-stricken countries, for a year or two, will need rehabilitation loans, because they will require far more raw materials, equipment, and live stock than they can pay for out of current production.

3. Loans, however, are only a stop-gap, though often a necessary one. Far more important than rehabilitation loans will be the creation of better opportunities for war-stricken countries to sell to the rest of the world, particularly to the United States, South America, South Africa, and India. The ravages of war do not completely destroy the ability of a country to sell. Indeed, it is surprising what large supplies of certain commodities war-torn countries have on hand even before devastated industries have been restored. The invading troops in Normandy found shoes almost non-existent, but they found food not more plentiful than in Britain.

Better opportunities for war-stricken countries to sell would create opportunities for them to buy the thing they will require to restore scattered industries and depleted farms, and would help those countries to get rid of the exchange controls which are now universal. So long as a country is able to expand its exports only slow and painfully, and is dependent upon foreign loans prevent the depreciation of its currency, so long will carefully preserve exchange controls and other restrictions in imports. That is why large advances, either through an International Monetary Fund or an International Investment Bank, can make only limited contribution to the removal of trade restrictions.

4. Permanent monetary and credit arrangements are needed to protect nations against temporary pressure upon their currencies, to permit necessary changes in exchange rates to be made in an orderly manner, and to assure that governments never again will repeat the "beggar-my-neighbor" policies of 1931 and 1932.

5. Finally, the world needs a reversal of the trend toward economic self-sufficiency, which received a strong impetus from the first World War and an even stronger boost from the great depression of the Thirties. This does not mean that the efforts of many raw-material producing countries to diversify their industries should be opposed. During the late Nineteenth Century and the first
this century, the international specialization of production was carried too far, with the result that many countries became dependent for a large part of their standard of living upon the export of one or two raw materials—coffee, sugar, rubber, silk, wheat, wool, and meat. Between the two World Wars, however, the pendulum swung much too far in the direction of self-sufficiency. Some densely populated industrial countries of Europe (Italy, France, and Germany) even attempted to become self-sufficient in wheat, fats, and sugar. So limited are the natural resources and technical skills of most countries that each one finds many things which it can produce only at prohibitive costs. Between the extreme specialization of the late Nineteenth Century and the more recent trend toward extreme self-sufficiency, a happy medium should be sought.

What role should the United States play in reconstructing the world's international economic system?

There are those who suggest that the United States be a more or less permanent Santa Claus. They believe that an excess of exports could be financed only by "loans"—loans that would eventually turn into gifts, after producing bitter controversy over why the "debtor" country did not meet its obligations. The persons who assert that full employment can be provided only by an excess of exports are in effect saying that our economy cannot become self-supporting. That is a confession of economic defeatism which a young and vigorous nation should not be willing to make.

The most immediate contribution which the United States can make to world reconstruction is to make itself prosperous.

Prosperity here means a large demand by our industries for imports. The more we import, the easier will it be for foreign countries to meet their large and urgent needs for goods. In 1939, with a gross national product of $100 billion, our imports were $3 billion. After the war, with 55 million people employed and a gross national product of $155 billion, our imports would be about $7 billion or $8 billion.

Not only should the United States make itself prosperous, but it should keep itself prosperous. So important is the United States in the world economy that a depression here is bound to produce a disastrous drop in the price of raw materials throughout the world and to throw most countries into an economic tailspin.

The United States should support the principle of a large fund to protect the exchanges of the world from temporary pressure. We should not permit differences over details to prevent its establishment in ample time to be available during the critical period when stricken countries will need goods far in excess of their immediate ability to pay for them. Some arrangement, even though imperfect in details, will be infinitely superior to no arrangement.

Finally, the United States should take the lead in asking down barriers to trade. We are the logical country to do this, partly because of our immense domestic market, and partly because for most of the last twenty-five years this country has been able to sell her countries more goods than they have been able to sell to us. One of the greatest contributions which the United States could make to a sound and expanded world economy would be to bring our imports, as practicable, up to our exports. In other words, the United States, in the long run, should be hard to borrow from but easy to sell to. The United States should implement this policy (1) by continuing the negotiation of reciprocal reductions in duty, and (2) by accepting exchange rates which make foreign currencies cheaper in dollars than they were in 1939. So great will be the world's need for goods that we can be sure that any dollar exchange earned by sales to us will be converted into American-made goods and will lead to larger exports.

Time was when the United States obtained about eight percent of its standard of living by sending goods abroad and bringing back other goods. Before the war, however, we were getting less than five percent of our living by international trade. If, after the war, we were gradually to raise the proportion of our standard of living obtained by trading with other countries to ten percent of domestic production, our imports would be about $15 billion or $16 billion a year. Our people would be able to buy many things which they now cannot afford, and scores of countries which export raw materials and luxury products would feel the stimulus of rapidly expanding markets. Their expanded demand for road building machinery, mining machinery, machine tools, agricultural implements, locomotives, railroad cars, electrical equipment, trucks, automobiles, and a multitude of products of our factories would create a million or more additional jobs in our factories.

Although the United States would raise its standard of living by increasing its imports and its exports, it should honestly face the fact that the resulting shifts in production and employment would temporarily be painful for some people. The increase in imports would be in commodities which other countries can produce for less than the cost at which much of our output is produced—such as sugar, wool, copper, some fats and oils, wines, winter vegetables and fruits. The increase in our exports would come from those industries in which our superiority is greatest—particularly the manufacturing industries. Finally it would be advantageous to the country as a whole, to shift a million or two workers from agriculture, where they earn about 60 cents an hour at best, to manufacturing, where they earn better than 80 cents an hour.

The very fact that in economic matters the rest of the world is dependent upon the United States, exposes our country to great demands and to envy and misunderstanding. The United States must be willing to help the rest of the world, but it's help should take the form of assisting other countries to help themselves. Never in all history has one country had such an opportunity to give the world a rising standard of living, to foster conditions under which peace flourishes. What greater tragedy could there be than to make the sacrifices which we are now making and fail to seize this chance to create a world of hope and opportunity in which the spirit of goodwill among nations is able to flourish.

The pattern of progress in the science of electronics is determined by the achievements in creating and developing new and more efficient electron vacuum tubes. Therefore, the whole complex task of vacuum tube development—involving the intelligent application of many sciences—comprises the real science behind the science of electronics.

To create and produce the modern vacuum tube requires experience and skill of the highest order in these many sciences in addition to complete facilities for their application. The list includes everything from chemistry and metallurgy—the technology of glass fabrication and vacuum pumping—to physics, optics, thermo-dynamics and most important of all—Electronics.

The resources and resourcefulness of Eimac laboratories have accounted for many outstanding contributions to the science of Electronics. A fact which is attested to by the leadership which Eimac tubes enjoy throughout the world. These comprehensive facilities are continuously being utilized to achieve better and better results for the users of Eimac tubes.

Eimac Engineering is devoted solely to the development and production of electron vacuum tubes. However, since the electron vacuum tube is the heart of all electronic devices it is advisable for users and prospective users of electronics to look first to the vacuum tubes required. A note outlining your problem will bring advice and assistance without cost or obligation.

Write for your copy of Electronic Telesis—a 64 page booklet fully illustrated—covering fundamentals of Electronics and many of its important applications. Written in layman's language.
Many products on today’s drawing boards call for manual make and break of the electrical circuit—either momentary or locked for an indefinite period. The answer to that need is provided by Mallory in this versatile, dependable Push Button Switch.

The switch is available in two different types: a non-locking model which operates only when the button is pushed in and releases on removal of pressure... and a locking switch which maintains its position when the button is pushed in, and is released only when the button is pulled out. In either case, eight circuit combinations are provided, and the switches can be mounted on panels up to 3/4 inch thick with a single hole 7/16 inch in diameter.

For other precision electronic parts geared to today’s specifications and backed by Mallory’s wide application knowledge, send for the Mallory Catalog or see your Mallory distributor. A few typical Mallory products are mentioned at the left.

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Approved Precision Products
"An alert Navy must have appropriations from Congress for extensive research in time of peace. Research before a war is the only research which will do us any good on the day the enemy strikes."

James Forrestal, Secretary of the Navy, Saturday Evening Post, June 24, 1944.

**RESEARCH** . . . It is an unfortunate fact that a very great deal of the research which is now bearing us such good fruit in the war was started almost too late. In some branches of the armed services, forward-looking research had practically ceased, either due to lack of foresight or imagination, or due to the fact that Congress would not provide the funds for it. After every war, the people lull themselves to sleep with the happy hopes that no further war-like expenditures will be necessary, and, therefore, no more taxes need be collected for preparation for future conflicts.

Admiral Mahan, in his well known treatises on naval history, cites chapter and verse to show that after every war in which this country is engaged there arises a clamor to stop all warlike activities, to get back to “normal” and to stop spending money so that the people can make more of it.

As soon as peace seems close, watch for an outcry to lower taxes, to stop the expense of further research. Watch for all of the age-old arguments which a people, tired of war, eternally advance for going back to sleep. Remember that savings made by stopping research are only illusory; that money saved before a war is spent many fold after a war starts; that abundant research prior to a war may prevent it entirely.

**STANDARDIZATION** . . . Some people make fetish of the business of standardization. Certain the subject can be worked so hard that the potential benefits are not secured. Yet the recent happy conclusion of the conflict in the symbols used for electronic components leads one to hope that additional benefits could be secured by some standardization of the components themselves.

The vast number of different types of electronic components is a great waste of manufacturing effort, a waste of storage space, a great burden on radio service agencies and a great trouble to manufacturers and users of radio sets.

Most of the different types of components vary from each other in minor degree only; a very great number of them could be eliminated. It is true that the signer who uses the components would have far more types to choose from—but it is a fair assumption that he, too, would find his problems simplified, not made, by standardization of this kind.
The Mountains which have made
British Columbia so attractive to the tourist and so rich in
minerals, present many difficult problems to engineers. Among these is
the very real problem of providing satisfactory radio reception for the
scattered groups of listeners found in remote valleys among
several mountain ranges which divide the province. To the ex-
ception of the rapid attenuation of the short wave associated with rocky
mountain terrain, many of the radio circuits now in service, due to these
conditions, are plagued by what are known as "radio shadows".

In view of the nature of the tests to be conducted, the minimum power
required to serve a community of about 5000 population,
was chosen as a test site. In view of the need for high-power trans-
mitters, it was known that adequate performance could not be provided
one or two high-powered
mitters, regardless of how
strategically these might be located. While the use of short-
wave transmitters offered a partial solution, the wide angle of
transmission required and the distances involved were factors which
influenced the choice of test site.

To the test was added the requirement that the test site must be located
so that a signal could be received over a wide area. MARCONI's
TR50P shortwave transmitter, converted for use on
840 kc and operated under experimen-
tal license VESBC, was installed in the local telegraph repe-
ter station as shown in Fig. 3. The ground lead from the trans-

Initial Test Results

Everyone who has made field-
strength measurements knows that
telephone, telegraph and power
lines act as carrying conductors
for radio waves. With this in
mind, a test unit was set up with
the following objects in view:

(1) To determine the minimum
power required to serve a community
of from 500 to 5000 population.

(2) To determine the improve-
ment in coverage obtainable by
utilizing the carrying effect of nearby copper circuits.

(3) To determine whether or
not it would be possible to feed
limited power into local copper cir-
cuits without creating interference
on telephone and carrier-telegraph
circuits.

North Bend, a small railway town on the banks of the Fraser
River at a point known as the "Gateway to the Cariboo",
was chosen as a test site. In view of the nature of the tests to be con-
ducted, the site had much to recommend it. The town is on a
narrow ledge between a mountain and the river and on the other
side of the river a similar condition prevails. The nearest center
of population to the south is at Yale, about twenty-three miles
airline, and the nearest center of population to the north is at Lyt-
ton, twenty-five miles airline. (A
Canadian Pacific Communications
repeater station, carrying CBC
network service, is located in
North Bend and the strongest day-
time signal on the broadcast band
was somewhat less than 1.0 micro-
volt-per-meter.)

FIG. 1—Revelstoke, B. C., showing the nature of the terrain which renders
broadcast service difficult in this Canadian province

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Broadcast Relay System

Remote valleys in rugged western Canada are difficult to serve by conventional broadcast methods. The problem is solved by installing 25-watt transmitters in local telegraph and telephone offices through which network audio flows and feeding part of the r-f output of these transmitters back into the wire lines, which serve as carrier conductors.

The transmitter was connected to the common equipment ground. The antenna consisted of an inverted L with a flat top 120 ft long, running slightly above and approximately parallel with the telegraph lines.

During field-test periods power output was maintained at 16.2 watts. Peak program modulation was held at 60 percent except during station breaks, at which times the transmitter was switched to 100 watts. Even during the latter periods local and distant repeater operators were unable to detect any trace of interference on telephone, telegraph or carrier-telegraph channels.

It was not possible to make many field-strength measurements at the time, but readings on signals radiated directly by the antenna and not aided by telegraph line carrier characteristics indicated approximately 100 microvolts-per-meter at points five miles away from the transmitter. On the other hand, due to the carrying effect of the telegraph circuits, the signal at points up to 500 feet from these circuits and 15 miles from the transmitter gave readings of 300 microvolts-per-meter or more. The signal radiated by the telegraph lines, which could be followed up and down the right-of-way for approximately 40 miles, transferred to local circuits at Yale and Lytton, providing a usable signal even at these points although both are well outside the normal ground-wave service area.

Practical Application

The financial failure and closure of the privately owned station in Revelstoke, in the late fall of 1940, and subsequent requests from listeners in that area for continued service caused the CBC to consider methods of providing local service in Revelstoke, and the telegraph relay system was installed in 1941.

The problem was solved by adding a small r-f output to the low-power telegraph relay system. This r-f output was fed back into the wire lines at Revelstoke and was radiated through the conventional telegraph lines to the north of Revelstoke and to Kelowna.

FIG. 2—(above) Relief map of British Columbia. Circles indicate the location of low-power relay stations radiating a portion of their r-f output into telephone, telegraph and power lines as discussed in this article. Triangles show other stations of the CBC and squares identify private commercial stations associated with the network. 1—CBR-CBRX, Vancouver; 2—CFPR, Prince Rupert; 3—CBRG, Prince George; 4—CBRQ, Quesnel; 5—CBRL, Williams Lake; 6—CBRN, North Bend; 7—CBRA, Revelstoke; 8—CBRM, Creston; 9—CBRK, Kimberley; 10—CBRR, Cranbrook; 11—CBBF, Fernie; 12—CJVI, Victoria; 13—CJOR-CRWX, Vancouver; 14—CHWK, Chilliwack; 15—CFJC, Kamloops; 16—CKOV, Kelowna; 17—CJAT, Trail; 18—CKLN, Nelson

FIG. 3—(below) The experimental low-power relay station, installed in a telegraph repeater office at North Bend. It is now in permanent use.
service, presented an immediate opportunity for the CBC Engineering Division to put the foregoing experience to practical test. On October 22nd, 1940, the first low-Power Relay Transmitter", operating under the call CBRA, was installed and placed in operation on a six-hour-a-day schedule. In the beginning the inverted Marconu unit, with some other refinements such as temperature control of the crystal oscillator, was used. Although the transmitter was designed for intermittent service it stood up exceptionally well. However, because many points were demanding immediate service, the development of a special transmitter unit which work into various antennas on erratic local power supply was undertaken.

The requirements were as follows:

(3) The antenna-tuning unit should be relatively free from failure due to static or lightning.

(4) The unit should give long and reliable service on fluctuating or poorly regulated power supply.

(5) A minimum of meters consistent with reliable operation should be used.

(6) Meters should be provided to measure the audio input level, antenna current, percentage modulation, final amplifier plate voltage and final amplifier plate current.

(7) The unit should incorporate a monitor, with provisions to switch the input to either the audio line or the rectified r-f carrier.

(8) As the unit would in many cases be operated by relatively inexperienced personnel, a minimum of adjustable controls should appear on the exposed panel and the operation should be limited to throwing switches on and off and reading the meters.

(9) As an aid to servicing, it was proposed to fuse each major circuit separately and to construct the unit so that individual chassis units could be readily removed when required.

(10) The antenna coupling unit and final amplifier tank should be designed to permit efficient coupling with a minimum of harmonic radiation.

(11) Frequency response should be equal to, or better than, that of the network, or ± 2 db from 100 to 5000 cycles.

(12) The audio input should be arranged for bridging across a 600-ohm line and the input amplifier should have sufficient gain to permit 100 percent modulation peaks to be attained on line levels as low as —10 to —20 db.

(13) Last, but most important, all components should be operated well below their rated capacity.

As no equipment meeting all these requirements was available on the market, arrangements were made to cooperate with a local
radio manufacturer, Vancouver Radio Laboratories, Ltd., on the design of suitable units. (A number of equipment photos included here were supplied by the Laboratories.) This arrangement proved very satisfactory as the local plant already had considerable experience in the construction of transmitting units to be used in remote districts where long life with a minimum of service were essential factors. The resulting design is shown schematically in Fig. 4.

Requirements 1 and 2 were met by the use of two 807's or RK39's operated in parallel with 390 volts on the plates, as the modulated r-f amplifier, and two similar tubes, operating with 400 volts on the plates, as class-B modulators. Requirement 3 was met by the use of inductive tuning in the antenna tuning unit and by the use of a three-turn lightning choke, with horn gap to ground on the antenna side of the choke. This choke is installed outside, at the point where the load-in bus enters the building. A typical antenna installation is shown in Fig. 5.

Requirement 4 was met by the use of a Thordarson 350-watt voltage-regulating transformer between the local power outlet and the 110 volt a-c input to the transmitter.

Items 5 and 6 were met by the use of four meters. Instead of reading antenna current directly, a 0 to 1 ma d-c milliammeter reading rectified carrier is used to indicate normal antenna current and at the same time provide a means of maintaining proper current for the operation of the percentage-modulation indicating meter. A 0 db at six milliwatt volume-indicating meter provides both input audio and percentage modulation readings. The rather novel circuit used is discussed more fully later. Final amplifier plate voltage and current meters provide the other essential readings.

Item 7 was incorporated with the input and output V. I. meter circuit.

Item 8 was met by the use of meter jacks and screwdriver-operated controls which are normally concealed and protected by a dress panel.

Item 10 was met by the use of a 0.001 fixed-mica tank capacitor in the modulated amplifier stage and noise link-coupling between the final amplifier tank coil and the antenna tuning unit.

Items 11 and 12 were met by the use of high-quality audio components and by the addition of a single stage of audio amplification before the class-B driver stage.

Transmitter Design Details

The transmitters are made up of three units, as pictured in Fig. 6. The top section contains the speech amplifier, modulator, crystal oscillator, buffer and modulated r-f amplifier, shown in greater detail in Fig. 7. The oscillator and buffer tank coils are mounted in a shield can on top of this chassis, while the final amplifier tank coil and the antenna loading coil are mounted on the inside of the top of the cabinet.

Referring again to Fig. 4, the r-f section of the transmitter consists of a 6V6 crystal oscillator very loosely coupled to a 6V6 operating as a high-mu triode buffer. The buffer is capacitance-coupled to two 807's or RK39's connected in parallel and operating as a class-C modulated amplifier. A 0.001-µf fixed-mica capacitor is connected across the final amplifier tank coil and the circuit is tuned to resonance by means of taps and a rotor in the Ll coil form.

The antenna circuit is resonated by means of a tapped inductance and a rotor in the Ll coil form. The tank circuit and the antenna circuit are coupled by means of a link which has fixed coupling at the tank coil end and an adjustable sliding coupling at the antenna tuning coil end.

The oscillator and buffer plate circuits are tuned by means of variable capacitors. The tuning knobs are mounted on the front of the top chassis but are normally concealed by the dress panel. Four jacks are provided on the top chassis for test-metering the oscillator plate, buffer grid, buffer plate and final amplifier grid circuits.

The speech equipment consists of a 6C5 audio amplifier, 6C5 driver and two 807's or RK39's in push-pull as modulators. The input transformer is 10,000 ohms bridging, and the balanced primary terminal and center-tap leads are brought out to the rear.

The center unit contains a 6H6 carrier rectifier and 6V6 amplifier. Four meters are mounted on the...
control panel: carrier meter, volume indicator, milliammeter and voltmeter. The latter two are used to read the input to the final amplifier. Also on this panel are mounted the coarse and fine controls used to set the carrier meter to read mid-scale, the filament "off-on" switch, the plate voltage "off-on" switch, a meter switch and the 6V6 amplifier gain control.

The meter switch SW permits the V.I. meter to be connected to (1) the calibrating voltage, (2) the input from the audio network or (3) to read percentage modulation. With loudspeaker switch SW, "on", the meter switch also permits oral monitoring either off the network or off the air.

When the meter switch is in "calibrate" position the V.I. meter-amplifier is connected across a fixed a-c calibrating voltage which, due to the fact that a primary voltage-regulating transformer is used, is reasonably constant. This reading will indicate whether or not there has been any change in the original adjustment or gain of the amplifier. If the V.I. reads other than zero in the calibrate position the amplifier gain control is reset so that the meter reads 0 db. When these readings and adjustments are being made the loudspeaker switch must be in the "off" position. This substitutes a resistive load in place of the voice coil. With the switch set in the "modulation" position and the transmitter turned on and modulated 100 percent at 1000 cycles, the coupling of the sampling coil in the antenna tuning inductance is varied until the V.I. meter reads 0 db (100 percent modulation). The coarse and fine carrier-meter adjustments are then set so that the carrier meter reads 0.5 ma (mid-scale). Thereafter, if the V.I. reads 0 db when the meter switch is set on the calibrate position, the meter will indicate the approximate input level in db when the switch is set to "Input" and will indicate 100 percent modulation when the switch is set in the "modulation" position and the meter reads "0 db".

Three separate power supplies are mounted on the bottom unit. One power unit supplies the heaters on the middle unit and B voltages to the crystal oscillator, buffer and monitor amplifier. The second power unit furnishes the heater power for all of the r-f tubes and B voltage for the class C amplifier. The third power unit supplies the heaters of the audio tubes and furnishes the B voltage for the modulator tubes.

A separate transformer, which remains energized at all times, supplies the power for the crystal heating unit.

**Typical Installations**

The first of the new units was installed in Revelstoke in July, 1942, as noted in an earlier paragraph. This was followed by installations at North Bend in September, 1942, in the East Kootenay area at Fernie, Cranbrook, Kimberley and Creston in December, 1942, and in the Cariboo area at Williams Lake, Quesnel and Prince George in August, 1943. In addition to the units installed in B.C., three units have been shipped to eastern Canada and are now in service in Sioux Lookout and Nakina, Ontario, and in Edmundon, New Brunswick.

Station CBRF, operating on 940 kc at Fernie, is installed in the Canadian Pacific Railway's communication office in the Fernie railway station. The antenna is an inverted L running NE and SW, parallel with the telegraph lines and railway tracks. The flat top is 112 ft long and 50 ft high. The lead-in runs NW from the SW end of the antenna and is 78 ft long. The ground system is buried in and around the station garden plot. It consists of 500 ft of No. 10 bare copper wire buried under the antenna in the form of three parallel wires cross-connected at the center and at both ends. Each of these wires is securely fastened and soldered to the transmitter ground lead, which is a No. 6 rubber-covered flexible stranded copper cable. The lightning ground lead consists of a similar cable connected to a six-foot ground rod.

As no equipment rack space is available at this point the transmitter is installed on a small table designed to accommodate the transmitter and the voltage-regulating transformer.

As all transmitters are tuned to frequency and neutralized before shipping, the field installation con-
beams of bringing the antenna, round, audio and power leads to a transmitter unit and connecting it to the proper terminals. When has been done the equipment is turned on and the antenna circuit is tuned to resonance. The output is then adjusted by means of the variable-link coupling and, when properly adjusted, tone from an audio oscillator is fed to the input at the normal peak program level at that point and the balance of the adjustments are made so that all meters read correctly. During the installation a cathode-ray oscilloscope and standard impedance and distortion-dissimulating sets are used to assure normal operation.

The operators, who are usually members of the telegraph repeater staff, are instructed in the general operation of the equipment and are shown how to detect defective tubes and replace fuses. They are required to check the transmitter at least four times a day and enter all readings on a log sheet which is provided. For the first few weeks the logs are forwarded to the CBC regional engineer’s office once a week, but if the unit operates normally during the trial period the operators are requested to submit their sheets every two weeks. On receipt of these logs the average readings for each 10th day of operation is entered on a special sheet and this way there is a permanent record which shows the gradual failure of tubes, etc. If no abnormal readings or actual off-air periods are noted the units are recked three to four times a year. The checking is very thorough and similar in most respects to the work made during the original installation.

In order to avoid long rush-trips service a single unit which has failed in service, arrangements have been made with a selected radio serviceman in each locality to handle emergency calls. This man is supplied with a maintenance manual and up-to-date service data sheets. The men selected for this work are ex-amateurs, commercial diophones and code operators, skilled radio servicemen or motion picture projectionists. Except for emergency and temporary repairs parts are supplied by the CBC and are tubes, fuses, etc., form a part of each installation. This method of emergency servicing has proved quite satisfactory in the few cases where it has been required.

Another installation of particular interest is that at North Bend, where local 110-volt a-c power is not available during the day. At this point the transmitter operates, for a part of the broadcast period, on one of the 130-volt repeater storage batteries. The voltage is dropped to 115 volts by means of a series resistor and is converted to 115 volts a-c by means of a type 233 Electronic Labs., Inc. vibrating-convertor. As the frequency of the local power is fairly constant and as the battery-charging time-cycle is short, the voltage-regulating transformer was eliminated at this point. When operating on batteries the direct current drain varies from 3.1 (start) to 2.8 (finish) amperes. The normal a-c input to other units averages 248 watts, but the addition of the voltage-regulating transformer naturally increases the input slightly.

Program Pickup Facilities

As these units were designed for operation in the smaller communities and as no associated local studio facilities have been provided, the standard practice is to bridge the transmitter audio input across the CBC’s Trans-Canada program circuit. At the termination of a branch network circuit, or where the transmitter is fed from a separate amplifier, a 500-ohm non-inductive resistor is connected across the audio input terminals of the transmitter or this resistor and a 500-0-500 pad having the required loss is used to terminate the circuit. In all cases a 1:1 isolating transformer is connected between the network feed and the audio input to the transmitter. The use of this transformer, together with a separate ground for the r-f output of the transmitter, effectively prevents stray r-f fields.

Connected in this manner, these network satellite transmitters carry all programs on the CBC’s Trans-Canada network in the Province in which they are located. Call letters are assigned by the addition of a letter to the call letters of the predominant station in the Province.

In British Columbia the predominant station is CBR, hence the network satellite transmitters are assigned calls CBRA, CBRG, etc.

Improvements in Future Units

It requires long periods of service to show where improvements can be made and in the case of existing and new units the following conversions will be made:

(a) Oil-type filter capacitors will be installed to replace all high-voltage electrolytic units.

(b) All toggle switches will be replaced by switches which will handle considerably heavier loads. (The primary power switch sometimes fails in service although operated within the rated load. The contact resistance of the loudspeaker off-on switch increases with use until it becomes appreciable in relation to the relatively low impedance of the voice coil or resistive load).

(c) The loudspeaker unit will be fitted with a volume control.

(d) The first audio amplifier stage will be deleted, as the amplification provided by this stage is not normally required.

In addition to these changes, (Continued on page 304)
AUTOMATIC
Of Stills

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Some materials used in the field of electronics, such as phosphors, electron-emitting coatings and photosensitive surfaces, are of the impurity-sensitive type. The presence of one part in a million of a given impurity may alter some specific property by several orders of magnitude. It follows that any chemical research concerned with such materials will require reagents of the highest purity.

Since water is used in large quantities for almost all chemical manipulations, it is essential that a sufficient supply of very pure water be available. Three distillations will serve to produce water suitable for most uses. Our requirement of approximately 10 gallons per day of double-distilled water and five gallons per day of triple-distilled water makes it desirable that some sort of continuous system be employed which will operate with very little attention.

In the Laboratories, the primary distillation takes place in a conventional commercial still which feeds its product into a large glass-lined storage tank. From there the water is fed by gravity to the second stage of distillation. The second and third distillations are carried out in all-Pyrex stills, completely protected against airborne dust. The two glass stills are connected in series, the first being run at a rate approximately twice that of the second. Thus the first glass still delivers water directly to the boiling flask of the second, and the excess beyond that required to maintain a constant level passes through an overflow to double-distilled water storage. The second glass still delivers to triple-distilled water storage.

Two such combinations are in use and a fifth still is available to augment the double-distilled water production whenever it becomes necessary.

The Control Problem

The problem of automatic control comprises two phases: control of electric heater current, and control of the water level in the glass boiling-flasks. As the heater power never exceeds seven kw at 110 v, an ordinary electromagnetic switch capable of controlling the heating current. Control of the water level, however, is a more difficult matter. To meet the requirements of an air system well protected against airborne contaminants, a special type of valve and level indicator is required.

An electromagnetic valve designed by Ralph H. Plumlee and constructed as shown in Figure 1, proved satisfactory. The valve of the vertical-lift type utilizing spherical ground-glass joint as seal and plunger. A soft-iron laminate core is sealed inside the glass stem which extends into the center of a surrounding solenoid. Energization of the solenoid lifts the plunger permitting water to flow. When

FIG. 1—Electromagnetic valve used to control the flow of water to the boiling flasks

FIG. 2—Circuit of the electronic relay which operates the valve illustrated in Fig. 1 and an electromagnetic switch controlling current-flow to electric heaters beneath the boiling flasks
CONTROL

Current flowing through water between two electrodes sealed in the system operates an electronic relay. The relay operates an electromagnetic valve in the feed line and a switch through which power is delivered to the boiling-flask heaters current is flowing through the solenoid the weight of the core and stem is sufficient to close the valve.

An attempt to use a glass float and mechanically operated level control proved unsatisfactory. This method was unreliable and made it difficult to provide suitable sealing of the system. Various electronic methods of control were considered, including photoelectric cells, radio-frequency devices, and conductivity circuits. The latter seemed to offer the simplest approach.

The Electronic Solution

Although stills use single-distilled water having a low conductivity it was felt that a sensitive relay might be employed which would operate under these conditions. A commercially available electronic relay of the hard-tube type was tried and, although it could be made to operate on the low currents available, it was not suitable for reliable, continuous operation because of the need for constant readjustment. It was felt that a more positive type making use of a gas tube could be constructed.

The action of the unit finally put in use and shown schematically in Fig. 2 is quite simple. When the circuit between $T_1$ and $T_2$ is open the gas tetrode is maintained nonconducting during the positive swing of the plate by applying to the grid through $R$, the negative swing from the filament-supply winding of the transformer. The phase is advanced slightly by the capacitance coupling to potentiometer $R$, in order to compensate for the lag introduced by the transformer. The exact amount of phase advance required is determined by individual transformer characteristics.

Tripping of the unit is accomplished by imposing on the grid a sufficiently large voltage in phase with the a-c line (or plate) voltage. This occurs when $T_1$ and $T_2$ are connected together. The resistance of this connection (single-distilled water conductivity) may be as high as 60 megohms. Protective resistors $R_1$ and $R_2$ may be increased up to

(Continued on page 242)
SECONDARY

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WHEN AN ELECTRON current strikes an electrode surface, or, indeed, any surface, an emission of secondary electrons is produced. There is no known substance in which this effect does not occur. In fact, there is no substance which is known to act as a perfect absorber of any electrons which may impact onto it.

In electronic tubes, secondary radiation is sometimes useful, and sometimes undesirable. The phenomenon is complex, and information about it is scattered in various treatises many of which are commonly read only by those interested in pure physics. Most of these publications deal with the characteristics of secondary radiation, not from any interest in it for engineering purposes, but as a part of investigations into atomic structure.

This paper includes a survey of the existing information on secondary radiation and is presented from the engineering standpoint. It includes references to the original papers.

In most treatises on secondary radiation the electron energies are expressed in volts. The velocity, \( v \), in centimeters per second of an electron which has fallen through an electrostatic potential of \( V \) volts is \( v = 5.95 \times 10^4 \sqrt{V} \). The kinetic energy of the electron is \( \frac{1}{2}mv^2 \) and is therefore proportional to the voltage \( V \).

Energy Distribution of Secondary Electrons

In many publications on electronic engineering, as distinct from treatises on the physics of secondary electrons, it is sometimes stated that secondary electrons are radiated almost entirely at energies very low compared with the primary impact energy. This is not so.

A typical curve of energy distribution of secondary electrons is shown in Fig. 1. In this graph the number of secondary electrons radiated is plotted against the velocity (energy) with which the secondary electrons are shot out from a radiating surface. These secondary electron energies are plotted as a percentage of the primary impact energy. The primary impact energy is 155 volts. It will be observed that an appreciable number of secondaries are radiated at energies about equal to the primary impact energy, although there are a larger number radiated at very low velocities. Very thorough researches have been made during the last two decades into this question of secondary radiation energy distribution.1°

Methods of Determining Energy Distribution Curve

The general kind of energy distribution of the secondary electrons shown in Fig. 1 appears to hold over quite a wide range of primary impact velocities (20 to 10,000 volts).2° It has been confirmed very carefully for most of the pure metals, and is known to hold in general for the other materials employed in radio tubes.

This kind of secondary electron energy distribution does not appear to depend on the angle of incidence of the primary beam onto the emitting surface,3° nor does it appear to depend on the angle of emergence of the secondary electrons, though this point does not appear to have been quite so conclusively demon-
A thorough survey of existing American, British and other information on the subject, arranged for maximum usefulness to electronic engineers engaged in designing electron multipliers, dynatrons, beam tetrodes, pentodes and other tubes in which secondary electrons resulting from electron bombardment are either utilized or suppressed.

In Fig. 2 an electron gun is arranged to produce a beam of primary electrons at a known velocity. The primary electrons are arranged to collide with a surface which here radiates secondary electrons. Some of the secondary electrons pass through an aperture in the diaphragm into a Faraday cylinder. The amount which are able to enter depends upon the potential of a retarding electrode so positioned as shown and upon the initial energies of the secondaries themselves.

The arrangement of Fig. 5 enables the energies to be obtained for the secondary electrons at all angles. The primary electron beam strikes a radiating surface which is at the center point of a collecting sphere. A retarding potential is applied to this sphere, and the number of electrons reaching it is measured as a function of this potential.

In the arrangements of Fig. 4 and 5, the energy distribution curve is obtained by differentiation of the curve of current to the Faraday cylinder or collection sphere as a function of the retarding potential.

Interpretation of Curve

The general results of all these methods agree. The particular curve shown in Fig. 1 is given by Rudberg and is obtained by the magnetic method.

It is generally agreed that the energy distribution curve of Fig. 1 may be interpreted as follows: Peak A represents that portion of the emergent electrons which retains the full primary energy. At secondary electron velocities between about 98 and 50 percent of the primary velocity, the number of secondary electrons radiated does not change much with the secondary electron velocity. Large quantities of secondary electrons are emitted with low velocities, as indicated by peak B, but the number emitted drops rapidly as secondary velocity approaches zero (at secondary energies of the order of tenths of a volt and less).

Peak A of the curve is produced by electrons which emerge after being elastically reflected. They result from diffraction unaccompanied by loss of energy to the atoms which are being bombarded by the primary electrons. All other parts of the curve are produced by secondary electrons which have been deflected by repeated collision accompanied by considerable energy loss.

Those secondaries contributing to parts of the curve other than A are usually referred to as emitted or true secondary electrons. Those contributing to part A of the curve are usually referred to as reflected electrons. For this reason the phenomenon as a whole is usually referred to as secondary radiation, and the words emitted and reflected are reserved for the special meanings set out.

Action at Low Impact Velocities

With primary impact velocities below about 10 volts it has been found that the energy distribution of Fig. 1 does not hold. The secondary radiation consists almost entirely of reflected electrons which retain the full primary energy, so that the whole of the radiation is contained in a peak like A on Fig. 1.

The percentage of emitted secondary electrons to reflected secondary electrons increases steadily up to primary velocities of the order of 1000 volts, after which it falls once again. As previously mentioned, however, the general shape
function of the retarding potential. This potential is expressed as a percentage of the impact energy in volts.

In pentodes and beam tetrodes, the prevention of the flow of secondary electrons is one of the primary objects of the tube design. With reference to Fig. 5, it will be realized that if the collector sphere is at a potential (with respect to the cathode) which is 90 percent of the impact potential of the radiator (also measured in volts with respect to the cathode), then a retarding potential of 10 percent will exist between the collector sphere and the radiator. Figure 6 shows that under this condition the secondary radiation current flowing to the collector electrode will be 54 percent of the total secondary radiation from the radiator.

All this, of course, assumes quasi-steady-state conditions as regards voltage, (i.e., that the voltage does not vary rapidly with time), and that no appreciable space charge due to the primary or secondary electrons exists in the space between the emitter and the collector sphere. The physics measurements quoted in this paper are all made under static conditions, and care has been taken to avoid space charge effects, but these effects must not be forgotten when applying the information to practical radio tubes. Such tubes when in operation are very seldom free from space charge effects.

Some relationship exists between the secondary energy distribution curve and the material of the emitter. This has been found by Sharam to be in agreement with the atomic properties of the material. At voltages of the order of 8000 volts, however, Stehberger failed to find any such connection. The answer to this question is rather vague at present.

Angular Distribution of Secondary Radiation

The relative amount of secondary radiation at various angles from a surface may be determined by apparatus such as that illustrated in Fig. 7. The Faraday collector is rotatable with respect to the radiating surface. The angle of incidence of the primary electrons to the normal of this surface is indicated by $\alpha$ and the angle of secondary radiation by $\beta$. The number of secondary electrons per unit angle may thus be determined.

Measurements of angular distribution have been carried out by a number of workers. While there is some experimental evidence of optical reflection of the primary electrons (i.e., $\alpha = \beta$), the

<table>
<thead>
<tr>
<th>Secondary emitter</th>
<th>Max. value of sec. radiation coeff.</th>
<th>Primary impact velocity (volts) at which max. of sec. radiation coeff. occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caesium (compound layer)</td>
<td>8.5</td>
<td>400-600</td>
</tr>
<tr>
<td>Rubidium (compound layer)</td>
<td>5.75</td>
<td>700</td>
</tr>
<tr>
<td>Beryllium</td>
<td>5.4</td>
<td>600</td>
</tr>
<tr>
<td>Calcium</td>
<td>4.95</td>
<td>590</td>
</tr>
<tr>
<td>Barium</td>
<td>5.72</td>
<td>530</td>
</tr>
<tr>
<td>Potassium (compound layer)</td>
<td>5.5</td>
<td>600</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2.4</td>
<td>400</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.63</td>
<td>380</td>
</tr>
<tr>
<td>Platinum</td>
<td>1.52</td>
<td>1000</td>
</tr>
<tr>
<td>Silver</td>
<td>1.47</td>
<td>800</td>
</tr>
<tr>
<td>Gold</td>
<td>1.45</td>
<td>780</td>
</tr>
<tr>
<td>Tunsten</td>
<td>1.33</td>
<td>685</td>
</tr>
<tr>
<td>Nickel</td>
<td>1.3</td>
<td>500</td>
</tr>
<tr>
<td>Tantulum</td>
<td>1.3</td>
<td>685</td>
</tr>
<tr>
<td>Copper</td>
<td>1.27</td>
<td>600</td>
</tr>
<tr>
<td>Iron</td>
<td>1.27</td>
<td>400</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>1.27</td>
<td>375</td>
</tr>
<tr>
<td>Nickelium</td>
<td>1.17</td>
<td>400</td>
</tr>
<tr>
<td>Carbon (lamablack)</td>
<td>0.6-1</td>
<td></td>
</tr>
</tbody>
</table>

FIG. 5—The retarding potential method of arriving at the velocity distribution of secondary electrons emitted and reflected from a radiating surface.

FIG. 6—Ratio of secondary electron current travelling to a collector and the total secondary radiation, plotted as a function of the retarding potential between the radiator and the collector of Fig. 1 holds between about 20 and 10,000 volts.

FIG. 7—Use of an angularly adjustable collector to measure the secondary radiation coefficient of both reflected and emitted electrons as a function of the angle of emission to the normal.
idence of this effect is by no means generally accepted. At present it seems reasonable to assume a cosine distribution of secondary radiation, as shown in Fig. 8; that is, the intensity of the secondary radiation varies as \( \cos \beta \), and this distribution is virtually independent of \( \beta \). The maximum value of the secondary radiation varies, however, with \( \beta \). This effect is discussed in greater detail later.

### Secondary Radiation Coefficient

The arrangement of Fig. 5 may be used for measuring the total radiation of secondary electrons if the collector sphere is at a slightly higher potential than the dissipating surface. This measurement is in fact a summation of the five of Fig. 1, and gives the ratio between the total number of secondary electrons and the total number of primary electrons striking the emitter. This ratio is generally referred to as the total secondary radiation coefficient. It must always be remembered, when interpreting values of this ratio, that in cases a velocity distribution must be assumed. In the case of impact energies between about 10 eV up to the order of 10,000 volts, a distribution would be that of Fig. 1.

In practical electronic devices the current ratio of secondary current to a given electrode near the primary emitter to the primary electron current will depend (among other things) upon this velocity distribution. Not all the secondary electrons necessarily contribute to the secondary electron current.

The total secondary radiation coefficient plotted against the primary electron impact energy was of the characteristics to be investigated by the earliest workers.

### Secondary Radiation Coefficient of Pure Metals and Carbon

Typical measurements of the total secondary radiation coefficient are shown in Fig. 9A and 9B. These curves have been confirmed by many investigators. The curves tend to a maximum and then fall as the primary impact velocity increases still further. The maximum value of coefficient obtained lies between about 1.2 and 5.5 in the case of pure metals. Its highest value is of the order of 8 to 11 for compound surfaces of caesium of the kinds used in secondary electron multipliers and the like. Not many substances have coefficients of less than unity. That for carbon varies between 0.6 and 1.0.

Provided that the metal surfaces are clean and are completely degassed, the secondary radiation coefficient is found to be about the same by many different investigators.

Table I (from Kollath) shows typical values of the maximum secondary radiation coefficient, and the values of primary impact energy at which it occurs, for a number of substances.

### Secondary Radiation Coefficient of Composite Surfaces

Copeland has obtained interesting results by evaporating various substances onto a metal foundation. Evaporating caesium onto gold increased the secondary radiation coefficient of the combination several times over that of gold alone. He also investigated other combinations of layers and foundations. The results appear to be explainable in terms of the degree of penetration of the primary electrons through the surface layer, and the varying absorption of the secondary electrons by the different substances used.

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**FIG. 9A**—Coefficient of total secondary radiation as a function of primary impact energy in volts for the materials commonly used in vacuum tubes

**FIG. 9B**—Coefficient of total secondary radiation as a function of primary impact energy in volts for various substances
4 to 5. It was observed that calcium and lithium belong to the alkaline-earth group of metals. They have low work functions and they have a high thermionic and photoelectric emission. An investigation of caesium/caesium-oxide/silver was a natural step, and high secondary electron coefficients resulted. It was discovered, however, that neither a low work function nor a high photoelectric sensitivity is the only factor concerned in producing a high secondary electron coefficient. Typical results for composite surfaces on silver are shown in Fig. 10.

The following table is given by Weiss for various values of the maximum secondary radiation coefficient for caesium/caesium oxide deposits on various metal foundations.

The processing of the layer produced is of great importance. The deposit used as the composite surface is probably of the order of monoatomic thickness.

In detail, the production of secondary electron emissive surfaces is, like the production of coated thermionic cathodes, largely an empirical process.

Secondary Radiation Coefficient of Insulators

There is comparatively little information in this matter, but it seems that secondary emission from insulators consists largely of electrons that have a low velocity compared with the primary electron velocity. The cosine law of distribution appears to hold, and the coefficient can exceed unity. There is, however, a difference with regard to the angle of incidence of the primary electrons impacting the radiator. In the case of conductors, the secondary radiation coefficient increases continuously with the angle of incidence, but in insulators this is not so. The coefficient increases up to a critical angle of incidence in either direction from 0 deg, beyond which the coefficient drops sharply and then again increases, as shown in Fig. 11.

This critical angle has been found to be evident only at certain levels of primary impact velocity in the range from 1300 to 3000 volts. The critical angle increases with increasing voltage, and eventually vanishes. It is also affected by tempera-
Mechanism of Secondary Electron Radiation

The quantitative analysis of the atomic mechanism of the phenomenon is in a very rudimentary state. In fact, a survey of the subject reduces itself largely to an unsatisfactory recital of disjointed experimental facts rather than to a coherent statement of theory. Kollath's paper gives an excellent outline of the situation up to 1937. The relationship between secondary radiation phenomenon and the atomic structures of various metals gives no very conclusive result, nor has the work function any very useful relationship, though there has been shown to be some proportionality between the secondary radiation coefficient and this quantity. The depth of penetration of the primary electrons has been estimated, and Becker arrives at a calculated depth of penetration of about 30 Angstrom units (about 15 to 20 atomic layers) at primary impact velocities of the order of 500 volts.

Emission Time of Secondary Electrons

As far as the author is aware, no measurements or computations of this quantity have yet been made. It may prove, however, to be very important in view of the increasing use of extremely high frequencies in electronics. So far, the only conclusion appears to be—and this is a unanimous one—that the time of emission is less than 10⁻⁹ second. This is as much as several times the periodic time at the highest radio frequencies now being brought into use. Modern ultrahigh-frequency technique might enable the time to be measured. A suggestion due to Kollath involves comparing the times of arrival of electrically reflected primary electrons with those of secondary electrons. Experimental difficulties, appear, however, to be considerable.

Secondary Emission Transit Times

In view of the initial velocity spectrum (Fig. 1) common to all secondary radiation (the fact that secondary electrons are not all emitted at the same velocity), secondary electrons traveling from the emitter to another electrode do so with differing transit times. This effect is of substantial importance to the operation of vacuum tubes at very high frequencies, and is dealt with later in this paper.

SECONDARY RADIATION IN ELECTRONIC ENGINEERING

In electronic engineering, secondary radiation is sometimes found to interfere with the desired operation of the radio tube in which it occurs. Sometimes, on the other hand, it is utilized as an essential part of the mechanism of operation.

The Dynatron Valve

In a tetrode valve, when the screen grid is at a higher potential than the anode, secondary radiation from the anode may travel to the screen grid and produce a negative resistance characteristic in the anode circuit over a range of anode voltages. Hence the valve can be made to generate oscillations. This effect was first described by Hull.

In considering these results with
respect to modern radio techniques due regard must be paid to secondary radiation transit angle effects.

Secondary Electron Multipliers

Secondary electron multipliers of both the magnetic and electrostatic types are so well known that it is unnecessary to describe them in detail. In multipliers, the primary electrons strike an emissive surface which is of such a kind as to produce a high ratio (usually between 8 and 11) of total secondary radiation coefficient. Secondary electrons thus radiated are caught by another plate from which further secondaries are again radiated. This process is repeated several times in order to produce a very high total magnification of the original primary electron beam current.

The primary electron beam can be controlled by either photoelectric effects or by voltage control. Greater importance appears to attach to the amplification of photoelectric currents than to voltage control, as the limitations of the latter type cause it to be rather specialized in application. An interesting and comparatively recent example of voltage control has been described by Wagner and Ferris. Control of the primary electrons in secondary multipliers by deflecting them instead of using a control grid appears to have been first described by Hopkins. The composite caesium/caesium-oxide/silver curve in Fig. 10 shows the ratio of secondary emission current to primary current obtained from one of the radiating surfaces in a multiplier.

Since secondary electrons are not emitted with a single velocity, but with a spectrum of velocities, the transit angle between the radiators in the multiplier also has no single value.

In Fig. 13, the ordinates represent the relative number of secondary electrons emitted at each of various relative overall transit angles of the secondary electrons in a 3-stage electron multiplier. The relative overall transit angle is expressed as a fraction of the transit angle which would exist if the secondary electrons were emitted with zero velocity. It will be observed that the transit angles of the individual secondary electrons vary over a wide range. Furthermore, secondary electrons are radiated from different parts of the radiator, and have to travel along paths of different lengths to reach the next electrode.

The result of these combined effects has been shown by Malter to produce a high-frequency cut-off in the response of the multiplier as a whole. The resulting frequency cut-off of a typical multiplier is shown in Fig. 14.

Farnsworth Multipactor

Another application of secondary electron multiplication involves the utilization of transit time to produce high-frequency oscillations. This idea was first put forward by Philo T. Farnsworth.

Reduction of Screen Grid Current

In many screen-grid radio tubes the anode is maintained during operation at a potential higher than that of the screen grid. Secondary radiation of quite a considerable amount is produced at the points of impact upon the screen grid of the primary electrons which constitute the space current. The secondary electrons travel from the screen grid to the anode and so decrease the screen grid current, and increase the anode current, very considerably. This results in an increase in the static transconductance of the tube. It must not be forgotten that due to the varying transit angles of the secondary electrons, this increase will not hold at very high frequencies. The phenomena produced will be somewhat similar to that exemplified above with respect to secondary electron multipliers. There seems to be no published information in this matter.

Secondary Radiation from Cathodes

In certain tubes—notably the magnetron—the cathode may be bombarded by primary electrons which return to it at considerable velocities. By adding to the emission, the resulting secondary radiation may have an appreciable effect on the operating characteristics of the valve.

The Pentode

In the great majority of electronic tubes, secondary radiation is a nuisance and elaborate steps have to be taken to prevent it from interfering with the operation of the tubes. It will be clear from Fig. 5 and the associated text, however, that attempts to prevent the radiation of secondary electrons from the electrodes of radio tubes are foredoomed to failure. In fact, quite early engineering experiments confirmed this.

Since secondary radiation itself cannot be prevented, the only remaining thing to do is to prevent the secondary electrons traveling from one electrode to another. This is the idea behind the pentode.

It is almost unnecessary to describe this well-known tube in detail. The traverse of secondary electrons from the anode to the screen grid when the anode is at a lower potential than the screen grid during operation is prevented partly by the use of a retarding potential. A grid (called the suppressor grid) is interspersed between the screen grid and the anode and is maintained at a low potential.
Primary electrons pass through the spaces between the suppressor grid wires. A retarding potential exists between these spaces and serves to reduce the secondary radiation current from the anode to the suppressor grid to a fraction of the primary electron current (see Fig. 4 and 6). At the same time, due to the cosine law of distribution (Fig. 8), only a small number of secondary electrons are directed towards the gaps in the suppressor grid. This results in a still further reduction of the total secondary electron current.

A further effect which tends to reduce the adverse flow of secondary electrons is the addition to the retarding potential caused by space charges. Both primary and secondary electrons contribute to a space charge potential. The combination of all these effects (and possibly others) operates in a very complex manner, and the author is not aware of a satisfactory quantitative theory, but pentode valves are readily designed by empirically determined means.

Remembering that the potential between the wires of the suppressor grid cannot be zero; the primary electrons themselves would be prevented from arriving at the anode, it is untrue that the operation of a pentode explained merely by the interrelation of a retarding potential would be prevented from arriving at the anode and screen grid. Retarding potential which did not reduce the potential between the wires of the suppressor grid to zero would still leave a considerable number of secondaries flowing. This is clear from Fig. 6. Curve A in Fig. 15 shows the familiar tetrode characteristic, which is produced in the absence of a suppressor grid. Curve B shows the characteristic of a pentode, and curve C is the type of characteristic that might perhaps be expected if a suppressor grid were used to operate solely by producing a retarding potential.

**Critical-Distance Beam Tetrodes**

In 1931 the author, working on the production of the then novel idea of producing beams of electrons of appreciable fractions of an amperie at a few hundred volts, found that if the space current in a dynatron type of tetrode is confined to a beam, an optimum value exists for the distance of the anode from the screen grid (accelerating potential) through a small aperture as in Fig. 16, only a very small part of the resulting secondary radiation will succeed in leaving the cavity. This is the principle of the Faraday cylinder previously referred to (Fig. 3, 4, and 7). Attempts have been made and suggested to utilize such cylinders as the anodes or collector electrodes of practical radio tubes. Since in such radio tubes the effective anode area for the collection of primary electrons must usually be considerably greater than the small aperture illustrated in Fig. 16, these attempts have not been very successful as far as the author is aware.

**Secondary Electron Traps**

Due to the cosine distribution of secondary radiation (Fig. 8), if a beam of primary electrons enters an enclosed metal cavity (at a position grid; he named this distance the critical distance) at which the passage of secondary electrons from the anode to the accelerating grid is prevented. The anode characteristic then obtained is of the kind illustrated in Fig. 17. The sharp knee at the lefthand side of the curve is characteristic of this type of tube and results in a considerably lower distortion level than the more rounded knee of the pentode (Fig. 15).

Tubes of this kind were made in 1931 and were put on the market in England by a commercial firm in 1935. They came into wide use, under the name of beam tetrode when this tube was first marketed (in America) in 1936; yet, like the pentode (the invention of which dates from 1926), there is again no satisfactory published theory. The straight part of the anode characteristic of this valve (Fig. 17) can only be accounted for by the reduction of the traverse of secondary radiation to a very small fraction indeed of the total radiation. By reference to Fig. 6, it will be seen that this appears to infer a retarding potential virtually equal to the primary impact velocity itself.

Attempts have been made to explain this critical-distance characteristic in terms of the potential minimum produced by space charge, but the author has shown that the magnitude of the retarding potentials predicted by this theory is not sufficient (by a factor of several times) to prevent the occurrence of the dynatron kink in the anode characteristics. Moreover, the problem is not merely one of preventing the passage of secondary radiation at one set of values of anode current, anode voltage, and screen voltage. It is, on the contrary, that of maintaining a flat working surface of the characteristic over a wide variation area (Fig. 17). A purely space-charge retarding potential theory leads to no such range of working currents and voltages.

A complete formulation of the problem must include the effects of the formation of the primary electrons into a beam (without which the effect seems not to take place in practice), the variation of the density of this beam with control grid voltage, the energies of the
secondary* electrons, the angular distribution of the secondary radiation, the end effects, and the depression of space potential due to the presence of low-potential conductors near the screen-grid-anode space. (An approximate theory of the beam tetrode can, however, be produced to take these factors into consideration, and the author hopes to present it in due course when war-time matters permit.)

It has been pointed out by the author some time ago* that if the accelerating voltage is higher than a few hundred volts, the critical-distance effect is not produced satisfactorily. This appears to have a relationship to the increase in the area of peak A in the secondary radiation energy distribution curve (Fig. 1) at the higher primary impact velocities.

Secondary Emission from Grids

Grids and other electrodes in electronic tubes which are struck by electrons will emit secondaries which, particularly in tubes where optical images are to be formed, may be very undesirable. Such effects may be minimized, though not eliminated, by treating the surfaces involved. Coating with carbon black or like methods are used (Fig. 9A).

Secondary Radiation from Insulated Electrodes and Insulators in Vacuum Tubes

If an insulated conductor is positioned in the path of a beam of primary electrons, its potential will depend upon the impact energy of the primary electrons and upon the secondary electron coefficient of the conductor.

For instance, referring (Fig. 9A) to the curve for nickel, it will be seen that it becomes unity at a primary impact velocity of approximately 1750 volts. The initial potential of a clean insulated electrode made of nickel will, in the absence of a flow of primary electrons, be that of the space in which it is situated. If this potential, and the impact energy of the primary electrons upon the nickel electrode are both above 1750 volts, then, from Fig. 9A, the total secondary radiation coefficient will be less than unity. The insulated nickel electrode will therefore charge negatively until its potential reaches 1750 volts, when the secondary radiation coefficient is unity, and the number of electrons leaving the electrode will be equal to those reaching it. This, of course, assumes space-charge-free conditions and assumes further that all the secondary electrons emitted by the nickel are collected by other electrodes in the tube.

If, again, the space potential of the insulated nickel electrode and the initial energy are between about 160 and 1750 volts, then, from Fig. 9A, the total secondary radiation coefficient is less than zero. The insulated electrode will charge up negatively until it reaches zero po-

of a vacuum tube) due to secondary radiation may vary discontinuously and profoundly affect the space potential in the tube as a whole, and therefore in many instances upset the operation of the device. In the absence of more information on the secondary radiation coefficients of insulators, and because of the complicated nature of their behavior, it is not possible to state any useful theory. In radio tubes care is taken to minimize the results of bulb charging. This is done by causing the electrode assembly to be self-shielding (i.e., semi-enclosed as far as the operative part of the electron beam is concerned) or by putting a conductive film (such as collodial graphite) on the walls of the glass envelope and connecting it to a suitable part of the electrode system. This is found to be necessary in cathode-ray oscillograph tubes where the beam is not enclosed by the metal electrodes.

Conclusion

It is remarkable, considering the extreme importance of secondary radiation in electronic engineering, that there are so many gaps in the published information and theory. The author would appreciate any additions or corrections to this paper.

REFERENCES

(5) Campbell, N. R., Phil. Mag., 24, p. 783, 1912.

(Continued on page 180)
In this rugged terrain near Kwellin, capital of Kwangsi Province, native workers make radio equipment used by the Chinese Army and Government-operated broadcast stations. Known as the Central Radio Works, the plant is operated by the National Resources Commission. Note parking lot.

Components are assembled as above where capacitors and vacuum tubes receive the dextrous attention of Chinese employees. Below, a worker finishes up the wiring on a transmitter, while a coolie, right, forms the local version of a conveyor line in transporting units around the plant.
PHOTOTUBE CONTROL

Flow rates as constant as ± ½ percent are achieved by a system which combines a rotameter for light-source interruption with phototubes, amplifiers, and thyratrons to control a motor-driven regulating valve.

**By ROBERT C. McNICKLE**

**FIG. 1—Construction of a rotameter is shown in this sectional drawing. Position of the float depends on differential pressure which is automatically maintained constant by variations in the annular opening between float and tube as the float rises and falls. Flow-rate indication is linear.**

**FIG. 2—Block diagram shows general operation of the flow-control unit. Provisions are incorporated to cancel out effects of line-voltage fluctuation and changes in color of the controlled fluid.**

Rotameters are simple instruments which accurately indicate the rate of flow of liquid or gas in a pipe line. They are widely used in chemical process, power, and other industries. The instrument, shown in Fig. 1, usually consists of a vertical, transparent, tapered, glass tube and a metering element inserted inside the tube. The small end of the tube is at the lower portion, and the metering element, variously shaped depending upon fluid requirements, is free to move up or down along the axis of the tube. The position assumed by this element directly indicates flow rate. The gas or liquid being metered flows from the bottom to the top of the tube.

Theory underlying the operation of this type of flow indicator is based on the flow equation, \( Q = CA \sqrt{2gh} \), where \( h \) is a constant by virtue of the constant net weight of the metering element (commonly called the float or rotor), and \( A \) a variable due to the taper of the tube. The force counter to the float weight is the head differential induced by the fluid flowing through the annular aperture between the outside diameter of the float and the inside diameter of the tube. Thus the rate of flow varies directly as annular area and the calibration of the instrument is linear.

In other words, forces on the float are in balance; weight of the float minus buoyancy equals area of the top of the float, times differential pressure. If the flow rate increases, the differential across the float will increase, and the float will rise to new position to maintain a fixed differential pressure across it. Rate of flow is accurately measured...
OF FLUID FLOW

FIG. 3—The complete unit. Elevating handwheels are below and hand-automatic controls are on the front panel of the controller. Plastic light-transmission bars project through slots on either side of the rotameter tubes.

Throughout the entire tube range 2 to the variable orifice (fixed differential) principle, and is not limited to a narrow range such as in the case in the fixed orifice type of flow meters.

Self-supervised Operation

For the past ten years, there has been a demand for automatic control applied to rotameters. Brooke Engineering Co. developed a control for this type of meter several years ago. The control operated on an induction principle such as is commonly used in other types of instruments. The float had an iron rod which hung down inside a center-tapped coil, mounted below the rotameter. This coil was electrically balanced against a similar, remote coil having an iron rod that could be positioned by hand.

Differences in balance of the two coils when the float moved out of its preset balance, were fed into an electronic relay which caused a motor to operate. This, in turn, opened a closed valve to correct the flow rate. This type of control was not entirely satisfactory, due to the fact that its sensitivity was only plus or minus 1 percent, and phase shifts caused unstable operation if the control point was not near the center of the coil. Also, it could not be used on small sizes of rotameters, because the magnetic effect of the coil on the iron rod attached to the float was so great as to affect the sensitivity and accuracy of the rotameter.

About a year ago, a large refinery had a process in which they wished to maintain the flow rate of a fluid to ±1 percent and it was decided to use a fully compensated electronic relay, receiving its signals from phototubes. This system had been in successful operation for many years, measuring the smoke density of large industrial boilers and adjusting the air supply to maintain a fixed smoke color at the boiler outlet.

For the rotameter application, it was decided to use two light beams, one shining across the top of the float, and the other across the bottom of the float. Each light beam was applied to a phototube, and the outputs of the phototube amplifiers were electrically balanced against each other to cancel out the effects of voltage changes and color deviation of the liquid.

If the float in the rotameter moved due to a change in flow, one phototube received more light and the other, less light. This unbalance caused a thyratron to operate a motor with compensation and with full torque at all times. This motor changed a control valve in the correct direction to restore the float to the set value within ±1 mm (0.0098 in.)

Disposition of Parts

Arrangement of the various pieces of equipment is shown in Fig. 2. The rotameter is mounted on a stand, in front of a panel as in Fig. 3. The electronic relay, with its light source common to both beams, and its phototubes, amplifiers, thyratrons, and allied equipment, is mounted behind the panel, as in Fig. 4. Lucite or Plexiglass bars are used to transmit the light
out to the rotameter and back to the phototubes. The electronic relay is mounted on an elevator assembly which permits the operator to raise or lower the entire assembly to change the rotameter control setting. The unit is also supplied with a switch which permits the operator to remove the control from "automatic", and to raise or lower the float to any desired value.

In addition to the compensated controlling action, described later, other features may be included in the electrical circuit when required. For example, automatic shut-down if any of the fluids in the process cease flowing or go beyond predetermined values, or if tubes or light source fail.

In most cases, a lock-in circuit must be employed to return the float within the range of the light beam if the characteristics of flow are such that an occasional surge in the fluid will raise or lower the float out of the light beam. This lock-in feature is most important. Essentially, it consists of electromagnetic relays which are actuated by the phototube amplifiers just before the float leaves the light beam. The lock-in feature discerns which way the float moved and operates the motor at full speed to return the float to the light beams where the thyatron can come into operation.

Referring to the circuit diagram in Fig. 5, when the output of $V_s$ goes beyond a predetermined limit, as set by $R_{in}$, a type 2050 thyatron in the lock-in circuit fires to energize a relay. When energized, this relay disconnects the cathode of an opposing 2050 so that it cannot operate, and puts a high positive voltage on the grid of the thyatron $V_s$ to run the motor at full speed. The lock-in circuit does not come into play until the float is about ready to leave the light beam.

The electronic relay employed converts impulses from a pair of phototubes into signals sufficiently large to run a reversible motor. Net movement of the motor is proportional to the signal and the motor has full torque at all times. The electronic relay provides electrical compensation by means of a circuit which varies the thyatron grid voltage by charging and discharging a capacitor at variable rates. Such compensation is similar in results to mechanical throttling and reset but is accomplished electrically without the use of relays, open contacts, or moving parts.

The light source is a 120 v bulb directed through two pieces of Lucite or Plexiglas to form two light beams shining across the rotameter. They are spaced so that when the float is in balance, one half of each light beam is blocked out and the other half of the beam passes through the fluid and metering tube to other bars of Lucite, and thence to the phototubes. The phototubes are of the high-vacuum type and are not appreciably affected by voltage changes.

**Circuit Details**

Direct-current bias for the phototubes, amplifiers, and thytrons is furnished by the 6L6 rectifier. One half of the tube acts as an ordinary high-voltage half-wave rectifier, taking voltage drop across a load resistor, while the other half utilizes the drop across the tube, giving low voltage. Both plate outputs are filtered. Resistors $R_s$ and $R_t$ provide grid bias for $V_s$ and $V_t$, while $C_t$ and $C_s$ provide a-c grid-to-cathode return.

Phototubes $V_t$ and $V_s$ are so connected to their amplifiers $V_s$ and $V_t$ that the more light received by the phototubes, the lower the amplifier plate output. With this arrangement, it is possible to keep a nearly constant plate output of the amplifiers with a variable voltage. For instance, if the voltage falls, the light source dims, plate voltage of $V_s$ and $V_t$ drops, and the phototubes decrease the negative grid voltage of the amplifiers, thereby increasing plate output to approximately the same value as at the higher voltage. This will take care of voltage changes in the order of ±5 v at 115 v. For greater changes of voltage the plate outputs of $V_s$ and $V_t$ will vary up or down together, but since these plate outputs are balanced against each other in $T$, it will not affect the control. With the amplifier plates balanced against each other, color changes of the liquid in the rotameter will also cancel out.

The plate of $V_t$ is connected to one half of the primary of push-pull transformer $T$, and the plate of $V_s$ is connected to the other half. Assuming the float is in neutral, light on $V_t$ equals light on $V_s$, plate outputs of $V_t$ and $V_s$ will be equal and cancel each other in the primary of $T$, and there will be no voltage developed in the secondary. If the float moves down from the neutral position, $V_t$ receives more light, and $V_s$ less light, therefore the grid of $V_t$ will become more negative, and the grid of $V_s$ less negative. The plate output of $V_t$ will become

---

**FIG. 4—In a rear view, motor drives and control valves appear below the electronic relays. Mercoid units mounted on the valve shafts include limit switches and extras which can be used to operate relays on terminal panel for automatic shut-down feature**
water and that of \( V \), less, causing a voltage to be developed in the secondary of \( T \). Since the primary voltage is pulsating half wave, an a-c voltage will be developed in the secondary.

A fixed, negative d-c bias of approximately 10 v is maintained on grids of \( V \) and \( V \), by the rectifying tube which the float is in balance. If the float falls, as assumed above, the negative half of the a-c voltage developed in one half of the secondary reduces the negative grid voltage to approximately 2 v and \( V \) fires. The tube in a direction which changes the valve to restore float to neutral. Note that the position of tubes \( V \) and \( V \) is 180° out of phase with the emission of \( V \) and \( V \).

**Anti-Hunt Compensation**

It can readily be seen that if the motor were to run at full speed under float, the float reached its neutral position hunting would occur. To induce a compensating effect, \( C \) is used in the following manner. When \( V \) is weak, the motor will then have a long time delay. If the signal from \( T \) is weak, the motor will be energized and a short time charge \( C \) a small amount, and the time of delay will be short. In other words, the net rate of movement of the control valve will be proportional to the amount the float moves from neutral.

Capacitor and resistor values are so chosen that if the float moves a great distance, the motor will run at full speed without interruptions. As the float approaches neutral, the motor begins to step at a speed proportional to the distance from neutral. Capacitor-resistor combinations \( C_1-R_1 \) and \( C_2-R_2 \) also have a somewhat compensating effect but on a relatively small scale.

If the float had moved in a direction to fire \( V \), a negative feedback voltage would have been induced in the motor field not being used. This induced voltage would be equal to the voltage running the motor, and would cause compensation as described above.

By this system the motor always has full torque, regardless of how close the float is to balance. This is extremely important for highly sensitive controls, otherwise, should the valve stick, the torque delivered by the motor near the neutral point would not be sufficient to restore the float to its original balance point. This is often a limiting factor in many control devices.

Successful field operation of 64 of these units for several months has demonstrated that an extremely accurate control can be applied to devices where it is necessary to maintain a movable body in a fixed position. If greater sensitivity is required, concentrated light beams can be employed. By this method, a slight change in float movement will cause a greater signal change.
A Generator of Damped

Spark discharges between 400 series-paralleled metallic spheres develop ½ watt of power at 7,000 Mc for the irradiation and stimulation of cells in biological studies.

(d) The energy of the electromagnetic waves generated by discharges between small spheres is of the order of 10⁻² watt.

In order to utilize these conclusions in a practical way a large number of metallic spheres were fixed in a non-conducting frame, individually insulated, and at convenient terminals high voltage was applied. (The excitation of the spheres may be in parallel, in series or in series-parallel. The last disposition was preferable.)

Figure 1 shows a schematic arrangement of the circuit of the apparatus. It follows the theory of the spark-gap circuit once widely used in radiotelegraphy with damped waves, except for the fact that in this instance the spheres oscillate and radiate at the same time.

Description of Apparatus

The apparatus, shown in Fig. 2, is mounted on top of a cabinet in which a transformer is housed. Two

FIG. 1—Schematic of the generator

APPARATUS which has for its purpose the production of power at extremely high frequencies is usually associated with radio transmission but that described here was designed for use in the field of biology.

The generation of damped electromagnetic waves by means of spark discharges between metallic spheres dates back to the beginning of the century. A complete discussion of the early work is out of place here, and for hypotheses and theories on the subject we refer the reader to the appended bibliography.

Design Considerations

Some of the conclusions of earlier experiments which were kept in mind in designing the apparatus follow:

(a) When a metallic sphere is excited by electric sparks, highly damped trains of waves are generated.

(b) The approximate length of the fundamental wave is given by Thomson's formula \( \lambda = \frac{2\pi d}{\sqrt{8}} \), where \( d \) is the diameter of the sphere.

(c) The surface of the spheres must be and must remain highly polished, otherwise the discharge ceases to be oscillatory and becomes aperiodic.

FIG. 3—Close-up of the left edge of the unit, showing how binding-posts which may be seen in a vertical line are used to permit adjustment of fins

FIG. 4—Paralleled round porcelain rods provide vertical grooves in which spheres may be placed, keeping them equally spaced and well insulated

FIG. 5—Partial view of the unit, with some spheres removed to show how treated wooden strips provide horizontal spacing
Microwaves

BY ANGELO MONTANI

Electric arms at the sides support a cylindric-parabolic reflector which the radiating element is positioned.

The transformer used was taken from an old x-ray machine, and is rated at 100,000 r.m.s., 500 w. Its terminals are connected through high-frequency chokes to two comb-like rods, each of which has ten adjustable “fins.” The rods are equipped with binding-posts which permit adjustment of the fins. A set of binding-posts associated with each of these rods may be seen in a vertical line in Fig. 3.

Ten parallel rows of metallic spheres, each row having 46 spheres in series, constitute the generating and radiating element. The spheres are plain metallic balls such as those used in ball bearings, plated with platinum to prevent as big as possible rusting due to one produced by the sparks.

To obtain individual insulation, each sphere straight porcelain rods, 47 in all, were assembled against a flat wooden back to constitute a corrugated surface having grooves, in each of which 10 spheres could be located in a vertical row, as shown in Fig. 4. With a disposition every sphere is horizontally spaced the same amount from the spheres to the left and right, which is important for a even distribution of sparks.

Horizontally between each row of spheres long strips of treated wood, were inserted as shown in Fig. 5. I hold the 460 spheres against the porcelain rods a sheet of flat glass is provided to cover the entire face of the radiant element.

The diameter of the spheres is 4 mm, and therefore the fundamental wavelength is approximately 43.4 mm. The power radiated by the whole system of 460 spheres at the fundamental wavelength is around 4 watt. (Assuming that the power of the harmonic waves decreases according to the square of the number of their natural sequence, the power of the tenth harmonic, or 4.3 mm, would be 4 × 10⁻⁴ w., and the power of the one hundredth harmonic, or 0.43 mm, would be 4 × 10⁻⁶ w.)

Purpose of Apparatus

The purpose of the apparatus was to make available in the biological field those radiations which fall between the centimeter waves and the heat rays, and to find out if such radiations might be of use in therapy.

Living things are made up of billions of individual “cells.” These cells generally vary in size 10⁻⁶ cm and 10⁻⁴ cm, and are larger in vegetals and smaller in viruses. If we want to stimulate a cell we can do so by irradiating it with waves of the same order of magnitude, since under these conditions at least partial resonance may be expected.

Rays shorter than light excite the electrons of the atoms which form the cells, no matter where those electrons are. They may belong to a neuron or to a rock. On the other hand, short waves as used in diathermy cause in the tissue as a whole variable charges which, associated with the osmotic and capillary phenomena, alter the circulation of the liquids of the body. In both instances, the cellular metabolism that ensues is not a specific direct reaction of the cells to the radiation, but a derived effect. Cells in tissues represent a tridimensional grating, and with waves of proper dimensions it may be possible in the future to institute a new kind of spectroscopy of the living tissues and determine if there exists a kind of selective absorption peculiar to every type of cell.

Biological Use

Between March and June, 1941, six biological experiments were performed with the above apparatus (Continued on page 306).
Electronics in PETROLEUM PLANTS

Analytical methods involving a large portion of the electromagnetic spectrum are being used continuously today in petroleum production and research to identify molecules in complex gas or liquid samples and determine the exact concentration of each component.

MODERN AVIATION GASOLINE of the "100 plus" octane number variety, the all-purpose military lubricants required in today's highly stressed equipment, and pure chemicals produced from petroleum for the manufacture of synthetic rubber were all unheard of in World War I. The swift progress of petroleum research in the development of these products and the rapid translation of laboratory processes for their manufacture into vast commercial operations has spurred on the analytical chemist to new heights. Without the participation of the electronics industry, this progress would have been impossible.

In the past the simplest methods served to control the manufacture of gasoline and lubricating oils. Today, measurement of such simple properties as gravity, viscosity, and boiling range is not sufficient.

Modern research demands far more explicit information. Usually the research chemist, and often the production engineer also, will not settle for anything less than knowing the complete composition in terms of the molecules present. When new methods developed for research purposes are applied to industrial control, our dependence upon stable amplifiers and electronic detectors and recorders becomes complete.

These modern radiation methods have again stressed the importance of the electromagnetic spectrum to the petroleum chemist. The regions most frequently employed in this field include the x-ray, ultraviolet, visible and infrared portions of the spectrum. Naturally the technique resembles that of the physicist more than that of the chemist. The chemist endeavors to make materials react with specific reagents to yield a unique product which will identify some component of the original sample and which can preferably be weighed or titrated to determine the concentration of the unknown component in the sample.

The physicist, on the other hand, usually makes measurements on the sample as received, often returning the sample still in its original condition. Such physical measurements yield new and direct information concerning the sample. These methods are frequently much more rapid than wet methods and only a small amount of the sample (sometimes less than a milligram).

<table>
<thead>
<tr>
<th>Methods of Generation</th>
<th>Emitted When Atoms Are Disintegrated (Radioactivity)</th>
<th>Emitted by Sudden Stoppage of Fast Moving Electrons</th>
<th>Radiated by Hot Bodies</th>
<th>Radiated from Hot Bodies</th>
<th>Spark-Gap Discharge and Vacuum-Tube Oscillators</th>
<th>Coil Rotating in Magnetic Field, Vacuum-Tube Oscillators</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Photography</td>
<td>Luminescence</td>
<td>Chemical Action</td>
<td>Ionization</td>
<td>Photoelectric Action</td>
<td>Diffraction by Prisms and Finely Ruled Gratings</td>
<td>Diffraction by Prisms and Coarsely Ruled Gratings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods of Detection</th>
<th>3,000,000</th>
<th>600</th>
<th>1,000,000,000</th>
<th>1,000</th>
<th>11,000</th>
<th>1,100,000</th>
<th>1,000,000,000</th>
<th>1,000</th>
<th>10</th>
<th>6-60 cycle per second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (Waves per Unit Time)</td>
<td>1,000,000,000</td>
<td>1,000</td>
<td>1,100,000</td>
<td>1,000</td>
<td>10</td>
<td>10</td>
<td>100</td>
<td>100</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Type</td>
<td>Not Electric</td>
<td>Electric</td>
<td>Gamma Rays</td>
<td>X-Rays</td>
<td>Ultra Violet</td>
<td>Infrared</td>
<td>Experimental</td>
<td>Fast</td>
<td>Slow</td>
<td>Audible Sound</td>
</tr>
<tr>
<td>Wavelength (Distance Between Wave Crests)</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

FIG. 1 — The frequency spectrum, with upper boxes showing how various portions of the spectrum can be generated and detected for use in the petroleum analytical field.

September 1944 — ELECTRONICS
The Frequency Spectrum

Most uniform oscillatory wave motion belongs to the electromagnetic spectrum which is shown schematically in Fig. 1. Sound, electrons, some nuclear rays, reciprocating mechanical motion, etc., are not electromagnetic in character and their wavelength or frequency regions can be shown only approximately. The radio spectrum is now well known up to about 1000 kc, but from here on to 1,000,000 kc lies a relatively unexplored region which promises to be very important in the future.

The infrared region is somewhat arbitrarily said to begin at about 1,000,000 Mc or 300 microns, but the region from 300 to 30 microns is largely only of academic interest at present. The region from 30 microns (300,000 Angstroms) to .05 Angstrom is that in which the analytical methods described in this paper operate. In the shortest wavelengths are found hard x-rays and gamma rays. In the past two or three years gamma rays have been used to "log" oil wells and determine where oil-bearing strata might occur even though metal casing has already been set within the well.

With the advent of the cyclotron and similar atom smashers, nuclear rays have been used in numerous novel experiments involving radioactive "tracers". Atoms of a specific element can be "tagged" by making them artificially radioactive and then followed throughout the course of a reaction by following the progress of the radioactive atoms.

Cosmic rays, the most penetrating radiation known, are generated outside the earth's atmosphere. They have been found to discharge electroscopes after penetrating 18 feet of lead. Day and night we are subject to bombardment by cosmic rays.

The energy per quantum of electromagnetic radiation varies directly with the frequency, as shown in Table I. It is instructive to inspect briefly this energy variation, for this in part dictates the troubles encountered in detecting the radiation and dictates the energy available for photochemical reac-
tion. Thus, the short wavelength radiation such as x-rays and ultraviolet rays readily enters into photochemical reactions. Ultraviolet and visible radiation readily activates photoelectric surfaces. The long-wavelength infrared and radio waves in general cannot enter into photochemical reactions because the energy per quantum of radiation is too small. Radiation of wavelength longer than about 2 microns cannot expel photoelectrons from photoactive surfaces which would be stable at room temperature.

**Mass Spectrometry**

The newest of the new analytical tools applied to petroleum problems is the mass spectrometer. Commercial instruments are capable of routine refinery control work to provide accurate petroleum gas analyses in amazingly short times on samples so small that their size is dictated by sample handling techniques in collecting and transporting the sample rather than the amount required for analysis. Mass spectrometry finds its greatest usefulness within the petroleum industry as a method that replaces tedious low-temperature fractional distillation and accompanying techniques for the control of refinery gaseous streams.

In the rapid spectrometric methods devised to analyze the petroleum "gas cut", the instrument time required is about 1 to 1.5 hour per sample and results from the data obtained can be calculated in from a few minutes to several hours depending upon the problem. This method soon proves its value when one realizes that other methods require from 4 hours to several days to do the same job. Usually the results from the mass spectrometer are more accurate and the method is less subject to operator errors.

The mass spectrometer is so named from certain similarities it possesses to an optical spectrometer. The latter separates light into its various component wavelengths by the dispersion obtained in passing light through prisms or gratings. The mass spectrometer separates gas molecules according to their mass by ionizing the gas, accelerating these ions, and deflecting them in a magnetic field. Gas from the sample is made to pass through several tiny orifices, so that a constant flow occurs into the spectrometer tube in which a high vacuum is maintained by continuous pumping. Electrons from a heated filament are accelerated by passing through a potential gradient and fall on the entering gas stream, causing ionization and dissociation of some of the gas molecules. The molecules not thus excited are drawn out of the system by the exhaust pump. The ions and ion fragments thus formed are urged toward a slit in a plate by a small potential difference and then are accelerated to very high velocity by an electrode arrangement similar to that in an electron gun. The resulting high-velocity ions are directed into a magnetic field. Only certain ions having the correct mass-to-charge ratio will travel through the center of the analyzer tube and ultimately lose their charge to the ion collector from whence their current is amplified and measured.

By variation of the accelerating potential and/or the magnetic field, such an instrument can be made to determine the relative abundance of various weight ions. This data can be converted to the relative abundance of the various molecules in the initial sample by comparing the unknown mass spectrum with...
The mass spectra of known pure hydrocarbons, since the unknown mass spectrum can be considered a summation or superposition of the mass spectra of all the components of the sample.

**Infrared Absorption**

At the present time the mass spectrometer is used in the petroleum industry primarily to determine the molecular composition of complex mixtures of gaseous materials. Other spectroscopic methods are generally used to determine the composition of liquid or higher-molecular-weight samples and certainly in rather simple gas mixtures. For example, in high-octane aviation gasoline, it is well known that certain types of molecules are desirable and others undesirable. But any of both the good and bad molecules are very much alike in all their physical properties and often cannot be isolated by even the best fractional distillation techniques. Thus, n-heptane has zero octane and isoctane has 100 octane number. Present-day aviation miracles would be impossible if such n-heptane was present in the fuel, but n-heptane and isoctane can be separated by distillation, if at all, only by very laborious procedures. Infrared spectroscopy readily differentiates between these hydrocarbons, as is illustrated in Fig. 2.

All this is possible because the frequency of the 1- to 30-micron infrared region corresponds to the vibration frequencies of atoms or groups of atoms in hydrocarbon molecules. As long as any molecule is not at absolute zero, the atoms in the molecule are constantly oscillating about their positions of equilibrium. For example, a hydrogen atom vibrates against a carbon atom in aliphatic hydrocarbons with a frequency corresponding to a wavelength of 3.4 microns. This vibration is a simple stretching vibration wherein the frequency of oscillation is, to a first approximation, determined by the mass of the vibrating atoms and the valence forces which bind them together. A typical analogy is the resonance vibration of two spheres of given weights connected by a spring. If the tension of the spring is increased the resonance vibration will occur at a faster frequency and this happens in molecules also. In ethane, H₂C-CH₃, the carbon atoms are connected by a single bond and vibrate against each other at 993 cm⁻¹. In ethylene, H₂C=CH₂, the carbons are connected by a double bond or stronger spring. The vibration is more rapid, at a frequency of 1623 cm⁻¹. [1 cm⁻¹ = 1/λ (cm)].

The vibrations just described are all simple stretching vibrations. Atoms also may vibrate in such a fashion that angular motion occurs and such vibrations are called deformation or bending vibrations.
For example, an H-C-H or CH\textsubscript{2} group in aliphatic hydro-carbons has a strong deformation vibration at 1,460 cm\textsuperscript{-1}. Atomic groups may rotate with respect to one another, thus yielding still another type of motion having a characteristic frequency. Many combinations of the above types occur to yield combination frequencies. Any molecular vibration which is accompanied by a change of dipole moment is "infrared active" and will absorb, by resonance, radiation corresponding to the frequency of vibration.

**Raman Spectroscopy**

Raman spectroscopy\textsuperscript{4,5} supplies essentially the same information concerning molecular composition as infrared absorption studies but accomplishes the task in a different manner. In Raman spectrography, light of characteristic and usually visible wavelength, such as that from a mercury discharge tube, is allowed to illuminate the sample. Light originating in the sample at a direction perpendicular to the incident beam is dispersed in a large-aperture spectroscope and the resulting spectrum photographed and examined. This scattered and/or re-emitted light coming from the sample contains light of frequencies corresponding to that of the incident beam plus or minus the frequencies of various vibrating groups within the sample, and thus can be used to identify the parent molecules. Samples for Raman investigation must be well fractionated just as with infrared.

The photographic process complicates quantitative interpretation of Raman spectra, and a direct-reading, automatic-recording detecting system for the visible light emanating from a Raman spectrograph would greatly enhance its industrial usefulness. Multiplier phototubes have already been successfully applied to this problem.\textsuperscript{10}

**Experimental Difficulties with Infrared Spectroscopy**

Infrared spectroscopy is used at present in the petroleum industry to a much greater extent than Raman, even though the experimental difficulties in infrared work constitute a formidable list. To mention a few, ordinary optical materials will not transmit infrared radiation in the wavelength region used and prisms and windows of sodium chloride, potassium bromide and lithium fluoride are used in conjunction with front-surfaced mirrors.

These are now available in large perfect crystals of synthetic manufacture but the chloride and bromide are readily attacked by water vapor and must be handled accordingly in use. Gratings are not useful for general survey work because overlapping orders of spectra prevent their use. But for certain work, they have the advantage of being easily changed to suit different spectra.

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**TABLE 1. Quantum Energy of Some Electromagnetic Radiations**

<table>
<thead>
<tr>
<th>WAVELENGTH</th>
<th>APPROXIMATE COLOR</th>
<th>ENERGY per quantum (ergs)</th>
<th>ENERGY per einstein (kilo-cal.)</th>
<th>RELATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angstroms</td>
<td>Microns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300,000</td>
<td>30</td>
<td>Infrared</td>
<td>0.066 x 10\textsuperscript{-19}</td>
<td>0.95</td>
</tr>
<tr>
<td>100,000</td>
<td>10</td>
<td>Vibration</td>
<td>0.196</td>
<td>2.85</td>
</tr>
<tr>
<td>10,000</td>
<td>1</td>
<td>Photographic</td>
<td>1.96</td>
<td>28.5</td>
</tr>
<tr>
<td>7,000</td>
<td>0.7</td>
<td>Red</td>
<td>2.81</td>
<td>40.7</td>
</tr>
<tr>
<td>6,500</td>
<td>0.62</td>
<td>Orange</td>
<td>3.17</td>
<td>45.9</td>
</tr>
<tr>
<td>5,800</td>
<td>0.58</td>
<td>Yellow</td>
<td>3.39</td>
<td>49.1</td>
</tr>
<tr>
<td>5,200</td>
<td>0.53</td>
<td>Green</td>
<td>3.71</td>
<td>53.8</td>
</tr>
<tr>
<td>4,700</td>
<td>0.47</td>
<td>Blue</td>
<td>4.18</td>
<td>60.5</td>
</tr>
<tr>
<td>4,250</td>
<td>0.42</td>
<td>Violet</td>
<td>4.68</td>
<td>67.6</td>
</tr>
<tr>
<td>3,000</td>
<td>0.30</td>
<td>Ultraviolet</td>
<td>6.55</td>
<td>94.8</td>
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<tr>
<td>1,000</td>
<td>0.1</td>
<td>Vacuum Ultraviolet</td>
<td>19.6</td>
<td>285</td>
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<tr>
<td>100</td>
<td>0.01</td>
<td>Long X-rays</td>
<td>19.0</td>
<td>285,000</td>
</tr>
<tr>
<td>1</td>
<td>0.001</td>
<td>X-rays</td>
<td>10.600</td>
<td>285,000</td>
</tr>
<tr>
<td>0.1</td>
<td></td>
<td>Gamma Rays</td>
<td>195,000</td>
<td>2,850,000</td>
</tr>
</tbody>
</table>

*The einstein is similar to the faraday or chemical equivalent of electrical energy.*
re difficult to identify in this region. Even the water vapor and carbon dioxide in the air must be eliminated from the optical path through the instrument or a correction made. The optical arrangement of one such instrument is shown in Fig. 3.

The radiation involved in spectroscopy is of very low inherent energy, as shown in Table I. It cannot be photographed at wavelengths longer than 12,000 A or 1.2 microns, and will not actuate photoelectric cells above about 1.7 microns. It can only be detected by tiny thermocouples, bolometers, radiometers, etc. Such instruments must detect temperature changes with a limit of error equal to, or less than, 0.0005 deg C. The most commonly used detector is the thermocouple. The microvolt output of the thermocouple must develop about full-scale deflection on the recording instrument used. Since the usual resistance is only about 15 ohms and the period about 1 second, electronic amplification is difficult. Sensitive galvanometers with their accompanying vibration troubles must be avoided. The authors know of at least one case where, in the past few months, a thermocouple has been made with sufficiently small mass so that its period is faster than 1 second and electronic amplification of the thermocouple output has become possible. The spectrograph in use at the Socony-Vacuum Laboratories uses a bolometer as a detector. Electronic amplification is used and results to date indicate that this combination marks an important step forward.

**Ultraviolet Absorption Spectroscopy**

The readily accessible ultraviolet region of the spectrum from 2,000 to 12,000 A up to the visible region also displays phenomena related to the structure of molecules. Molecules rich contain resonating groups, such as dioleins which contain conjugated unsaturated carbon groups, exhibit selective absorption of ultraviolet light.

Of particular interest to the petroleum industry, aromatic hydrocarbons and drying oils and resins yield characteristic ultraviolet absorption spectra by means of which such molecules can be identified. Saturated hydrocarbons do not absorb appreciably in this region. Thus, the identity and concentration of some aromatic compounds (those which may be present in gasoline) can be determined without separation from the paraffinic hydrocarbons.

An analysis has been reported wherein straight-run or saturated naphtha is split into five fractions over the range of 125-150 deg C and these fractions analyzed for ethylbenzene and the three xylenes with an accuracy better than that of any other available procedure. More (Continued on page 308)
INFLUENCE OF FEEDBACK

Analysis of the use of negative feedback to reduce source impedance in amplifier stages and transmission lines, as required in video design and other applications where high-frequency response must be improved or loudspeaker "hangover" must be eliminated.

INVERSE FEEDBACK is widely used in amplifiers today to stabilize gain, improve frequency response, and reduce distortion. One other extremely valuable feature of negative feedback is the apparent reduction of source impedance it may cause; this is not only important in itself, but may also serve as a basis for analyzing all the other features of feedback.

Impedance Consideration

Let us then derive a formula for the variation in source impedance with feedback. The gain of a feedback amplifier is

\[ \alpha' = \frac{\alpha}{1 + \alpha \beta} \] (1)

where \( \alpha' \) = gain with feedback, \( \alpha \) = gain without feedback, and \( \beta \) = ratio of feedback voltage to output voltage, or the fraction of output voltage fed back (negative for degeneration).

As the load impedance approaches infinity the equation

\[ \alpha = \frac{-\mu Z_L}{Z_L + R_F} \] (2)

approaches the value \( \alpha = -\mu \), and \( \alpha' \) approaches the value \(-\mu/(1 + \mu \beta)\), where \( \mu \) = amplification factor of the tube, \( R_F \) = plate resistance of the tube, and \( Z_L \) = load impedance.

In Fig. 1, which is the equivalent circuit of an amplifier stage, one method of finding the source impedance would be to connect a load of such value that the voltage at \( T_1 \), measured exactly half the value it would have if the load impedance were infinite, in which case \( Z_L \) would equal \( R_F \). Practically, this would mean choosing a value of \( Z_L \) such that \( \alpha = -\mu/2 \). The same reasoning holds true for an amplifier with feedback, where \( R_F = Z_L \) when

\[ \alpha' = \frac{-\mu}{1 + \mu \beta} \] (3)

Substituting Eq. (2) in Eq. (1),

\[ \alpha' = \frac{-\mu Z_L}{Z_L + R_F} \frac{1 + \beta \mu Z_L}{1 + \beta \mu Z_L} \] (4)

To find the apparent plate impedance we need only substitute the value of \( \alpha' \) given by Eq. (3) in Eq. (4) and solve for \( Z_L \), which will be the value of load impedance required to make \( \alpha' \) equal one half its maximum value, and will therefore also be the source impedance of the amplifier:

\[ \frac{1}{2} \left( \frac{-\mu}{1 + \mu \beta} \right) = \frac{-\mu Z_L}{Z_L + R_F} \frac{1 + \beta \mu Z_L}{1 + \beta \mu Z_L} \]

Solving for \( Z_L \),

\[ Z_L = R_F \frac{1}{1 + \mu \beta} \] (5)

(In this equation \( \mu \) must be negative. Strictly speaking, it should always be, because of the 180 deg phase reversal in an amplifier stage).

From this formula it can be seen that negative feedback in effect reduces the plate resistance of a tube, and in a practical case can make a pentode or beam power tube have a source impedance as low as that of a triode, or lower.

It is well known that pentode and beam power output stages have poor frequency response and appreciable distortion. These defects are manifested mainly in two ways.

Defects of Pentode and Beam Tubes

First, the speaker tends to have "hangover"; that is, the cone and voice coil assembly tends to vibrate at its own natural period when a transient or a steep wave front signal is applied, and the amplifier's output will be far above normal when a signal is applied whose frequency is equal or close to the mechanical resonant frequency of the speaker. This does not occur in a triode because the low-impedance source shunts the speaker's counter emf and effectively damps the vibration. A pentode or beam tube with enough feedback to approximate a triode's plate resistance will behave similarly.

The second effect is a response which rises with increasing frequency; this happens because the primary inductance of the output transformer presents an appreciable (and, of course, varying) load to the tube throughout the audio spectrum. In a triode stage the
ON SOURCE IMPEDANCE

Transformer primary's inductive reactance is high compared to the be's plate resistance except at the very lowest audio frequencies, and hence a fairly uniform response is obtained. As in the first case, feedback will enable a beam power or pentode tube to give similar performance.

Pentode voltage amplifiers can be made to have a feedback advantageously also, it will lessen the effect of the output capacitance of the next tube and therefore improve the high-frequency response.

In general, it may be said that where feedback will improve the operation of any tetrode or pentode amplifier whose load contains shunt active components.

Current Feedback Circuit

The foregoing discussion and derivation assume that $\beta$ is constant regardless of changes in load impedance. This is true in the circuits of Fig. 2 or in any circuit where the portion of the output voltage is fed back. If we consider Fig. 3, however, we see a network in which a stage of the output voltage is fed back which depends on the load current rather than on output voltage, and $\beta$ is not constant but depends on $Z_L$. Therefore, in this case, $\beta$ is determined by the ratio of voltage drop across $R_L$ to the stage drop across $Z_L$. Therefore, we have:

$$\beta = \frac{r_i R_P}{r_i Z_L}$$

The circuit of Fig. 3, Eq. (2) becomes:

$$\alpha = -\frac{\mu Z_L}{Z_L + R_P + R_F}$$

Eq. (4) becomes:

$$\alpha' = \frac{-\mu Z_L}{Z_L + R_F + R_P}$$

Substituting Eq. (6) in Eq. (8),

$$\alpha' = \frac{-\mu Z_L}{Z_L + R_F + R_P}$$

Simplifying,

$$\alpha' = \frac{-\mu Z_L}{Z_L + R_F + (1 - \mu) R_P}$$

Eq. (9) is identical with Eq. (2) except that $\alpha$ becomes $\alpha'$ and $R_P$ becomes $[R_F + (1 - \mu) R_P]$. Our formula for apparent source impedance, considering $\mu$ negative as in Eq. (5), is:

$$R_F' = R_F + (1 - \mu) R_P$$

Thus in Fig. 3 or in any current feedback circuit, the tube's plate resistance is increased, and hence the output current tends to be stabilized, rather than the output voltage as in a voltage feedback circuit. Current feedback will not improve frequency response because if the load impedance varies with frequency $\beta$ will also vary. For this type of feedback Eq. (1) becomes:

$$\alpha' = \frac{a}{1 + a R_P}$$

Current feedback is especially undesirable in power amplifiers for it tends to stabilize the output transformer's magnetizing current (i.e., make it sinusoidal), and thus produce a distorted output voltage.

Phase Inverter

The circuit in Fig. 4 represents a phase inverter network which utilizes feedback. Half the load resistance is in the plate circuit and the other half is in the cathode circuit, hence $\beta = -0.50$, $\alpha' = 2$ and $E_i = -E_0$. This is, apparently, quite a good circuit for phase inversion; however, if we examine it in the light of the above discussion we can see an interesting problem. Looking back into the plate circuit we see a current feedback arrangement and a high-impedance source. On the other hand, the cathode load sees a voltage feedback circuit and a low-impedance source; thus it is apparent that the network will not give perfect phase inversion. A pentode would give especially poor results in such a circuit; however, the writer has obtained satisfactory results by using a low-$\mu$ triode with a low value of load resistance in such an arrangement.

Load in Cathode Circuit

Figure 5 is an interesting application of voltage feedback. The entire load is placed in the cathode circuit, so that $\beta = -1$, and from Eq. (5) $R_F'$ very nearly equals $R_F/\mu$ or $1/G_m$. This circuit is useful where a very low source impedance is required, as for instance in certain video applications.

Conclusions

A significant fact to remember is that by using Eq. (5) and the circuits in Fig. 2 and Fig. 5 it is possible to match any tube to any load whose value is equal to or greater than $1/G_m$.

In reverse feedback reduces the gain of an amplifier of course, but this is no problem with present-day high-gain tubes, and the advantages of feedback offset this.

FIG. 4—Circuit using feedback for phase inversion

FIG. 5—Cathode-loaded circuit with extremely low source impedance
Significant features are reviewed. These include low power loss, high breakdown voltage, space economy, stable dielectric constant, low temperature coefficient, high efficiency, good dielectric strength, and self-healing capabilities.

Vacuum capacitors for 7500 peak voltage in 25 and 50 µf sizes are supplied by General Electric Co. in the style at the left. Applications for the same capacitances at 16,000 peak volts are filled by the type at the right. Size comparisons with air capacitors give these units ten-to-one advantage for the same voltage rating.

By HERBERT B. MICHAELSON
New York, N. Y.

IN MODERN RADIO and electronic apparatus, the conventional air capacitor is often suitable because its power losses are ordinarily so small as to be almost unmeasurable. However, both air and solid dielectrics have certain limitations, many of which can be obviated by the use of vacuum or gas-filled capacitors.

Vacuum Capacitors

Electrodes of vacuum capacitors are coaxial cylinders or bell-shaped plates sealed in evacuated glass envelopes, with leads brought out to metal end-cups. Capacitive edge effects are minimized by the coaxial construction, and, because electrostatic field strength has an essentially constant value at all points on the polished surfaces, a uniformly high breakdown voltage is achieved. Electrode spacing is of the order of 0.06 in., height of the cylindrical plate being less than an inch in a typical 50-µf unit.

Metal must be a type that will not give up occluded gases and thus reduce the high vacuum. Tantalum has been used successfully by some manufacturers.

Air pressure within a typical vacuum capacitor is as low as can be obtained by pumping alone—or less than one micron of mercury. When flashover occurs, the plates, as described by George H. Floyd, General Electric Co., have a tendency to clean up, rather than to corrode or become pitted, because of the extreme scarcity of oxygen and other gases within the envelope.

Fixed vacuum capacitors are available in sizes ranging from 3 to 250 µf, with ratings varying from 5,000 v to 35,000 v peak. In practice, these ratings are extended where necessary by use of series-parallel combinations, forming an unusually compact capacitor bank for very high voltages. A typical 50-µf unit has an overall length of 3-5/16 in., a diameter of 1-5 in., and a rating of 7,500 v peak. Manufacturers of vacuum capacitors include: Eitel-McCullough, General Electric, General Electronics, and Jennings Radio Mfg.

Electrical Characteristics

Breakdown of a gaseous dielectric does not occur until the potential is great enough to cause collision ionization. The breakdown rating of an air gap within a glass envelope decreases, as air is exhausted, until a certain barometric pressure is reached. Down to this point, the mean free electron path is being lengthened, and the mobility of gaseous ions is increasing aiding ionization. After this point, further exhaustion of air results in a sharp increase of dielectric strength because ionization is now actually hampered by a scarcity of gas molecules. Sparking potential then depends mostly upon the number of gas particles between the plates.

Figure 1 gives typical voltage breakdown curves of plane electrodes, spaced at 1 and 2 cm, at various air pressures. Voltage breakdown in a uniform field is actually a function of the product of gas pressure and plate spacing, as given by Paschen’s Law. However, this does not apply accur...
Vacuum Capacitors

...at very low or at very high pressures, where sparking potential depends on surface condition and material of the electrodes.

Minimum sparking-potential for 1 cm. spacing in air is 342 v. In other words, for any given electrode spacing, breakdown voltage will decrease as pressure is reduced, down to a certain point. When a breakdown voltage as low as 342 is reached, further reduction in pressure is not possible, to start sparking. The same is true for any electrode spacing, whether it be 1 mm., 10 cm., or 100 cm. The shape of the curve for a given spacing will, of course, vary, but the lowest point of any curve will be exactly 342 v., where the gas between electrodes is air. Minimum sparking potential for other gases is not identical with that of air.

Boiled down to its essential fact, the vacuum theory holds that a gas will ionize most readily when a certain number of gas molecules strike the electrodes. When the number of molecules, electrons collide too frequently with them, losing most of their speed, and thus never reaching the opposite plate.

Obviously, from Fig. 1, very high breakdown gradients can be reached with short electrode spacings and low atmospheric pressures. Millikan succeeded in obtaining breakdown ratings as high as 600,000 v. per mm. in high vacuum. Air at normal pressure (76 cm of mercury) and 25 deg. C is rated at about 3,000 v. per mm. (Townsend) assuming a uniform electrostatic field. Certain grades of good mica, 3 mm thick, are rated at 58,000 v. per mm.

Altitude Reduces Breakdown Voltage

As shown in Fig. 2, flashover ratings of air capacitors decrease with a rise in altitude. Also, an increase of humidity causes a thin film of moisture to form on the plates and spacing insulators of a typical air capacitor, thus appreciably affecting the flash-over voltage. This humidity-voltage variation may be as much as 7 percent in practice. Corona losses, too, become an important consideration as the decreasing breakdown rating approaches applied voltage in an
aircraft capacitor. Absence of internal corona and stability of voltage ratings make vacuum capacitors well suited to aircraft applications.

Where a capacitor has a solid dielectric such as mica, breakdown potential varies with the frequency of applied voltage, temperature of the material, moisture present, and thickness of dielectric. Somewhat irregular ratings are often the case at higher frequencies because of the difficulty about placing a solid dielectric in perfect contact with the plates—even under great pressure. Where high rf potentials are involved and where a small lumped capacitance is required, the vacuum unit is more satisfactory than most other types because of its smaller size and more stable breakdown rating.

**Power Loss Factors**

Dielectric of most capacitors has a dual or multiple nature, and no solid or liquid material is completely free from power loss. For example, in a typical mica capacitor, there is mica between the plates, and there is also some insulator such as a plastic or ceramic material in contact with the leads. The general effect of this outer insulator can usually be disregarded, except at ultrahigh frequencies or in devices of very small capacitance. In vacuum units, the glass envelope acts as an outer dielectric, but the area of contact with the end-caps is so small, and the dielectric path so long, that the effects of the glass are negligible. For all practical purposes, the high vacuum can be considered the sole dielectric, and the capacitor has an exceptionally high Q.

Power losses of solid and liquid insulators include those due to insulation resistance, dielectric absorption, and hysteresis. These losses are a function of frequency, rising sharply at very short wavelengths. Loss factor is probably the best criterion of the efficiency of a capacitor, and can be found by multiplying the dielectric constant by the power factor. Phase displacement due to the glass and high vacuum dielectrics of a vacuum capacitor is obviously very slight, resulting in a low loss angle and a correspondingly-low loss factor. Resistance of the plates and leads, skin effect, and eddy currents are other minor sources of power loss, but dielectric absorption and hysteresis losses in this kind of capacitor are approximately nil.

There is, then, an extremely high ratio of susceptance to conductance, because of low dielectric loss. The only other possibility of power loss would be a conduction current of an ionic character through the

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**FIG. 3.** Rise in breakdown potential with pressure increase in this curve results from greater opportunities for collision between a travelling electron and nitrogen molecules as more of them occupy a given space. This inhibits ionization.

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**Dispersión of internal elements is here illustrated for an early Johnson pressure capacitor. This type is described as partially variable. Diameter is 10 in. and the shell is thick-walled, seamless, and heavily copper plated.**

**Pressurized, gas-filled capacitors made by E. F. Johnson Co. follow a basic design. Fixed and variable units both have copper-plated, drawn-steel shells in 6-in. diam. Miter-gear drive serves on variable version shown here.**
Fluctuation of permittivity is not the only cause of frequency variation of capacitance, however. For example, typical variable air capacitors are relatively stable, but their capacitance is likely to be affected somewhat by atmospheric moisture, temperature changes, age and vibration. The dielectric constant of dry air at normal pressure is about 1.000559, and that of water, about 85. Thus, a slight increase of humidity will raise the capacitance of such a unit. The dielectric constant of the vacuum capacitor is probably very close to 1, and is materially unaffected by external factors.

Mechanical Structure

Certain types of vacuum capacitors are designed so that thermal expansion of the boro-silicate glass is the same as that of the metal end-cups which are iron-nickel-cobalt alloy. This careful matching of temperature coefficients prevents change of capacitance with temperature. Rugged, cylindrical-plate construction also leads to more stable values than those of clamped, parallel-plate, air units. These are usually subject to stresses in the insulating supports due to vibration, aging, or bending of plates.

Geometric capacitance is not identical with effective capacitance—the value actually used in practice. For example, equivalent series capacitance of an air, vacuum, or pressure unit is given by the equation

$$C_e = \frac{C}{1 - LC \omega^2}$$  \hspace{1cm} (1)

where $C$ is total geometric capacitance, $L$ is inductance of the plates and leads, and $\omega = 2\pi f$. From this it can be seen that plates and leads of the capacitor cause a rise in effective capacitance with increasing frequency. A good quality variable (Continued on page 320)

![Graph showing relationships between current, voltage, and frequency for ideal vacuum capacitors](image-url)
Beam Blanking

A three-tube electronic unit permits photographing a complete transient trace on a cathode-ray oscilloscope screen with high detail and no fogging. Arrival of transient trips a trigger circuit, releasing the blanked beam, and provides a dotted “Z” timing wave.

By WALTER RICHTER

Most modern cathode-ray tubes are provided with a grid by means of which it is possible to interrupt the electron beam producing the spot on the screen. Commercial oscilloscopes containing these tubes are provided with a control which applies a negative voltage to this control grid and makes it possible to interrupt the beam at will.

For the photography of transients, some of the instruments provide a so-called “single-sweep” feature. When the single-sweep circuit is put into operation, the beam is biased sufficiently so that the spot does not appear on the screen, but the starting of the transient or any desired tripping impulse is used to sweep the spot across the screen just once. This is a highly desirable addition, but there are two points which prove to be somewhat undesirable.

First, even with the beam biased so as not to strike the screen, there are scattered electrons striking the screen, leading to a reasonably strong background illumination. If for any reason the camera shutter has to be opened an appreciable time before the expected transient begins, an undesirable amount of fogging of the film takes place.

Secondly, if it is desired to obtain a picture of the complete transient, then it is of course necessary to adjust the rate of the single sweep to such a value that the time taken by one sweep is equal to the total time of the transient. The resulting oscillogram can therefore not be any longer than a single sweep. It is quite obvious that considerable detail of the transient may become lost in the picture due to the need of compressing it into a single sweep.

Suppose now that instead of only one, we permit five sweeps, with the rate of sweep adjusted to such a value that one sweep will take place in a time equal to one-fifth of the time of the transient, or in other words, the time of five sweeps will equal the duration of the transient. The oscillogram will then consist of five branches, each one representing one-fifth of the transient.

An example of a transient as it would appear with a single sweep appears in Fig. 1(a), while Fig. 1(b) shows this same transient spread over five sweeps. Corresponding segments in the two traces are similarly marked.

With the number of sweeps limited to a reasonable value, such as 5, there is usually no difficulty in piecing the individual branches properly to each other since the displacement from the zero line and the slope must be the same at the right and left hand edges of the oscillogram. The piecing together of the segments may be further facilitated by having enough brilliancy so that the return sweep produces a faint trace which then connects the proper branches with each other. It is
Circuit for Oscilloscopes

Film-eggging Problem

It is entirely feasible to obtain a result by designing an electronic circuit that will make the sweep reappear itself for a definite number of cycles, but this still does not remove the possibility of fogging. Therefore a more desirable situation would be one in which the sweep operates continuously, and the beam is released only for the desired exposure. In principle, this is a rather simple procedure; all one has to do is to keep the grid of the cathode-ray tube sufficiently negative to cause cut-off of the beam, and thus this negative bias is the proper value for the time of exposure.

From a practical point of view, however, there is a serious handicap standing in the way of an easy solution, due to the following condition: When operating a cathode-ray tube, the average potential of the deflection plates should be near the anode potential. This condition is ordinarily met by placing the anode of the cathode-ray tube or near ground potential, which in turn places the cathode at a negative potential amounting to a thousand volts or more with respect to ground. Since the grid must be made negative with respect to the cathode, this means that the operating potential of the grid is also one to several thousand volts negative with respect to ground.

Insulating Problems

With this in mind, it is clear that the problem of shifting the grid potential with respect to the cathode by 100 volts or so is not too easy. One could install a relay, the coil of which would be insulated sufficiently from the contact structure and by means of which the grid voltage could be shifted from one value to another, but any mechanical device of this nature with its mechanical and electrical inertia and the possibility of bouncing contacts is practically ruled out.

The circuit described in the following paragraphs is nothing but a trigger circuit which can be tripped by an impulse transmitted through a capacitor to the proper point in the circuit. The whole trigger circuit and its power supply is insulated from ground for a voltage equal to the operating voltage of the cathode-ray tube. The components are mounted on an insulating panel or on a steel chassis which in turn is insulated from its housing or from the chassis of the oscilloscope.

The only special component needed is a power transformer for the trigger circuit, the primary winding of which is insulated from the core and the other windings for a voltage equal to the operating voltage of the cathode-ray tube. If such a transformer is not available, a 1:1 insulating transformer may be employed which permits the use of any standard small power transformer for the trigger circuit.

Provisions are also made to apply a dotting or "Z" signal to the grid of the cathode-ray tube. The circuit is so arranged that dotting and tripping do not interfere with each other.

Operation of Trigger Circuit

Figure 2 shows the diagram of the complete circuit. The tripping circuit consists of a double triode, VT, which with its associated resistors $R_1$, $R_2$, $R_3$, and $R'_2$ and $R'_3$ forms a trigger circuit. When one
aircraft capacitor. Absence of internal corona and stability of voltage ratings make vacuum capacitors well suited to aircraft applications.

Where a capacitor has a solid dielectric such as mica, breakdown potential varies with the frequency of applied voltage, temperature of the material, moisture present, and thickness of dielectric. Somewhat irregular ratings are often the case at higher frequencies because of the difficulty about placing a solid dielectric in perfect contact with the plates—even under great pressure. Where high rf potentials are involved and where a small lumped capacitance is required, the vacuum unit is more satisfactory than most other types because of its smaller size and more stable breakdown rating.

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**FIG. 3.** Rise in breakdown potential with pressure increase in this curve results from greater opportunities for collision between a travelling electron and nitrogen molecules as more of them occupy a given space. This inhibits ionization.
Fluctuation of permittivity is not the only cause of frequency variation of capacitance, however. For example, typical variable air capacitors are relatively stable, but their capacitance is likely to be affected somewhat by atmospheric moisture, temperature change, age and vibration. The dielectric constant of dry air at normal pressure is about 1.000658, and that of water, about 85. Thus, a slight increase of humidity will raise the capacitance of such a unit. The dielectric constant of the vacuum capacitor is probably very close to 1, and is materially unaffected by external factors.

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Geometric capacitance is not identical with effective capacitance—the value actually used in practice. For example, equivalent series capacitance of an air, vacuum, or pressure unit is given by the equation

$$C_e = \frac{C}{1 - \frac{1}{LC} \omega^2}$$

where $C$ is total geometric capacitance, $L$ is inductance of the plates and leads, and $\omega = 2\pi f$. From this it can be seen that plates and leads of the capacitor cause a rise in effective capacitance with increasing frequency. A good quality variable capacitor is shown in the accompanying illustration. Straight line passing through any two factors reveals the third.

Relationships between current, voltage, and frequency for 50μH vacuum capacitors of the types in an accompanying illustration are established for reference on this nomograph. Straight line passing through any two factors reveals the third.

(Continued on page 320)
Beam Blanking

A three-tube electronic unit permits photographing a complete transient trace on a cathode-ray oscilloscope screen with high detail and no fogging. Arrival of transient trips a trigger circuit, releasing the blanked beam, and provides a dotted "Z" timing wave.

By WALTHER RICHTER
Alle-Chainers Manufacturing Co.,
Milwaukee, Wisc.

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For the photography of transients, some of the instruments provide a so-called "single-sweep" feature. When the single-sweep circuit is put into operation, the beam is biased sufficiently so that the spot does not appear on the screen, but the starting of the transient or any desired tripping impulse is used to sweep the spot across the screen just once. This is a highly desirable addition, but there are two points which prove to be somewhat undesirable.

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**Insulating Problems**

With this in mind, it is clear that the problem of shifting the grid potential with respect to the cathode by 100 volts or so is not too easy. One could install a relay, the coil of which would be insulated sufficiently from the contact structure and by means of which the grid voltage could be shifted from one value to another, but any mechanical device of this nature with its mechanical and electrical inertia and the possibility of bouncing contacts is practically ruled out.

The circuit described in the following paragraphs is nothing but a trigger circuit which can be tripped by an impulse transmitted through a capacitor to the proper point in the circuit. The whole trigger circuit and its power supply is insulated from ground for a voltage equal to the operating voltage of the cathode-ray tube. The components are mounted on an insulating panel or on a steel chassis which in turn is insulated from its housing or from the chassis of the oscilloscope.

The only special component needed is a power transformer for the trigger circuit, the primary winding of which is insulated from the core and the other windings for a voltage equal to the operating voltage of the cathode-ray tube. If such a transformer is not available, a 1:1 insulating transformer may be employed which permits the use of any standard small power transformer for the trigger circuit.

Provisions are also made to apply a dotting or "Z" signal to the grid of the cathode-ray tube. The circuit is so arranged that dotting and tripping do not interfere with each other.

**Operation of Trigger Circuit**

Figure 2 shows the diagram of the complete circuit. The tripping circuit consists of a double triode, \( VT \), which with its associated resistors \( R_1, R_2, R_3 \), and \( R'_1, R'_2 \) and \( R'_3 \) forms a trigger circuit. When one
aircraft capacitor. Absence of internal corona and stability of voltage ratings make vacuum capacitors well suited to aircraft applications.

Where a capacitor has a solid dielectric such as mica, breakdown potential varies with the frequency of applied voltage, temperature of the material, moisture present, and thickness of dielectric. Somewhat irregular ratings are often the case at higher frequencies because of the difficulty about placing a solid dielectric in perfect contact with the plates—even under great pressure. Where high rf potentials are involved and where a small lumped capacitance is required, the vacuum unit is more satisfactory than most other types because of its smaller size and more stable breakdown rating.

Power Loss Factors

Dielectric of most capacitors has a dual or multiple nature, and no solid or liquid material is completely free from power loss. For example, in a typical mica capacitor, there is mica between the plates, and there is also some insulator such as a plastic or ceramic material in contact with the leads. The general effect of this outer insulator can usually be disregarded, except at ultrahigh frequencies or in devices of very small capacitance. In vacuum units, the glass envelope acts as an outer dielectric, but the area of contact with the end-cups is so small, and the dielectric path so long, that the effects of the glass are negligible. For all practical purposes, the high vacuum can be considered the sole dielectric, and the capacitor has an exceptionally high Q.

Power losses of solid and liquid insulators include those due to insulation resistance, dielectric absorption, and hysteresis. These losses are a function of frequency, rising sharply at very short wavelengths. Loss factor is probably the best criterion of the efficiency of a capacitor, and can be found by multiplying the dielectric constant by the power factor. Phase displacement due to the glass and high vacuum dielectrics of a vacuum capacitor is obviously very slight, resulting in a low loss angle and a correspondingly-low loss factor. Resistance of the plates and leads, skin effect, and eddy currents are other minor sources of power loss, but dielectric absorption and hysteresis losses in this kind of capacitor are approximately nil.

There is, then, an extremely high ratio of susceptibility to conductance, because of low dielectric loss. The only other possibility of power loss would be a conduction current of an ionic character through the

![Image of capacitors](https://example.com/capacitors.jpg)

Pressurized, gas-filled capacitors made by E. F. Johnson Co. follow a basic design. Fixed and variable units both have copper-plated, drawn-steel shells in 8-in. diam. Miter-gear drive serves on variable version shown here

Disposition of internal elements is here illustrated for an early Johnson pressure capacitor. This type is described as partially variable. Diameter is 10 in. and the shell is thick-walled, seamless and heavily copper plated.

![Graph](https://example.com/breakdown_potential.png)

**FIG. 3.** Rise in breakdown potential with pressure increase in this curve results from greater opportunities for collision between a travelling electron and nitrogen molecules as more of them occupy a given space. This inhibits ionization.

ELECTRONICS  September 1944
Fluctuation of permittivity is not the only cause of frequency variation of capacitance, however. For example, typical variable air capacitors are relatively stable, but their capacitance is likely to be affected somewhat by atmospheric moisture, temperature change, age and vibration. The dielectric constant of dry air at normal pressure is about 1.000658,* and that of water, about 85. Thus, a slight increase of humidity will raise the capacitance of such a unit. The dielectric constant of the vacuum capacitor is probably very close to 1, and is materially unaffected by external factors.

Mechanical Structure

Certain types of vacuum capacitors are designed so that thermal expansion of the boro-silicate glass is the same as that of the metal end-cups which are iron-nickel-cobalt alloy. This careful matching of temperature coefficients prevents change of capacitance with temperature. Rugged, cylindrical-plate construction also leads to more stable values than those of clamped, parallel-plate, air units. These are usually subject to stresses in the insulating supports due to vibration, aging, or bending of plates.

Geometric capacitance is not identical with effective capacitance—the value actually used in practice. For example, equivalent series capacitance of an air, vacuum, or pressure unit is given by the equation

\[
C_e = \frac{C}{1 - LC\omega^2}
\]

(1)

where \(C\) is total geometric capacitance, \(L\) is inductance of the plates and leads, and \(\omega = 2\pi f\). From this it can be seen that plates and leads of the capacitor cause a rise in effective capacitance with increasing frequency. A good quality variable

(Continued on page 320)

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![Graph](image-url)
aircraft capacitor. Absence of internal corona and stability of voltage ratings make vacuum capacitors well suited to aircraft applications.

Where a capacitor has a solid dielectric such as mica, breakdown potential varies with the frequency of applied voltage, temperature of the material, moisture present, and thickness of dielectric. Somewhat irregular ratings are often the case at higher frequencies because of the difficulty about placing a solid dielectric in perfect contact with the plates—even under great pressure. Where high rf potentials are involved and where a small lumped capacitance is required, the vacuum unit is more satisfactory than most other types because of its smaller size and more stable breakdown rating.

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**FIG. 3.** Rise in breakdown potential with pressure increase in this curve results from greater opportunities for collision between a travelling electron and nitrogen molecules as more of them occupy a given space. This inhibits ionization.
Fluctuation of permittivity is not the only cause of frequency variation of capacitance, however. For example, typical variable air capacitors are relatively stable, but their capacitance is likely to be affected somewhat by atmospheric moisture, temperature change, age and vibration. The dielectric constant of dry air at normal pressure is about 1.000558, and that of water, about 85. Thus, a slight increase of humidity will raise the capacitance of such a unit. The dielectric constant of the vacuum capacitor is probably very close to 1, and is materially unaffected by external factors.

**Mechanical Structure**

Certain types of vacuum capacitors are designed so that thermal expansion of the boro-silicate glass is the same as that of the metal end-cups which are iron-nickel-cobalt alloy. This careful matching of temperature coefficients prevents change of capacitance with temperature. Rugged, cylindrical-plate construction also leads to more stable values than those of clamped, parallel-plate, air units. These are usually subject to stresses in the insulating supports due to vibration, aging, or bending of plates.

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where $C$ is total geometric capacitance, $L$ is inductance of the plates and leads, and $\omega = 2\pi f$. From this it can be seen that plates and leads of the capacitor cause a rise in effective capacitance with increasing frequency. A good quality variable capacitor (Continued on page 320)

![Diagram](image)

**Table:**

<table>
<thead>
<tr>
<th>Current (Amps-Peak)</th>
<th>Current (Amps-RMS)</th>
<th>Voltage (Volts-Peak)</th>
<th>Voltage (Volts-RMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>15</td>
<td>3,000</td>
<td>2,000</td>
</tr>
<tr>
<td>15</td>
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<tr>
<td>15</td>
<td>15</td>
<td>3,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

Relationships between current, voltage, and frequency for 50μfd vacuum capacitors of the type in an accompanying illustration are established for reference on this nomograph. Straight line passing through any two factors reveals the third
aircraft capacitor. Absence of internal corona and stability of voltage ratings make vacuum capacitors well suited to aircraft applications.

Where a capacitor has a solid dielectric such as mica, breakdown potential varies with the frequency of applied voltage, temperature of the material, moisture present, and thickness of dielectric. Somewhat irregular ratings are often the case at higher frequencies because of the difficulty about placing a solid dielectric in perfect contact with the plates—even under great pressure. Where high rf potentials are involved and where a small lumped capacitance is required, the vacuum unit is more satisfactory than most other types because of its smaller size and more stable breakdown rating.

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Pressure increase / Breakdown potential

<table>
<thead>
<tr>
<th>Pressure (Lb/ sq in)</th>
<th>Breakdown Potential (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>30</td>
<td>25</td>
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<td>80</td>
<td>50</td>
</tr>
<tr>
<td>90</td>
<td>55</td>
</tr>
</tbody>
</table>

FIG. 3. Rise in breakdown potential with pressure increase in this curve results from greater opportunities for collision between a travelling electron and nitrogen molecules as more of them occupy a given space. This inhibits ionization.

\[ \text{Pressure in Lb/ sq in} \quad \rightarrow \quad \text{Breakdown Potential in Kilovolts} \]

Disposition of internal elements is here illustrated for an early Johnson pressure capacitor. This type is described as partially variable. Diameter is 18 in. and the shell is thick-walled, seamless, and heavily copper plated. The capacitance is a multiple of 100-

Values of very small capacitance. In vacuum units, the glass envelope acts as an outer dielectric, but the area of contact with the end-cups is so small, and the dielectric path so long, that the effects of the glass are negligible. For all practical purposes, the high vacuum can be considered the sole dielectric, and the capacitor has an exceptionally high Q.

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Beam Blanking

A three-tube electronic unit permits photographing a complete transient trace on a cathode-ray oscilloscope screen with high detail and no fogging. Arrival of transient trips a trigger circuit, releasing the blanked beam, and provides a dotted "Z" timing wave.

By WALther RICHTER
Allen-Chatmers Manufacturing Co.,
Milwaukee, Wisc.

Most modern cathode-ray tubes are provided with a grid by means of which it is possible to interrupt the electron beam producing the spot on the screen. Commercial oscilloscopes containing these tubes are provided with a control which applies a negative voltage to this control grid and makes it possible to interrupt the beam at will.

For the photography of transients, some of the instruments provide a so-called "single-sweep" feature. When the single-sweep circuit is put into operation, the beam is biased sufficiently so that the spot does not appear on the screen, but the starting of the transient or any desired tripping impulse is used to sweep the spot across the screen just once. This is a highly desirable addition, but there are two points which prove to be somewhat undesirable.

First, even with the beam biased so as not to strike the screen, there are scattered electrons striking the screen, leading to a reasonably strong background illumination. If for any reason the camera shutter has to be opened an appreciable time before the expected transient begins, an undesirable amount of fogging of the film takes place.

Secondly, if it is desired to obtain a picture of the complete transient, then it is of course necessary to adjust the rate of the single sweep to such a value that the time taken by one sweep is equal to the total time of the transient. The resulting oscillogram can therefore not be any longer than a single sweep. It is quite obvious that considerable detail of the transient may become lost in the picture due to the need of compressing it into a single sweep.

Suppose now that instead of only one, we permit five sweeps, with the rate of sweep adjusted to such a value that one sweep will take place in a time equal to one-fifth of the time of the transient, or in other words, the time of five sweeps will equal the duration of the transient. The oscillogram will then consist of five branches, each one representing one-fifth of the transient.

An example of a transient as it would appear with a single sweep appears in Fig. 1(a), while Fig. 1(b) shows this same transient spread over five sweeps. Corresponding segments in the two traces are similarly marked.

With the number of sweeps limited to a reasonable value, such as 5, there is usually no difficulty in piecing the individual branches properly to each other since the displacement from the zero line and the slope must be the same at the right and left hand edges of the oscillogram. The piecing together of the segments may be further facilitated by having enough brilliancy so that the return sweep produces a faint trace which then connects the proper branches with each other. It is
Circuit for Oscilloscopes

Film-Fogging Problem

It is entirely feasible to obtain a result by designing an electronic circuit that will make the beam repeat itself for a definite number of cycles, but this still does not remove the possibility of fogging. Therefore a more desirable action would be one in which the tube operates continuously, and the beam is released only for the first exposure. In principle, this is rather simple procedure; all that has to do is to keep the grid of the cathode-ray tube sufficiently negative to cause cut-off of the anode, and reduce this negative bias to the proper value for the time of exposure.

From a practical point of view, however, there is a serious handicap standing in the way of an easy solution, due to the following condition: when operating a cathode-ray tube, the average potential of the deflection plates should be greater than the anode potential. This condition is ordinarily met by placing the anode of the cathode-ray tube near ground potential, which in turn places the cathode at a negative potential amounting to a thousand volts or more with respect to ground. Since the grid must be made negative with respect to the cathode, this means that the operating potential of the grid is also one to several thousand volts negative with respect to ground.

Insulating Problems

With this in mind, it is clear that the problem of shifting the grid potential with respect to the cathode by 100 volts or so is not too easy. One could install a relay, the coil of which would be insulated sufficiently from the chassis by means of mechanical means, but any mechanical device of this nature with its mechanical and electrical inertia and the possibility of bouncing contacts is practically ruled out.

The circuit described in the following paragraphs is nothing but a trigger circuit which can be tripped by an impulse transmitted through a capacitor to the proper point in the circuit. The whole trigger circuit and its power supply is insulating from ground for a voltage equal to the operating voltage of the cathode-ray tube. The components are mounted on an insulated panel or on a steel chassis which in turn is insulated from its housing or from the chassis of the oscilloscope.

The only special component needed is a power transformer for the trigger circuit, the primary winding of which is insulated from the core and the other windings for a voltage equal to the operating voltage of the cathode-ray tube. If such a transformer is not available, a 1:1 insulating transformer may be employed which permits the use of any standard small power transformer for the trigger circuit.

Provisions are also made to apply a dotting or "Z" signal to the grid of the cathode-ray tube. The circuit is so arranged that dotting and tripping do not interfere with each other.

Operation of Trigger Circuit

Figure 2 shows the diagram of the complete circuit. The tripping circuit consists of a double triode, VT,, with its associated resistors R,, R,, R,, and R,, R, and R, forms a trigger circuit. When one
section of the tube is conducting, the other section is automatically biased to cut-off. Consequently, either one or the other section is conducting, but never both at the same time. An impulse transmitted to the grid of one section, in such a direction as to change the state in which it is at that instant, will therefore cause the circuit to go from one condition to the other.

One of the sections of VT, designated as a, performs the desired control action on the grid of the cathode-ray tube. This is accomplished in the following manner: when left-hand section a is non-conducting, the drop across the plate resistor \( R_p \) is small, since the only current flow through it is due to the current flowing through the high resistances \( R_a \) and \( R_p \). Point A will therefore be only a few volts negative with respect to the positive end of the power supply. The cathode of one section of the double diode \( V_T \) is connected to point A. The anode of this section is connected through resistor \( R_p \) to point D on potential divider \( R_a \), which is adjusted so that D is negative with respect to point A as long as tube section a is non-conducting. Consequently, no current flows through \( R_p \) and the potential of the grid of the cathode-ray tube with respect to the cathode is simply determined by the position of the arm on \( R_p \). This permits manual adjustment of the grid voltage on the cathode-ray tube to give any desired brilliancy, or to blank the beam if so desired.

If section a of \( V_T \) is made conducting, however, the plate current will cause a large voltage drop across the plate resistor \( R_p \). This makes point A negative with respect to point D, and consequently there will be a flow of current established through the right-hand section of double diode \( V_T \). Current flow is in the direction from point D through the diode to point A and is therefore such as to increase the grid bias of the cathode-ray tube over and above any value to which it may have been adjusted by the slider of \( R_p \). Consequently, by triggering the double triode from one condition to the other, a release or blanking of the beam may be obtained. The tripping impulse may be administered to the grid of either section. A negative impulse administered to the grid of section a, or a positive impulse administered to the grid of section b will make section a nonconducting and thus release the beam. Impulses to the opposite polarity will correspondingly blank the beam again.

**Production of Dotting Signal**

The left-hand section of the double diode is used to provide the "Z" or dotting signal. It is seen that the application of the proper type of signal (preferably a square-wave shape in order to avoid defocussing during the duration of the dot) through blocking capacitor \( C \), causes an alternating current to flow through resistor \( R_p \) which, during its negative half-wave, will cause a current flow through the left-hand section of the double diode, thus periodically biasing the grid of the cathode-ray tube.

It should be noted that blanking and releasing require only one impulse and not the maintaining of a certain voltage during the time that the beam is to be released.

The complete equipment can be made as a separate device which can be used with any oscilloscope of which the cathode and grid terminals have been brought out, or can be permanently incorporated in one of the oscilloscopes available on the market.
REMOTE MONITOR
or Directional Broadcasting

Direct measurement of the null point in the radiation pattern from a directional antenna system is accomplished with a modified receiver which gives a continuous microammeter reading at the transmitter.

By M. A. O'BRADOVICK  
Transmitter Supervisor  
Station KMPC  
North Hollywood, Calif.

REATURE USE of directional antenna systems by broadcast stations has increased the importance of means for measuring and indicating a check on the radiation patterns. Instruments for indicating a null in the several elements of directional arrays have been specially devised for the purpose and installed in as permanent parts of the transmitters. This makes possible means by which the desired null is produced, but is not a direct check on the radiation pattern itself, or what is of most importance, the strength of the signal radiated in the minimum signal or null-point direction.

A means of checking signal intensity directly provides an indication of the signal radiated toward the channel-sharing station with which interference must be avoided.

Unit in Continuous Service

Among the first examples of a signal-monitoring system of this type is one installed for the 10 kw transmitter of KMPC, North Hollywood, Calif, the last of this power to be installed before the war. Operating on 710 kc, KMPC shares the channel with KIRO, Seattle, Wash., 960 miles away.

At a distance of 1½ miles from the three 300 ft towers which make up the directional array, a simple type of monitoring receiver is installed on a 25 ft pole, surmounted by a loop antenna. The receiver operates continuously, energized from a 115-v line on the pole. The dc developed in the diode detector of the receiver is sent over a telephone line back to the transmitter, where it actuates a microammeter on the operator's console.

Steady deflection of this meter affords a constant and directly

(Continued on page 270)
Advantages over tuned interstage transformers in wide-band r-f and video amplifiers are discussed, performance is analyzed, expressions are set up for total voltage gain, bandwidth and skirt steepness ratio, and design curves are given for band widths up to 5 Mc.

By C. T. McCOMB and A. P. GREEN

Naval Research Laboratory
Washington, D. C.

OF THE MANY METHODS of coupling between stages of tuned amplifiers, probably the simplest is the common single-inductor coupling network. While the single inductor does not possess the versatility of the tuned transformer or of other more elaborate coupling networks, neither does it entail the complexity of design, manufacture, and alignment of other types of coupling.

Consideration of the characteristics of the single-inductor coupling network is made under conditions where the center frequency and bandwidth requirements are such that the single inductor exhibits its most useful features. The scope of application for this treatment of the single inductor is limited by only a few basic restrictions. In Fig. 1 is shown a schematic circuit for use of the single inductor in a coupling network. Variations of this circuit are of course possible, but they will not change the basic behavior of the network.

Figure 2 gives the fundamental equivalent network involving the inductor. The output capacitance of the preceding tube, the input capacitance of the following tube, and the distributed capacitance of the inductor and circuit are considered as a single shunt capacitor with respect to the inductor in the equivalent circuit.

In the analysis of the network, it
assumed as a first restriction that the inductor has a sufficiently high additional resistance so that its effective inherent resistance is large compared to the size of the damping resistor in the coupling network. As a second restriction, the plate resistance of the preceding tube is considered to be very large compared to the damping resistor. The first restriction is merely for purposes of analysis so that the damping action in the network can be considered as being due solely to a small shunt resistor. The second restriction limits the use of the analysis to those applications where the bandwidth requirements are small compared to the effective plate resistance of the tube. This last condition does not place a severe limitation on the usefulness of this work, because the great majority of all modulation applications will be beyond this range.

Total Voltage Gain for N Stages

An examination of the equivalent circuit of Fig. 2 shows that the voltage gain for a single stage is given by the expression

$$ V.G. = \frac{e_1}{e_0} = \frac{\omega C R_0}{R_f + Z} $$

with the above-discussed second restriction that $R$ is small compared to $R_0$, and since $Z$ can never be greater than $R$, then for this treatment $Z$ will be small compared to $R_0$ and we will have for one stage of amplification

$$ V.G. = \frac{e_1}{e_0} = \frac{\omega C R_0}{R_f + Z} $$

For $N$ identical stages, as in Fig. 3, the total gain at any frequency, $\Gamma_f$, will be

$$ \Gamma_f = (g_m Z)^N $$

From the equivalent circuit, $Z$ can be expressed by

$$ Z = \frac{1}{R_f + j \left( \omega C - \frac{1}{\omega L} \right)} $$

It is apparent that $Z$ is a maximum and equals $R$ when $\omega C = 1/\omega L$. If we let $\omega = \omega_c$ when $Z = R$ (at resonance), then $\omega C = 1/\omega L$ or $L = 1/\omega^2 C$, we have

$$ Z = \frac{1}{R_f + j \left( \omega C - \frac{1}{\omega L} \right)} $$

and the total gain will be

$$ \Gamma_f = (g_m Z)^N $$

At resonance,

$$ \Gamma_f = (g_m R)^N $$

FIG. 3—Use of single-inductor coupling networks (represented by equivalent impedance $Z$) in $N$ identical stages

FIG. 4—Voltage response characteristic of an amplifier stage using a single-inductor coupling network, showing significance of bandwidth for any specific value of relative voltage response off the resonant frequency
We can now advantageously express the total voltage gain at any frequency as a fraction, \( g \), of the total voltage gain at resonance, thus:

\[
\Gamma_f = \frac{1}{\frac{1}{R} + \left( \frac{\omega C - \omega_0^2}{\omega} \right)^N} \quad (1.23)
\]

With this expression for the total voltage gain at any frequency expressed as a function of some of the known constants of the network and the determinable factor, \( g \), we have a useful means for predicting the behavior of any single-inductor type tuned amplifier.

### General Bandwidth for \( N \) Stages

Since the total gain and the bandwidth are the two basic requirements for any tuned amplifier, it is necessary that an expression be obtained relating these quantities to the known constants of the network.

From Eq. (1.21) and (1.23) for total voltage gain,

\[
\Gamma_f = \frac{1}{\frac{1}{R} + \left( \frac{\omega C - \omega_0^2}{\omega} \right)^N} \quad (2.10)
\]

We are interested only in the magnitude of the impedance at any frequency so we may reduce the complex expression on the right to a real number and cancel out \( g_0 \), thus

\[
\alpha R^N = \left[ \frac{1}{\frac{1}{R} + \left( \frac{\omega C - \omega_0^2}{\omega} \right)^N} \right] \quad (2.20)
\]

Taking the \( N \)/2th root of the expression, we have

\[
\alpha \frac{1}{R} = \left[ \frac{1}{\frac{1}{R} + \left( \frac{\omega C - \omega_0^2}{\omega} \right)^N} \right] \quad (2.21)
\]

Rearranging terms results in the relation

\[
\left( \omega^2 - \omega_0^2 \right)^2 = \frac{\omega^2 \left( 1 - \alpha^{2/N} \right)}{\alpha^{2/N} RC} \quad (2.22)
\]

and since \( \omega = 2\pi f \) we can write

\[
f^2 - f_0^2 = \left( f_0 + f \right) \sqrt{\frac{1 - \alpha^{2/N}}{2\pi \alpha^{2/N} RC}} \quad (2.23)
\]

Then, since \( f_0^2 - f^2 = (f_0 + f)(f_0 - f) \),

\[
\Delta f = \sqrt{\frac{1 - \alpha^{2/N}}{2\pi \alpha^{2/N} RC}} \quad (2.30)
\]

For convenience of analysis, this expression for general bandwidth can be given most simply as

\[
\Delta f = \frac{\sqrt{1 - \alpha^{2/N} - 1}}{2\pi RC} \quad (2.31)
\]

This relationship shows the functional variation of the bandwidth of the amplifier with respect to the circuit constants and the relative voltage response ratio at which the bandwidth is considered. It shows that if \( R \) and \( C \) are fixed, both the bandwidth at any given relative response, \( g \), and the total voltage gain (since \( \Gamma_f = g \left( \frac{\omega_0}{\omega} \right)^N \)) will remain constant regardless of the value of the inductance, \( L \), employed. Thus it is seen that any inductance variation will change only the resonant frequency and will have no effect on the bandwidth or total gain.

An important relationship exists between the high and low frequencies, \( f_1 \) and \( f_2 \), for any relative response, \( g \), and the resonant frequency, \( f_0 \), of the coupling network. Dividing Eq. (2.25) by (2.26), we obtain

\[
f_2^3 - f_1^3 = \frac{f_0^3}{f_1^3} = \frac{f_1^3}{f_0^3} \quad (3.10)
\]

Solving this for \( f_0^3 \) gives

\[
f_0^3 = f_1 f_2 \quad (3.11)
\]

This establishes the well-known formulation that the resonant frequency is the geometric mean of the high and low response frequencies at any relative response of the amplifier. It follows that the response of an amplifier is thus geometric with respect to its resonant frequency, and a linear frequency plot of the amplifier characteristic will appear asymmetrical. For this reason a logarithmic frequency scale is usually employed so that the characteristic will appear symmetrical.

### Skirt Steepness Ratio

An interesting characteristic of the behavior of \( N \) stages of a single-inductor coupling network can be drawn from a consideration of the expression in Eq. (2.31) for \( \Delta f \). The quality of an amplifier is partially determined by its response to near signals relative to its desired bandwidth response. This characteristic is important in the signal-to-noise ratio of the amplifier since the total area under the response curve contributes to noise energy.
ile only an area proportional to signal bandwidth contributes to signal energy. This degree of lity is expressed as a factor, the steepness $S$, which is defined as the ratio of the bandwidth at 0 db response to the bandwidth -6 db response. This ratio is 1 to be an inverse index of the lity of rejection of the amplifier in that as the ratio becomes smaller, the response to near signal will be less. From Eq. 2.31 for and since for -60 db response 0.001 and for -6 db response 0.5, we have

$$\Delta f_{\text{max}} = \frac{1}{S}$$

(4.10)

It is seen from this expression that the skirt steepness is depending upon the number of stages not upon any of the other characteristics of the amplifier. The $S$, for amplifiers of from one up to eight stages is given in 5, along with representative response characteristics of amplifiers with different numbers of stages. A logarithmic frequency $\nu$ is used as discussed above in to obtain symmetrical curves. A three response characteristics printed are all down 6 db at a width of 2 Mc with a center frequency of 30 Mc. The difference seen the characteristics is due the number of stages used in.

is seen that a very great improvement in skirt steepness is obtained in going from one stage to greater number of stages. The more desirable characteristic is the response of the skirt steepness pare to that of two stages is evident from the curves. This rapid increase in the rejection of harmonics signals is so pronounced that may applications the use of additional stages will be justified even though the required total gain could be obtained with a fewer number of stages.

Effective Bandwidth for $N$ Stages

The effective bandwidth of a resonant response characteristic of the area equal to its total integrated power response. In order to apply this definition it is necessary to treat the power gain of $N$ stages. This is proportional to the square of the total voltage gain. From Eq. (1.22) for $\Gamma_r$, we can write for the power gain at resonance:

$$\text{Total power gain at } f_0 = P_{f_0} = K \Gamma_r^2$$

(5.10)

where $K$ is the impedance proportionality constant for the particular general circuit under consideration. From this we have, in a manner similar to Eq. (1.23),

$$\text{Total power gain at } f = P_f = \beta P_{f_0}$$

(5.11)

where $\beta$ is the fractional power response factor of the total power gain at resonance. It is seen that $\beta$ is the factor corresponding to $\alpha$ in Eq. (1.23) for voltage response.

Since we are interested in obtaining a relationship in terms of the maximum power response and the bandwidth, we can write

$$K \beta (\omega_0 R)^{N} = \frac{1}{R \left( \omega_0 C - \frac{\omega_0^2 C}{\omega} \right)^N}$$

(5.20)

This becomes

$$\beta R^{N} = \frac{1}{R + j \left( \omega C - \frac{\omega^2 C}{\omega} \right)^N}$$

(5.21)

Reducing the right side of the expression to a real number, since we are interested only in the absolute magnitude, and taking the square root of both sides of the equation gives

$$\beta R^{N} = \frac{1}{R + \left( \omega C - \frac{\omega^2 C}{\omega} \right)^N}$$

(5.22)

Comparison of this form of the equation with the similar form obtained in the consideration of general bandwidth in Eq. (2.20), gives us immediately the form of the solution. We see that $\alpha$ in Eq. (2.20) will be replaced by $\beta^N$. Using the notation $\Delta f_r$ to indicate the bandwidth with respect to the power response curve, we have

$$\Delta f_r = \sqrt{\frac{1}{\beta^N R^2}} - 1$$

(5.30)

This equation now gives the necessary expression for completing the evaluation of the effective bandwidth. We may now write the defining integral for the total area under the power response curve. We shall take the equation for $\Delta f_r$, which is the expressed bandwidth at any relative response $P_r$, and integrate with respect to $dP_r$ over the range of zero to $P_r$, which is the maximum power response. This will give the total area under the curve, an example of which is given in Fig. 6.

Area under power curve = \int_{0}^{P_r} P_r \Delta f_r dP_r

(5.40)

Applying the definition for effective bandwidth and noting it as $\Delta_{en}$, we can write

$$\Delta_{en} \Delta f_r dP_r$$

(5.50)

Using Eq. (5.10), (5.11), and (5.30), we can substitute in Eq. (5.50) as follows:

$$\Delta_{en} = \int_{0}^{P_r} \frac{P_r}{\beta^N R^2} - d_K \beta (\omega_0 R)^N$$

(5.51)

Noting in Eq. (5.51) that the variable of relative response is $\beta$, we can perform the indicated differentiation, simplify the expression, and evaluate the new limits of integration for $\beta$. This gives

$$\Delta_{en} = \int_{0}^{P_r} \frac{1}{\beta^N R^2} - 1$$

(5.52)

which is the definite integral expression for the effective bandwidth.

The above equation does not lend itself readily to integration, so we shall use a convenient substitution to reduce the expression to an easily integrated form. Letting $\beta = \cos \phi$,

$$d\beta = - 2N \cos \phi \sin \phi d\phi$$

and the equation becomes

$$\Delta_{en} = \int_{0}^{P_r} \frac{1}{\beta^N R^2} - 1$$

(5.53)

FIG. 6.—Example of power response characteristic the area of which is utilized in determining the effective bandwidth of a stage using a single-inductor coupling network.

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\[
\Delta f_s = -\frac{N}{\pi RC} \int_0^\pi \sin^2 \phi \cos \left(\frac{(N-1) \phi}{2}\right) d\phi \quad (5.53)
\]

The solution of this integral is direct, but for ease of general expression it is necessary to exclude the case of the single-stage amplifier. For this case \(N = 1\) and the integral becomes

\[
\Delta f_s = \frac{1}{2RC} \int_0^\pi \sin^2 \phi \, d\phi \quad (5.54)
\]

The solution to this is immediate and for one stage we have

\[
\Delta f_s = 1/4RC \quad (5.55)
\]

For more than one stage, the solution of the expression is obtained in the form of a series product. This is because the integration of the \(N\)th power of a trigonometric function is a repeated integral of reduced power. The general solution for the effective bandwidth for more than one stage is

\[
\Delta f_s = \frac{N}{16 RC} \prod_{a=2}^{N-1} \left(\frac{a-1}{a+2}\right) \quad (5.56)
\]

The above expression is seen to give the effective bandwidth of the amplifier in terms of the number of stages and the circuit constants \(R\) and \(C\). The equation can be written

\[
\Delta f_s = A_s/RC \quad (5.57)
\]

where

\[
A_s = \frac{N}{16} \prod_{a=2}^{N-1} \left(\frac{a-1}{a+2}\right) \quad (5.60)
\]

Now we can evaluate \(A_s\) for any number of stages and tabulate it. Then for a particular amplifier, \(C\) will be fixed by the circuit layout and type of tube used, but \(R\) must be chosen to satisfy the bandwidth requirement.

Table I gives the value of \(A_s\) for amplifiers of from one to eight stages. This is seen to be extremely useful for the above-discussed application. Also tabulated in Table I are the values of \(A_s\), which is the constant of bandwidth from Eq. (2.31) for general bandwidth, in which bandwidth is taken as the \(-3\) db response width. For this case we have

\[
\Delta f = A_s/RC \quad (5.70)
\]

where

\[
A_s = \frac{1}{2\pi} \sqrt{\frac{1}{A_s^2 N^2} - 1} \quad (5.71)
\]

These values were computed directly by letting \(a = 0.707\) and evaluating \(A_s\) for values of \(N\) from one through eight.

An examination of the two columns in Table I shows that as the number of stages increases, the constants become more nearly equal. This consideration leads to a desirable fact concerning the \(-3\) db down from maximum response at the effective bandwidth of a curve.

Letting \(\Delta f_s\) equal \(\Delta f_r\), we can solve for the relative power response \(\beta\) at the effective bandwidth for any value of \(N\). From Eq. (5.30) and (5.57) we have

\[
\beta = \left[1 + \frac{1}{(2\pi A_s)^2}\right]^N \quad (5.80)
\]

The \(-3\) db down at the effective bandwidth, in terms of \(A_s\), for \(N\) stages, is then

\[
dB = 10N \log_{10} [1 + (2\pi A_s)^2] \quad (5.90)
\]

Table II gives the \(-3\) db down response of the amplifier characteristic at the effective bandwidth for one through eight stages. These values are in the anticipated agreement deduced from the values of Table I; that is, as the number of stages increases, the values of effective bandwidth and the \(-3\) db down characteristic become more nearly equal.

The above-considered characteristics of the behavior of the single-inductor coupling network all give valuable yet simple equations for obtaining the design constants of an amplifier for a given set of conditions.

**Composite Total Voltage Gain and Effective Bandwidth Behavior for \(N\) Stages**

A composite relationship can be obtained for the complete behavior of \(N\) stages of single-inductor networks in which the total voltage gain, \(\Gamma_r\), is functional with respect to the effective bandwidth, \(\Delta f_s\), and the element constants of the networks. This relationship gives the complete design requirements for any amplifier using the two fundamental requirements of total voltage gain and effective bandwidth desired.

From Eq. (1.22) for total gain and Eq. (5.57) for effective bandwidth, we have

\[
\Gamma_r = \left(\frac{g_m A_s}{\Delta f_s C}\right)^N \quad (6.10)
\]

We see that \(\Gamma_r\) is expressed in terms of the effective bandwidth desired, \(\Delta f_s\), the effective bandwidth constant \(A_s\) (which is known and constant for any number of stages), the \(g_m\) of the tube, and the capacitance of the circuit. Thus for some independently chosen value of \(g_m\) and with \(C\) fixed by the circuit layout and type of tube used, we have \(\Gamma_r\), expressible in terms of the bandwidth desired and the number of stages.

For purposes of generalization in order to compute the desired family of curves we will arbitrarily assign reasonable values to \(g_m\) and \(C\). Letting \(g_m = 5000\) \(\mu\)hos and \(C = 25\) \(\mu\)f, we have

\[
\Gamma_r = \left(\frac{200 A_s}{\Delta f_s}\right)^N \quad (6.11)
\]

where \(\Delta f_s\) is expressed in megacycles. Figure 7 is a plot of this equation over the entire practical range of application, with \(\Delta f_s\) covering from 0.5 to 6.5 megacycles and from one through eight stages considered. With this figure one can obtain immediately the number of stages required for a particular set of design requirements.

For any other values of \(g_m\) and \(C\) in an amplifier the total gain that will be obtained is

\[
\Gamma_r = \Gamma_r \left(\frac{g_m}{5000}\right)^C \quad (6.20)
\]
where 
\[ R_m = (g_m R_m)^{2/3} \quad (6.21) \]

Thus the family of curves given in Fig. 7 is perfectly general with the above equation.

With the desired total gain fixed on an amplifier and with the value of \( g_m \) established to obtain that gain with the determined number of stages, the necessary value of shunt resistance \( R_s \) is obtained from eq. (6.21) for \( R_m \) thus
\[ R_m = \frac{\Gamma_e}{\Gamma_m} \quad (6.30) \]

Example of Use of Design Curves

In order to demonstrate the extreme simplicity of application of the design curves given in Fig. 7 an example will be presented.

Assume that an amplifier is desired to have a total voltage gain of 10,000 and an effective bandwidth of 2.0 Mc. The resonant frequency is not involved in the determination of either the number of stages or the shunt resistor \( R_s \), as discussed above. First, observation of Fig. 7 shows that for the conditions required the amplifier function have either 4 or 5 stages, with variations in \( C \) and \( g_m \) fixing the final choice. Four stages gives insufficient gain for the operational conditions of \( C = 25 \mu\text{f} \) and \( g_m = 0.00 \mu\text{mhos} \) that were chosen for Fig. 7, while five stages gives too much gain for these conditions. Assuming that the circuit layout is such that we will have 22 \( \mu\text{f} \) capacitance instead of 25 \( \mu\text{f} \) and in Fig. 7, we see from the caption for \( \Gamma \), that this will raise the total gain.

Let us take the two cases of 4 and 5 stages and compute what the operating \( g_m \) and the required shunt resistor \( R_s \), will be for our problem. For 4 stages, from Fig. 7 we have
\[ R_m = 10,000 = 3720 \quad \left( \frac{g_m}{22} \right)^{2/3} \]

Solving, we have
\[ g_m = 5000 \times \frac{22}{25} \left( \frac{10,000}{15,100} \right)^{2/3} = 4055 \mu\text{hmos} \]

Therefore,
\[ R_m = \frac{10,000}{4055 \times 10^4} = 6.00 \mu\text{ohms} \]

We see that to get exactly the same values set down for the amplifier problem when four stages are used, the operating \( g_m \) of the tubes would be raised slightly above the value used in Fig. 7. Finding this value, we can compute the value of \( R_s \).

Now taking our amplifier to have five stages, we obtain from Fig. 7
\[ R_m = 10,000 = 15,100 \quad \left( \frac{g_m}{22} \right)^{2/3} \]

Solving, we have
\[ g_m = 5000 \times \frac{22}{25} \left( \frac{15,100}{10,000} \right)^{2/3} = 4055 \mu\text{hmos} \]

Therefore,
\[ R_m = \frac{10,000}{4055 \times 10^4} = 6.00 \mu\text{ohms} \]

For five stages we see that the operating \( g_m \) of the tubes is reduced below that assumed for Fig. 7. \( R_s \) is then computed as in the previous case using the new \( g_m \).

From the above solution to the problem we see that the curves of Fig. 7 are completely definitive of the behavior of the general single-inductor coupling network and that for any particular amplifier the consideration of only the capacitance \( C \) that will be involved in the circuit need be determined. Then the operating \( g_m \) for the tubes and the required value of \( R_s \) can be determined directly.

Fig. 7-Design curves for determining the number of amplifier stages required to meet a particular set of design requirements when using single-inductor coupling networks in wide-band amplifiers.
Impedance Measurements

This discussion describes the test equipment and procedures for determining capacitance and inductance, as well as the natural frequency, distributed capacitance, resistance, and Q of inductors, by oscilloscopic observation of square-wave decay rates. Results of actual measurements are given, showing accuracy.

INTEREST in square waves has centered around their utility in indicating the transient reaction and wide-band response of circuits. In addition, square waves can be used to measure impedances by the following method. It employs a minimum of calibrated equipment, is simple in circuit and operation, rapid and, with the precautions described below, is highly accurate.

Advantages of square waves for testing lie in their multiple-frequency content. For example, in determining resonant frequency of a circuit, square-wave response indicates where the resonant frequency lies irrespective of what square-wave test frequency is being used.

On the other hand, the sine-wave response of the circuit will not give an indication until the test frequency has been adjusted approximately to the resonant frequency. Where the resonant frequency is altogether unknown, positive indication obtained from a square wave of any frequency eliminates the time-consuming necessity of hunting for the unknown frequency as in sine-wave testing.

Apparatus Requirements

Equipment needed for square-wave impedance measurements includes a square-wave generator of known frequency, a calibrated or standard impedance, and a cathode-ray oscilloscope. Either the square-wave frequency or the calibrated impedance must be variable (preferably the frequency if it must be one and not the other), but the range over which measurements can be made is greatly extended if both are made variable. Output impedance of the square-wave generator should be at most one-tenth the smallest impedance to be measured. If it is not low enough a cathode follower can be added, as in Fig. 1. The input impedance of the oscilloscope should be at least ten times larger than the largest impedance to be measured. As will be shown, this impedance can be as high as the grid input of a vacuum tube. If inductance or capacitance is to be measured, the calibrated impedance is a resistance. To measure resistance a calibrated capacitor is the more useful although an inductor can be used if necessary.

Consider the circuit of Fig. 2(a). It can be shown by operational analysis that if the generator provides a square wave of frequency $F = 1/(2\pi RC)$, the voltage developed across $R$ is of the form in Fig. 2(b). This voltage across $R$ decays during a half cycle to 0.043 of its initial value. An oscilloscope across $R$ is used to observe this decay of resistor voltage.

When the square-wave frequency

![Image](https://example.com/image.png)

**FIG. 1 (left)—Cathode follower decreases output impedance of generator while impedance transformer increases input impedance of oscilloscope in the general set-up of equipment used for square-wave testing.**

![Image](https://example.com/image.png)

**FIG. 2 (right)—Circuit response to a square wave of frequency $1/(2\pi RC)$ follows the law $e^{-Rt/RC}$ decaying from an initial value of 100 percent to a final value of 4.3 percent as at (b). Without sweep the trace appears as in (c). Moving the trace off center (d) increases the accuracy.**

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September 1944 — ELECTRONICS
With Square Waves

G. 3—High-pass (a) and low-pass (b) circuit outputs and inputs are compared at square-wave frequencies of equal impedance and time-constant conditions.

Method, the time-constant repetition rate has an advantage. However, the amplitude of the initial output voltage, as well as the final decay value, changes rapidly with circuit changes—which is not the case if frequencies near the equal-impedance frequency are in use.

Aside from being a source of annoyance during adjustments—it can be compensated for by continuous manipulation of the oscilloscope gain—this is no drawback. As a matter of technique the equal-impedance method may be preferred; it is quicker. But for higher accuracy, justifiable only if the precautions described previously are observed, the time constant method is superior.

With a particular set of equipment, the two methods can be used interchangeably to extend the range over which measurements can be made. For example, if the high-frequency response of the equipment is limited and the calibrated resistance fixed, use of the time-

<table>
<thead>
<tr>
<th>Circuit</th>
<th>( f = \frac{1}{2\pi RC} )</th>
<th>( f = \frac{1}{2RC} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equal Impedance</td>
<td>Time constant</td>
</tr>
<tr>
<td>(a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If a calibrated capacitor is inserted in the circuit, the resistance can be measured by connecting the oscilloscope to the circuit, thereby taking full advantage of the screen size as illustrated in Fig. 2(d).

Less reliable results than the preceding method—doubtless because of this added complication. Inductance is given by \( L = R/(2\pi f) \).

### Time Constant Method

An alternative to the preceding is to use a square wave with a repetition period of \( 2T \) where \( T \) is the time constant of the RL or RC circuit under study. That is, the period of a half cycle of the square wave is adjusted to equal the time constant of the circuit, with the result that by the end of each half cycle the output wave has fallen to 36.8 percent of its initial value. See Fig. 3(a). Capacitance is given by \( C = 1/(2\pi fR) \), and inductance by \( L = R/(2f) \).

This choice of repetition rate has the advantage of interrupting the decay voltage at a point of greater slope than in the equal-impedance method. Dimensions of the image on the oscilloscope are more sensitive to changes in circuit parameters and hence, as a measuring
extant method will permit measuring capacitors \( \pi \) times as large as could be measured by the equal-impedance rate.

**Extensions of the Method**

It is conceivable that other repetition rates could be used. The two frequencies mentioned have been chosen because of their particular significance in circuit analysis. One extension of the response analysis to a square wave of the equal-impedance frequency, which indicates the reason for making measurements at this particular frequency, is in determining the cut-off frequencies of filters or amplifiers.

Cut-off frequencies of communication circuits are often taken in sinusoidal analysis as those at which the output is half the mid-frequency power. This condition occurs at the equal-impedance frequency in simple \( RL \) and \( RC \) networks.

Because of the cascading of impedances and the use of compensation networks, the decay curves of communication circuits will no longer be simple exponentials, as in Fig. 3. However, the square-wave frequency at which the output decays to 4.3 percent of its initial value can still be taken as the low cut-off frequency. Thus the equal-impedance method can be used to measure low cut-off frequencies of complex circuits. A similar extension of the method can be made to measure high cut-off frequencies.

Caution must be used in making this extension because it is the deviation from the exponential curve which reveals most about communication circuits. This method only considers the information obtainable from the end points of the circuit response to square waves. Similar use can, with reservations, be made of the time constant method, and to measure high-frequency cutoff.

**Measurement of Q Factor**

Inductors, because of their distributed capacitances, have self-resonant frequencies above which they behave as capacitors. In choosing chokes and transformers, it is necessary to know not only their inductances, but also the frequency ranges over which they are inductive. By square-wave measurement, the self-resonant frequency of an inductor and its resonant \( Q \) can be determined.

The reactance of the inductor is measured by the previous technique. The inductor is then connected between the high sides of the square-wave generator and the oscilloscope; the low sides of the instruments are directly connected as in Fig. 4(a).

When excited by the multiple-frequency transient of the square wave, the inductor oscillates at its natural period with the result that there is a damped sine wave superimposed on the square wave which is being applied to the oscilloscope through the inductor, Fig. 4(b). The number of oscillations per cycle of the square wave, times the square-wave frequency, gives the natural frequency \( (f_n) \) of the inductor.

The square-wave frequency should be adjusted so that a whole number of cycles appears on each cycle of the square wave because counting fractions is difficult. Also, the square-wave frequency should be considerably lower (one-tenth is a convenient ratio) than the natural frequency of the inductor. This is partly because, as the square-wave frequency approaches the self-resonant frequency of the inductor, it forces the oscillations to the extent of changing their frequency, and partly because, with but a few cycles of oscillation per cycle of square wave, errors in estimating fractions or in observing when there are none, increase.

There is no gain in using a square-wave frequency lower than one-twentieth \( f_s \) because of the large number of cycles-per-square-wave which must then be counted. The half period of the lowest square wave that can be used must be no longer than the oscillation decay time of the self-resonant inductor.

The rate of decay of the oscillation is used to measure the a-c resistance of the inductor at its natural frequency. Because the impedance of the inductor at its resonant frequency is more dependent upon the \( Q \) of the inductor in this range than it is upon the simple inductance, the coil resistance at the natural frequency \( (R_s) \) is of greater significance at the upper frequency limit of usability.

This method is illustrated in Fig. 4(c). Transformers can be treated as combinations of self and mutual inductances, each having its own natural frequency and apparent a-c resistance. Critical damping can be quickly determined by this same method. Resonant circuits of all types can likewise be measured.

**Neutralizing Impedance Effects**

The input impedance of the oscilloscope reduces the shunt-arm impedance while the output impedance of the square-wave generator increases the series-arm impedance of the test circuit. Rather than attempt to correct analytically for these impedances, which can well be complex, it is better to remove their effect, especially since to do so is easy.

Reducing the output impedance of the square-wave generator by means of a cathode follower has been discussed. If the output impedance of the square-wave generator has a d-c path, as it will if a cathode follower is used, all the foregoing circuits provide d-c grid returns. Therefore, an impedance

(Continued on page 356)
Microsecond PULSE GENERATOR

Results of investigation to deduce deionization time of thyatrons used in a circuit providing pulse-type signals of variable duration at high repetition rates

By E. F. Kiernan

Although the thyatron gas tube has been in common use for some time as a switching or gating device, it has generally been assumed that its repetition rate had definite limitations due to the deionization time of the gas. Several investigators, however, have noted that deionization time does not necessarily limit the operational frequency under all circumstances and modes of operation.

In the course of some development work, a source of pulse-type signals of variable duration and variable repetition rate was required. Manufacturer's data indicated that the ionization time for typical thyatrons varied between 1 and 50 microseconds, and the deionization time did not exceed 1000 microseconds. Since the break-down or ionization time was well within the requirements, it appeared as though the deionization time would be the pertinent factor. One reference stated that this time varied directly with the gas pressure, inversely as the 3/2 power of the grid voltage, and directly as the 0.7 power of the anode current. It was also stated that as a grid-controlled rectifier the device could not be operated above 5000 cycles.

Obviously, little can be done about the gas pressure, which is fixed at the time of manufacture. The other two factors indicate that large grid voltages and low anode currents should be used to get short deionization times.

The basic test circuit arrangement utilized a thyatron to discharge a capacitor which was recharged from a d-c source through a limiting resistor, as in Fig. 1.

Results for an FG-57 thyatron with 60-cps excitation on the grid are given in Table 1, and show that the duration of the pulse is determined solely by the capacitance of the discharging capacitor.

After the capacitor value has been lowered to a point where the capacitor can charge to the applied direct voltage, the amplitude of the pulse is proportional to the size of the capacitor.

The pulses were viewed on the screen of a cathode-ray oscilloscope with a super-imposed transparent reference lattice. Pulse duration was evaluated, with any given setting of the sweep, by means of a sine wave of known frequency from an R-C oscillator. The frequency was adjusted until a half sine wave occupied the same number of divisions on the horizontal scale as did the pulse. Knowing the frequency, the time duration of a half cycle could be readily found.

The values for pulse duration in Table 1 include the points from which the pulse trace leaves the horizontal axis and returns to it. In the case of the 9.4-microsecond pulse the 63 percent and 37 percent points were less than 1 microsecond apart.

Repetition rates between 60 and 400 per second were found practical with smaller tubes such as the 884. Adequate shielding from stray fields and from light is recommended for the gas tubes, especially the more sensitive types such as the 2050, 2051, and 2D21.

![FIG. 1—Circuit used to generate pulses at high repetition rates (up to 400 per sec.), with waveform of output pulse. Performance data is in Table I](image-url)
Analysis of voltage waves in single-phase thyatron rectifier circuits with inductive-input filters, taking into account the variations in harmonic content with conduction angle. Basic equations are developed into a practical design procedure, and examples are given.

**FILTER For Grid-**

**S**ingle-phase full-wave rectifiers employing gas triodes (thyatrons) have been used in numerous applications where accurate and smooth control of the direct-current output is required. In some of these applications adequate filtering is necessary to reduce the output ripple voltage below some specified value. The usual filter design equations used in the case of the high-vacuum or gas diode rectifiers are not suitable because the magnitudes of the harmonic components to be filtered vary with the conduction angle of the tube.

Grid-controlled gas-tube rectifiers are usually controlled by means of a phase-shifting circuit that controls the point on the anode voltage wave at which the tube starts to conduct.

**Rectifier with Resistance Load and No Filter**

In Fig. 1 is shown a typical grid-controlled rectifier and phase-shifting circuit for controlling the conduction angle, with an illustration of the type of output voltage wave to be expected for a given angle of delay if the load is pure resistance. The action of the gas triodes and phase-shifter circuit will not be discussed further as this is usually dealt with in most texts on electronics, but rather, an analysis of the voltage waves and the design of filters for these waves will be considered in this paper.

In Fig. 2 is shown a typical output voltage wave in which the firing of the tube has been delayed for an angle \( \phi \) and tube conduction takes place through an angle \( \theta = \pi - \phi \) if the arc drop is assumed negligible. This recurring wave may be expressed by a Fourier series in the usual manner:

\[
e = E_{dc} + \sum_{n=1}^{\infty} A_n \cos nx + \sum_{n=1}^{\infty} B_n \sin nx \tag{1}
\]

where

\[
E_{dc} = \frac{1}{2\pi} \int_0^{2\pi} f(x) \, dx \tag{2}
\]

\[
A_n = \frac{1}{\pi} \int_0^{2\pi} f(x) \cos nx \, dx \tag{3}
\]

and

\[
B_n = \frac{1}{\pi} \int_0^{2\pi} f(x) \sin nx \, dx \tag{4}
\]

In the case of the wave shown in Fig. 2, \( f(x) \) is zero at \( x = 0 \) and \( f(x) \left|_{x=\pi} \right. = E_{max} \sin x \) where \( x = \omega t \) and \( E_{max} \) is the crest value of the transformer voltage from one end to center tap. In determining the coefficients \( A_n, B_n \) and \( E_{dc} \), the grid-controlled rectifier will be necessary to integrate only through the limits from \( \phi \) to \( \pi \) and multiply the result by two since the half-cycles are identical. Then

\[
E_{dc} = E_{max} \frac{\pi}{2} \int_0^\pi \sin x \, dx = \frac{E_{max}}{\pi} \left( 1 + \cos \phi \right) \tag{5}
\]

The direct current component of the voltage wave thus varies from zero to the value \( 2E_{max}/\pi \) as the delay angle is varied from \( \pi \) to zero. Figure 3 shows how the ratio \( E_{dc}/E_{max} \) varies with \( \phi \).

Since it is usually necessary to know only the magnitude of the harmonic terms present, a complete Fourier series for the wave is not necessary. Inspection of Eq. (1) will show that the \( n \)-th harmonic is given by \( A_n \cos nx + B_n \sin nx \), and therefore the magnitude of the \( n \)-th harmonic voltage is

\[
E_{n, max} = A_n + j B_n \tag{6}
\]

Substituting Eq. (3) and (4) in Eq. (6),

\[
E_{n, max} = \frac{1}{\pi} \int_0^{2\pi} f(x) (\cos nx + j \sin nx) \, dx \tag{7}
\]

Putting in for \( f(x) \) its value for the particular wave under study and changing the limits, we get

\[
E_{n, max} = \frac{2}{\pi} E_{max} \int_0^\pi \sin x \, e^{in\alpha} \, dx = \frac{2}{\pi} E_{max} \left[ \frac{e^{in\alpha} (\cos \alpha - j \sin \alpha)}{1 - n^2} \right] \tag{10}
\]

**FIG. 2—Wave form for grid-controlled rectifier with no filter**

**FIG. 1—Basic circuit of grid-controlled rectifier with phase-shift control**
by applying the principle of symmetry to the wave, it may be seen that $f(x) = f(\pi + x)$, for which it can be shown that no odd harmonics exist. If $n$ is given only even values, the limits substituted and the resulting equation expanded, he following expression for the rest value of the nth harmonic voltage results:

$$v_{n_{\text{max}}} = \frac{2E_{\text{max}}}{n} \sqrt{1 + \cos \phi \cos n\phi + n \sin \phi \sin n\phi}$$

(9)

Figure 3 shows the variation of the second and fourth harmonic rms with the angle $\phi$. It must be stressed that the curve shown in Fig. 3 can be used only with a non-saturation load as the presence of a filter changes the output voltage wave of the rectifier considerably. This fact is commonly overlooked, as has been pointed out by M. B. Tout.

**Rectifier with Inductive-Input Filter**

It was noticed in Fig. 2 that current flows for only a portion of each half-cycle if the load is non-inductive. If a series inductance is added, the current will tend to flow for a longer period of time but with a corresponding decrease in its peak value. If the inductance is made large enough, current will flow through the load circuit continuously. A critical value of inductance $L_c$, may be defined as that value which will just prevent the current from dropping to zero at any portion of the cycle.

If a grid-controlled rectifier with slaved firing angle has an inductive-input filter (Fig. 4) with the value of the inductance less than critical, damped oscillatory waves set up as shown in Fig. 5(a), and the circuit in general becomes very unstable. This type of operation is very undesirable and should be avoided by making $L > L_c$, for all values of load current and delay angle.

If $L > L_c$, the tube that is conducting will continue to conduct until the second tube fires, even though the anode potential swings negative with respect to the transformer center-tap over a portion of the cycle as shown in Fig. 5(b). This effect is produced by the induced emf of the input filter choke.

Since for this case the tube drop is constant throughout the whole cycle, it will not enter into the calculation of the harmonic terms and can be subtracted from the direct-current component.

A study of the wave in Fig. 5(b) will show that $f(x) = E_{\text{max}} \sin x - E_d$ in $\theta$. Substituting this in Eq. (2) gives

$$E_{d_x} = \frac{2E_{\text{max}}}{\pi} \int_0^{+\theta} \sin^2 dx$$

(10)

A plot of Eq. (10), neglecting tube drop, is shown in Fig. 6. It is seen that the complete range of output voltage may be covered with only a 90°-depression of delay angle. Values from this curve should be multiplied by $E_{\text{in}}/(E_d + E_{\text{in}})$ to correct for tube drop.

Substituting $f(x)$ into Eq. (7) gives for the nth harmonic

$$E_{n_{\text{max}}} = \frac{2E_{\text{max}}}{\pi} \int_0^{+\theta} \sin x e^{inx} dx$$

(11)

which when integrated, limits substituted, and reduced as before (with $n = 2, 4, 6, \ldots$) gives

$$E_{n_{\text{max}}} = \frac{4E_{\text{max}}}{(1 - n^2)} \sqrt{(\cos \phi \cos n\phi + n \sin \phi \sin n\phi)^2}$$

(12)

Since any filter designed to reduce the second harmonic voltage to a specified value will be at least four times more effective for the next higher harmonic, it is necessary to consider only the second harmonic in the design of the filter. Figure 6 shows the variation of the second harmonic voltage at the input to the filter with the delay angle $\phi$.

The usual procedure for determining the critical value of inductance required in single-phase full-wave diode rectifier circuits is to neglect all the harmonic terms except the second and solve the resulting equivalent circuit for the direct and alternating components of current through the choke. The critical value of inductance $L_c$, which will just keep a current flow at all times through the choke can then be determined from the critical condition of $I_{dc} = I_{dc_{\text{max}}}$.

This solution gives $I_{dc} = R_{\text{dc}}/1130$ for a 60-cycle impressed voltage, where $R_{\text{dc}}$ is the total direct current component of current.
expressed as a percentage of the d-c output voltage. Then
\[
\%\ \text{Ripple} = 100 \times \frac{E_d}{E_{dc\ \text{output}}}
\]  
(13)

where
\[
E_d = 4 E_{\text{max}} K_0 S / 3 \pi \sqrt{2}
\]  
(14)

and \(S\), the smoothing factor of the filter, is in accordance with the usual filter design equation
\[
S = \frac{1}{2\pi f_{\text{supply}} L \left( \frac{1}{R} \right)}
\]  
(15)

\(f_{\text{supply}}\) being 2\(f\) times the original supply frequency and \(a\) the number of sections in the filter.

The direct output voltage is the direct input voltage to the filter minus the voltage drop in the filter:
\[
E_{dc\ \text{out}} = \left( \frac{1}{2} E_{\text{max}} \cos \phi - E_d \right) - I_d R_f
\]  
(16)

and
\[
I_d = R_L + R_f
\]  
(17)

where \(R_L\) is the resistance of the load and \(R_f\) is the filter resistance. Substituting Eq. (17) into (16), then substituting the resulting equation along with Eq. (14) into (13) gives
\[
\%\ \text{Ripple} = \frac{4 E_{\text{max}} K_0 S \times 100}{3 \pi \sqrt{2} \left( \frac{1}{L} \sin \phi \right)}
\]  
(18)

In the case of rectifiers for voltages of the order of a few hundred volts or more and for delay angles up to 60 or 70 deg (larger angles than this are impractical), \(E_d\) in Eq. (18) may be neglected. Further, since \(R_c > R_f\), the quantity \(1 - \frac{R_c}{R_f}\) of Eq. (18) will be approximately equal to 1 (this approximation can be corrected for later), then Eq. (18) can be reduced to
\[
\%\ \text{Ripple} = \sqrt{2} K_0 S \times 100
\]  
(19)

For a single-section filter at 60 cps, Eq. (19) can be expressed as
\[
\%\ \text{Ripple} \times L \left( \frac{1}{C} \right) \times 10^{-4} = 0.831 K_0 \cos \phi
\]  
(20)

and for a two-section filter
\[
\%\ \text{Ripple} \times L \left( \frac{1}{C} \right) \times 10^{-4} = 1.46 K_0 \cos \phi
\]  
(21)

A plot of Eq. (20) and (21) which may be used for design purposes is shown in Fig. 7. If the d-c resistance \(R_c\) of the filter chokes is not small compared to \(R_f\), then the values of percent ripple \((L,C)\) should be multiplied by \(\left( R_c + R_f \right) / R_f \).

**Practical Design Procedure**

Ordinarily in the design of rectifier and filter systems the output voltage, current rating, and percent ripple that can be tolerated are specified by the use to which the rectifier is to be put, and it is the problem of the designer to choose circuit elements that will allow the specifications to be met in the most economical way. Unfortunately, when starting with the output or load requirements some cut-and-try calculations may be necessary, though the use of the curves in Fig. 6 and 7 will reduce the amount of work quite appreciably. Also, single-phase rectifiers are used only on relatively low-power installations where high accuracy in the design is not usually necessary.

While the equations predict that the output voltage can be varied from a maximum value down to zero, it is obvious from a study of Fig. 6 and 7 that it would require an infinite filter to do so if low percentage ripple is to be maintained. Practical limits on the maximum delay angle range between 60 to 70 deg. At 70 deg the output voltage will be reduced to about 34 percent of the value with zero delay.

The use of a swinging choke for the input inductance will reduce the cost of the filter considerably. Also, since the percent ripple increases with delay angle, the required LC product should be calculated for the largest delay angle. The following examples illustrate the design procedure for a typical rectifier.

**Examples**

Assume the load requirements are such that the load voltage is to vary between 500 and 1000 volts with a maximum percent ripple of 0.5 percent, and that the load current is to vary between 100 and 500 milliamperes. Neglecting tube and filter voltage drop as a first approximation, we find from Fig. 6 that \(E_{dc}/E_{\text{max}} = 0.636\) (for \(\phi = 0\)), or \(E_{\text{max}} = 1000/0.636 = 1570\) volts. From Eq. (10), \(\cos \phi = 500/2 \times 1570 = 0.5\), and \(\phi_{\text{max}} = 60^\circ\).

From Fig. 7, for \(\phi = 0\), \((L_c/R_c) \times 10^\circ = 0.88\). Since \(R_c = 1000/
\(10 \times 10^4 = 10,000\) ohms, then \(L = 1.8\) henrys. For \(\phi = 60^\circ\), \((L/L_r) \times 10^3 = 4.4\). Here \(R_r = 500/10^3 = 500\) ohms, and \(L = 500 \times 4.4 \times 10^3 = 22\) henrys. Hence the input inductance should be a minimum inductance of 22 henrys at a current of 100 milliamperes.

The amount of filtering necessary could always be calculated for the minimum delay angle. From Fig. 7, \(\phi = 60^\circ\), percent ripple \(\times (L/L_rC) \times 10^3 = 5.26\). For 0.5 percent ripple, \((L/L_rC) = 1052\). Therefore \(L_r = 1.8\) is a swinging choke having 22 henrys at 100 milliamperes and 6 henrys at 500 milliamperes, and if \(L\) and \(C\) are 4 \(\mu\) each, then \(L = 10^2 \times 2 \times 4 \times 4 = 11\) henrys. In this case a single-section filter would have been impractical because of large values of \(L\) and \(C\) required.

The inductance values of the above chokes are now known, their ratings may be determined from the choke design. Typical values to the above chokes rated at 500 milliamperes would be about 75 ohms each. Hence the voltage drop across the filter would be 2 \(\times 75 \times 0.5 = 75\) volts. Assuming the tube drop is 0 volts, the actual transformer voltage required would be \((1000 + 10)/0.636 \times \sqrt{2} = 1205\) volts effective across each side of the center-tap.

In the above example the effect of low-voltage supply on minimum delay angle and two other corrections mentioned earlier in the discussion are not considered because of their negligible effect. However, in the case of a low-voltage high-current rectifier, these corrections would have to be made and for the purpose of illustration they will be calculated for the above rectifier.

It will be noticed from Fig. 5(b) that the cathode-anode potential difference is equal to twice the transformer voltage at the instant the firing, and hence the minimum value of \(\phi\) is the value that will give twice the instantaneous transformer voltage equal to the ignition voltage of the tube. If FG-17 type thyratron tubes are used in the above application, the ignition potential will be approximately 40 volts. Hence \(40 = 2E_{max} \sin \phi_{min}\), and from Eq. (10) (include the filter which was determined from the approximate design), 1000 \(+\) \(x \times 2 \times 75 = (2E_{max}/\pi) \sin \phi_{min}\).

- 10. Therefore \(\phi_{min} = 40/180 \times \pi = 0.0017\), or \(\phi_{min} = 1^\circ\) and \(E_{max} = 180 \times 0.0017\). Hence \(E = 1705/\sqrt{2} = 1205\) volts, which is the full-load voltage rating of the transformer secondary from end to center-tap.

To calculate \(\phi_{max}\) from Eq. (10), \(500 + 0.5 \times 2 \times 75 + 10 = (2 \times 1705/\pi) \sin \phi_{max}\), from which \(\phi_{max} = 57.2^\circ\). Then from Fig. 7, applying corrections, \((L/L_r) \times 10^3 = 4.24\). Hence \((1 + 10/500) = 4.33\), and \(R_r = (500/100 \times 10^4) + 150 = 5150\) ohms. Therefore \(L_r = 4.33 \times 10^3 \times 5150 = 223\) henrys. Also from Fig. 7 for \(\phi_{max} = 57.2^\circ\), percent ripple \(\times (L/L_rC) \times 10^3 = 4.7\). Hence \((R_r + R_r)/R_{\max}\) and \((R_r + R_r)/R_r = (1000 + 150)/1000\) since this correction should be calculated for the lowest load resistance possible for \(\phi_{max}\), i.e., for \(R_r = 500/0.5 = 1000\) ohms. Then \((L/L_rC)_{\max} = 1080\) for 0.5 percent ripple.

As before, if \(L_r\) is a 25-6 henry swinging choke and \(C\) and \(C_s\) are each 4 \(\mu\) each, then \(L_r = 1080/6 \times 4 \times 4 = 11.25\) henrys.

It can be seen that in this example the more exact calculation gave practically the same solution as the approximate design based upon the curves with no corrections except that for the transformer voltage. In low-voltage power supplies, however, it would be well to make an approximate solution from the curves, find the approximate value of \(R_r\), and then recalculate the values as was done above.

The curves and design procedure have been checked experimentally and were found to be correct within the limits of experimental error.

REFERENCES


FIG. 7—Curves for determining filter constants for grid-controlled rectifiers
Voltage/db

CONVERSION DEVICE

Linear polar-coordinate graphs are readily interpreted. Plotted data need not be normalized and the size of the time-saver is flexible. An antenna radiation problem is worked out as an example

By Edwin Dyke
Lear Avion, Inc.
Grand Rapids, Mich.

Polar-coordinate graphs following any fixed $E^2$ law may be readily interpreted in terms of db by means of the two-piece transparent plastic conversion device illustrated.

The function of piece (a) is to set up a proportionality between the db scale of piece (b) and the plotted graph. Thus the graph need not be normalized and the size of the two parts of the conversion device is immaterial so long as they are large enough to fit the graph. Piece (a) can be made up readily by ruling squares (any convenient size) on a transparent sheet. For piece (b), the scale shown here can be transferred to a strip of similar material. Two successive photographic negatives of an ink drawing will yield an excellent transparency, often called an "Ozalid transparency.

Suppose, for example, that a linear-voltage antenna radiation pattern (such as the one shown here) drawn to polar coordinates is to be converted. Piece (a) of the device is oriented by centering its upper left-hand corner over the center of the graph with the aid of a pin, and is then rotated to any convenient position.

The vector of maximum amplitude is selected as a reference point $V$ and, with the aid of the nearest arc on the graph, is traced to one edge of piece (a) as shown at $R$. This edge of piece (a) is now a fixed reference line. At the reference line the arc is tangent to a horizontal line on piece (a).

With piece (a) held in position as described above, piece (b) is oriented by centering its infinity calibration ($\infty$) over the center of the graph, again with the aid of the pin, and then rotating piece (b) until 0 db intersects the tangent line at point $T$.

The db equivalent of any voltage point on the graph may now be read on the db scale of piece (b). As shown here, for instance, the db equivalent of point $P$ is determined by following an arc to the vertical reference line $R$, following a horizontal tangent line from that point to the calibrated edge of piece (b) and reading $-7.5$ db. The same curve plotted in power would yield for the point $P$, $-3.75$ db, obtained by dividing the answer by 2.
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Dielectric Heating of Tire Cord Sets Twist

TWIST-SETTING of textile yarns with electronic heating is being accomplished by Industrial Rayon Corp. in a new process invented by the company's technical staff.

The twist of the rayon tire cord is set by submitting packages of the cord to dielectric heating. Heat generated in the cord is distributed so uniformly that spools or cones containing 18 pounds or more of rayon tire cord may be effectively treated. Such giant cones are used in the weftless method of tire construction.

The process is completed in a matter of minutes and results in the production of a cord in which the twist is uniformly set. Control of the moisture content of the cord may be facilitated by wrapping the cones of cord in moistureproof paper before processing.

The equipment originally installed for this process has been in operation at Industrial Rayon's Cleveland plant for more than eight months and includes high frequency power generating units having outputs of approximately 22,500 BTU per hour each. They were furnished by the Girdler Corp., through its Thermex Division, and each unit is capable of handling several thousand pounds of packaged tire cord in a 24 hour period. Additional high-frequency twist-setting units are to be installed in two other plants.

Patent applications covering the use of high-frequency heating for twist-setting of textile products generally, including tire cord, have been assigned to Industrial Rayon. The new process is also being used by The B. F. Goodrich Company, under license from Industrial Rayon, in connection with production of rayon tire cord. Radio Corporation of America supplied the high frequency power units used by Goodrich.

Rapid Gas Analysis for Vapor Control

MANY INDUSTRIES are concerned with the problem of controlling contaminated atmospheres. Elaborate air-conditioning systems, special section hoods, etc., are employed in plants to draw off vapors and gases and in many instances workers wear gas masks during certain operations. In spite of these precautions, it is usually necessary to make periodic checks of the air in various parts of the plant to determine whether the concentration of the volatile substance is being held within the safety level.

Most gas analyzers require 15 minutes or more to take an air sample and show only the average concentration of the gas during that period of time. With this technique, momentary high peaks escape observation. An electronic instrument developed at E. I. du Pont de Nemours can run continuous samples and give direct and instantaneous readings. This permits accurate second-by-second observation of the vapor level in each step of a manufacturing process.

V. F. Hanson, of the Electrochemicals Department of the du Pont Company, designed the original instrument. A modified model, intended particularly for carbon disulfide analysis, has been developed by Dr. Shirleigh Silverman, assisted by Dr. J. W. Ballou and W. H. Warhus, all of the Rayon
MALLORY resistors are serving today in production, research and actual battle to speed the moment of victory. Every day their usefulness increases as science, widening the field of electrical and electronic development, builds new devices for controlling, counting, measuring, detecting.

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Technical Division of the company. The Mine Safety Appliance Co. is planning to manufacture instruments of this general type.

Operation of the ultraviolet photometer is based on the phenomenon of light absorption by gases. Most gases absorb light of some particular wavelength, in effect casting a shadow where that particular wavelength line would otherwise have fallen. In a spectrum that shadow is known as an absorption line. Carbon disulfide, for example, strongly absorbs light having a wavelength of 3132 Angstrom units, in the ultraviolet range.

Comparison System

The instrument is so constructed that the air to be analyzed is pumped through several small chambers, which filter out dust, oil and moisture, and thence into a pair of parallel tubes, about 31 inches long. The contaminated air runs into the first tube and then through a canister of activated charcoal which removes carbon disulfide, and passes purified air into the second tube. This permits a continuous comparison of the purified with the contaminated air and very minute differences may be detected.

Rays of ultraviolet light from a mercury lamp pass through the two tubes and fall upon a sodium phototube mounted at the opposite end of each tube. A vacuum-tube amplifier follows the phototubes and actuates a microammeter for readings.

Filters in the optical system have been so selected that about 60 percent of the photometric response of the cell is due to light of 3132 Angstrom units in wavelength, the light which carbon disulfide absorbs. No other atmospheric element has been found in plants where this instrument is used that absorbs either this band of light or the 3650 Angstrom unit band, which accounts for most of the remainder of the photocell's response. One part of carbon disulfide in a million parts of air will produce an absorption of 0.02 percent.

In one test, 61 readings were made during the nine minutes required to open, dump and clean out a large vessel in which material was treated with carbon disulfide. During most of the operation the concentration of gas remained below 20 parts per million and older methods of analysis, which could give only the average for this entire time interval, would show no danger points. However, the ultraviolet photometer revealed that the concentration rose to 60 parts per million at one moment and to 40 at another. The ventilating equipment was therefore modified in order to eliminate these peaks.

Magnetic Inspection of Bolts and Castings

The tubes on the panel control a current impulse of 40,000 amperes for magnetizing bolts and castings. The transformer is mounted on trucks to permit short lead lengths to the test positions.
wherever a tube is used...

**HIGH-SPEED PHOTOGRAPHY**

The Lee Strobo-Speed lamp stops action of rapid movement, with a flash of about one thirty-thousandth of a second. One flash exceeds in light intensity the illumination of 2,000 kilowatts of ordinary incandescent lamps. Operates on 115 volts, 60 cycles, A.C.

**THERE'S A JOB FOR**

**Relays by GUARDIAN**

In the Lee Strobo-Speed lamp a rectifier tube is employed to build up a high charge on a bank of condensers. These are discharged through the flash lamps when the Guardian Series 15 relay is energized. This special application illustrates the flexibility of design incorporated into Guardian relays. The Guardian standard Series 15 was selected for the job and engineered to meet the high voltage requirements and other special conditions.

Another Lee Strobo-Speed unit with three flash tubes operating from three banks of condensers also employs the Series 15 relay. In this application the relay is equipped with additional switches to handle three circuits instead of one. Contact switches in both units are specially insulated to withstand the high voltages.

The Series 15 is a compact unit having a maximum switch capacity of 10 pole, single throw with 1½ amp. contacts; 6 pole single throw with 8 amp. contacts; 4 pole double throw with 12½ amp. contacts. Coils for standard voltages range up to 220 volts and may be equipped with copper slug time delay on release or attract.


**GUARDIAN ELECTRIC**

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tenance cost on the battery equipment has run approximately $3000 yearly. To cut down this expense, A. E. Soderholm, of the company's engineering staff, started work on a method of using electronic equipment to replace the batteries. As a result of his research and study, electronic units were built to specification by General Electric Co.

The electronic equipment shown in the photograph makes available a source of power which is constant, day in and day out, at a fixed amperage. By the use of thyrons and ignitrons, a current impulse of 40,000 amperes is available which provides deeper penetration and greater concentration of the oxide-iron particles. The estimated yearly maintenance cost of the electronic equipment is $50, principally for replacement of vacuum tubes.

With the vacuum tube power supply as a source of current, the hazard of fire is completely eliminated as there are no electric arcs.

Another advantage is the elimination of lost motion due to period shut downs previously experienced during battery changeover and charging periods.

**Flame-Failure Control of Industrial Furnaces**

If the flame fails in furnaces fired by pulverized coal, oil or gas, electronic flame-failure safeguards can prevent the development of explosion hazards. In its simplest form, the equipment shuts off the fuel supply and attracts the operator's attention by a signal. Such systems may be modified by the addition of various interlocks, furnace purges, automatic ignition, relights, timers, alarms, and other devices.

Operation of the equipment depends upon detecting a flame's existence by a phototube or an electrode, or both. Furnaces burning pulverized coal or oil, in which flame luminosity is light yellow, or brighter, generally use the phototube detector. Ordinarily a blue flame, such as gas burners make, requires an electrode detector which is a conductor of electricity with a resistance of from 1 to 100 megohms.

At flame failure, the resulting change in the current through the phototube or electrode exposed to the flame is amplified by electronic tubes to the desired value. The circuit of one of the simplest forms of flame-failure safeguards is shown in Fig. 1. This system, made by Wheelco Instruments Co., is used on an oil-fired furnace with push button opening of the fuel valve or manual lighting of the flame with a torch.

**Photoelectric System**

The diagram shows no-flame conditions, when, for example, the flameguard has been energized but the fuel valve is still closed. The operation of the circuit can be traced by assuming transformer instantaneous polarity as shown. Secondary S, supplies current to heat the cathodes of the twin vacuum tube T. Transformer secondaries S1 and S2 complete a circuit from cathode C to anode A, secondary S, resistor R1, and secondary S2. Until there is a flame, phototube P is inactive and there is no potential on...
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grid \( G \), consequently current can flow between cathode \( C \) and anode \( A \).

The voltage drop across resistor \( R \) puts a negative potential on grid \( G \). How this potential is produced can be easily seen by considering secondary \( S \), alone. If a connection were made between grid \( G \) and cathode \( C \), current from \( S \) would flow from grid \( G \), to cathode \( C \), then from \( C \) to \( A \), and back to \( S \).

In the absence of the connection between \( G \) and \( C \), there exists a negative potential equal to that of secondary \( S \), and this side of the tube cannot conduct. As a result the relay coil remains dead, a circuit for this coil being through secondary \( S \), cathode \( C \), anode \( A \), secondary \( S \), and back to the relay, but it is blocked by grid \( G \).

Relay contacts, therefore, remain closed in the position shown, and the pilot light is energized through contact \( L \), to show a no-flame condition.

**Valve Open**

Closing the pushbutton connects the fuel-valve-opening coil across the line. This valve opens and when the fuel is burning with sufficient flame the phototube conducts on the reverse transformer polarity from that in the diagram. This circuit is from terminal \( N \) of secondary \( S \), the relay coil, resistor \( R \), to ground through the phototube resistors \( R \), and \( R \), back to \( S \). The anode of the phototube connects between \( R \) and \( R \), which puts a negative potential on grid \( G \) equal to the voltage drop across \( R \), and \( R \), and charges capacitor \( D \).

When the polarity of the transformer reverses, capacitor \( D \) discharges through resistors \( R \), \( R \), and \( R \), and maintains the negative potential on grid \( G \) to block the circuit between cathode \( C \) and anode \( A \). Blocking the circuit removes the potential on \( G \), and the right-hand side of the tube completes the relay-coil circuit.

This circuit is from \( S \), through cathode \( C \), anode \( A \), secondary \( S \), the relay coil, and back to \( S \). Energizing the relay coil causes it to open contact \( L \), to extinguish the pilot light and close contact \( L \), to short-circuit the pushbutton and put the fuel-valve coil circuit directly across the line. When the pilot light goes out the operator knows the burner has been lighted and he releases the pushbutton.

**Flame Failure**

If for any reason the flame fails, the phototube becomes inoperative and removes the negative potential from grid \( G \). Current can again flow from cathode \( C \) to anode \( A \) to give grid \( G \) a negative potential and block the right-hand side of this tube, as previously explained.

Since the circuit is blocked between \( C \), and \( A \), the relay coil deenergizes, to open contact \( L \) and close \( L \). The former opens the fuel-valve-coil circuit, and this valve closes to shut.

![Diagram](FIG. 1-Simple flame-failure system for an oil-fired furnace. A pushbutton opens a solenoid-operated fuel valve and the flame is lit manually with a torch)
A vital component of the Hearing Aid is the Microphone which must be small, light, moisture-proof and possess the frequency response adapted to the Hearing Aid Device. Often the Microphone must be chosen to fit the threshold of hearing of the patient. Shure Research has succeeded so well in controlling the frequency response and output level of small size Hearing Aid Microphones that, today, Shure Brothers produces microphones for practically every major manufacturer of Hearing Aids.

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off the oil. Closing of contact \( L \), lights the pilot lamp to signal the operator that the fire is out.

To prevent the relay dropping out during transient flame disturbances, such as puffs and flickering, that temporarily shut light off from the phototube, a capacitor \( D \), connects across the relay coil. Time delay in relay opening after its coil circuit is blocked depends on the size of the capacitor and the charge on it just before flame interruption. This time can be adjusted but if insufficient to overcome effects of transient flame disturbances, it may be lengthened by increasing capacitance.

**Flame Conduction Type**

Figure 2, a gas-burning system developed recently by Brown Instrument Co., includes a flame-electrode, main gas burner, pilot burner and automatic ignition. The control part of the system uses two twin vacuum tubes, \( T \) and \( T' \). Assume no-flame conditions with the line switch closed. The cathodes of the two tubes are heated and the pilot light energized from the transformer secondary \( S \), as indicated by the arrowheads. Secondary \( S \) completes a circuit through resistor \( R \), cathode \( C \), and anode \( A \), of tube \( T \), back to \( S \). Under this condition grid \( G \) does not have a negative potential and this side of the tube conducts when the polarity of secondary \( S \) is the reverse of that shown. This circuit is from terminal \( M \) of secondary \( S \), to cathode \( C \), anode \( A \), through resistor \( R \), back to \( S \). Voltage drop across \( R \), puts a negative potential on the grids of tube \( T \), to block the relay-coil circuit. This circuit, when not blocked, is from terminal \( N \) of secondary \( S \), through the relay coil, secondary \( S \), cathodes \( C \), anodes \( A \), back to \( S \).

**Ignition of Pilot**

Closing the start button completes the circuit from the line through the ignition coil, contact \( L \), start and stop buttons, back to the line, as indicated. A circuit is also completed through the pilot-valve coil, the start and stop buttons, to the line. The pilot valve opens and the ignition system lights the pilot flame and it contacts the electrode. Then a circuit is completed from secondary \( S \), through the flame, the flame electrode, re-
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CML Electronic Generators are generating hundreds of kilowatts of power—through wide frequency range—for scores of manufacturers. The Model 1400, especially valuable for complete tests on the production line, delivers 1400 watts of power from 300 to 3500 cycles single phase. Regulation from no load to full load is within 4%. Maximum distortion with a resistive load is within 10%.

This generator includes a variable frequency oscillator followed by several driver stages. The output stage employs a pair of 833-A tubes in Class B. The CML 1400 overcomes the usual control difficulties of this type of high impedance power source by means of a special control circuit which maintains output voltage at a substantially constant level from no load to full load.

SCHEMATIC DIAGRAM

Grid G connects, through resistor \( R_n \), between the electrode and resistor \( R \), which puts a negative potential on this grid to block the circuit from cathode \( C \) to anode \( A \). Capacitor \( D \) is also charged and when the polarity of the transformer reverses, the capacitor discharges through resistor \( R \) and maintains a negative potential on grid \( G \) to block the circuit through \( R \), and \( S \).

Absence of current through \( R \) removes the negative potential from the grids of tube \( T_n \) and the relay coil is energized. The circuit for this coil is through secondary \( S_n \), cathodes \( C_n \) anodes \( A_n \), secondary \( S \), and the relay coil. Energizing this circuit opens contacts \( L \) and \( L_n \) and closes contact \( L_n \). Opening contacts \( L_n \) and \( L_n \) opens the pilot-lamp and ignition-coil circuits, but the pilot valve is held open by the circuit through the pushbutton. When the pilot light goes dark, it denotes that the pilot flame has been established and has contacted the electrode.

Main Flame

Closing contact \( L_n \) completes the main gas-valve coil circuit from the right-hand side of the line, through the main gas-valve coil, contact \( L_n \), the stop button, then to the left-hand side of the line. This valve opens and the operator holds the start button closed, releasing it when the main burner ignites. The main valve circuit remains closed through contact \( L \), and the stop button. As long as the flame contacts the electrode, the relay holds its contacts closed to the flame position. Should the flame fail for any reason, it will remove the negative potential from grid \( G \). This tube will again complete the circuit for secondary \( S \), through resistor \( R \), to make the grid of \( T \), negative and block the relay coil circuit. Its contacts then return to the start position and break the main gas-valve coil circuit through contact \( L_n \) after which the valve closes. The system then remains in a safe no-flame position until the start button is pressed, when the operations just described repeat.

During normal operation, pressing the stop button opens the main gas-valve coil and this valve closes. The operator holds the button open until
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he sees the pilot lamp light, when he knows that the equipment has returned to safe no-flame position.

If the electrode were to bend down and touch the gas burner it would form a closed circuit to ground the same as when a flame exists. This danger is provided against because when the electrode grounds, capacitor D discharges so rapidly that the potential on grid G decreases to where its side of the tube conducts and makes tube T grids negative to block this tube. The tube then acts the same as when the flame extinguishes; the relay opens its contact to close the fuel valve and light the pilot light. This system is therefore protected against either breaking or short-circuiting of the electrode. If the electrode breaks and does not contact the flame, it creates no-flame conditions to close the main fuel valve automatically. Grounding the electrode also closes the fuel valve.

Industrial Applications of the Fluoroscope

A COMPARISON of radiographic and fluoroscopic techniques that have been developed as part of the expansion of industrial x-ray use since the start of the war was made by R. W. Mayer of Kelly-Koett Mfg. Co. in addressing the Pittsburgh section of the American Industrial Radium and X-ray Society. He pointed out that the Government, as a customer, will not be in the picture to require x-ray inspection of airplane castings, tank welds, armor plate, etc., from the sole standpoint of safety—although there might be some government safety regulations calling for x-ray inspection of certain vital parts of airplanes used as public carriers.

"Many industrial x-ray users who started using the equipment originally because of government requirements, have learned the value of inspection beneath the surface for the information it provides, enabling them to improve quality, reduce costs and save labor. It is likely that these users will pass along what they have learned and establish acceptance standards of their own on purchases of castings, welded parts and assembled units.

Equipment

"One contribution to industrial x-ray expansion is the improvement
THE KLYSTRON converts DC energy into radio frequency energy by modulating the velocity of an electron beam between spaced grids. The ultra-high-frequency waves thus generated are so short that they approach heat and light waves in the electro-magnetic spectrum.

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of presently available types of x-ray machines and the creation of new machines and accessory devices as our own knowledge increases.

Progress thus far has been much greater along the lines of straight radiography than on fluoroscopy. The reason for this is that x-ray has been, for years, a tool for the medical profession and equipment and medical traditions have been carried over into industry. For example, the standard medical size 14 x 17 in. film is just about right for the human torso, but no engineer would have established such dimensions, although they happen to work out very satisfactorily.

“Medical x-ray equipment for radiography required only minor modification for industry, but the medical fluoroscope is another matter. The principal reason for the slow development of the fluoroscope in medicine is the limit of x-ray that a patient can stand without safety. Medical machines are made to cut back automatically to 5 milliamperes when used for fluoroscopy, and the radiologist is extremely careful to restrict the time that a patient is exposed.

“For some time the fluoroscope has been used to spot the presence of foreign bodies in packaged food, tobacco, soap, cereals, etc. Or, a large manufacturer of chewing tobacco experienced labor troubles and when the strikers left their job they tossed nails, hairpins, and other foreign articles into the pit of unpackaged tobacco. That tobacco company now has a fluoroscope, and a girl observes checks every package. There is a difficulty in detecting such impurities since they are usually metal, or, at least, of a density vastly different from the pure article, at fall under the general heading of gross defects. The only problem on such inspection are those of mechanical nature.

Improved Sensitivity

“Fluoroscopic inspection permits instant separation of the good from the bad—no waiting for films to develop and dried, no film at no dark room, no delay. Saving mount, costs go down, and for the reasons there have been many attempts to widen the field of application of the fluoroscope, but stumbling block has always been
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lack of sensitivity. Until very recently, a sensitivity of 15 percent was considered normal, 10 percent good, and under very unusual circumstances, 8 percent might be seen. Today, these limits can be just about cut in half and a sensitivity of 5 percent or better can be counted on as a regular day in and day out production standard.

Limitations

"It is well to recognize some of the inherent limitations of fluoroscopy. In the first place, radiographic technique charts on penetration do not apply. Considerably higher voltages are required on a fluoroscope than on a film. The time factor, which permits the effect of the X-rays to accumulate on film, is totally absent on the fluoroscopic screen. The screen shows only the instantaneous image. True, there is some "after glow", but that is a different phenomenon entirely.

This limitation immediately translates itself into a limit of thickness that can be fluoroscoped because it is not practical to use a unit of more than 220 kv or 250 kv capacity for fluoroscopy. The reason for this limit is principally a matter of safety. As the voltage is increased over these limits, there must be more than a proportionate increase in the thickness of lead and lead glass of the viewing cabinet. Moreover, with fluoroscopy, the X-ray is left turned on for a much longer period of time than is the case with radiography, which increases the importance of providing adequate protection. Our industrial laboratory has found the practical limits to be approximately 2" of aluminum and approximately 1/" of steel.

A second limitation is sensitivity. Radiographic penetrators are based on 2 percent sensitivity, although on good radiographic work, flaws on the order of 1 percent can be shown. While some excellent sensitivity claims have been made on the part of reliable observers, we prefer to state that the fluoroscope is practical for sensitivities of 5 percent and a little better, at this time.

Thirdly, the fluoroscopic screen provides no permanent record. The results obtained are in what the observer sees and if a check is re-
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"Fourthly, the degree of success with fluoroscopy depends on personal factors to a greater degree than is the case with radiography.

Advantages

"These limitations have been listed in order to make it clear that fluoroscopy must not be considered a complete substitution for radiography. In the final analysis, the fluoroscope has definite advantages of time and cost and also has certain exclusive advantages of its own. For example, a radiograph provides a picture in only one plane, but in a fluoroscope the part can be rotated which provides a third dimension to definitely fix the location of the defects. Also, certain types of defects, such as cracks and fissures will only appear on a film if the part is so placed that the plane of the crack lines up with the direction of the x-ray beam. The chances are very slim indeed of being able to place a part on film in exactly such a position, but in a fluoroscope the part can be twisted and turned until—suddenly—there it is.

"On most applications, fluoroscopy will find its greatest value as a supplement to radiography rather than to be used alone. That is, the ultimate in an inspection set up—that lends itself to fluoroscopy at all—is a combination layout arranged to provide ready change-over from one to the other without sacrificing any of the advantages of either.

Needs

"Let us consider what this involves. A fluoroscopic screen is observed through lead glass and the only practical arrangement involves the use of some sort of lead lined cabinet with lead glass viewing window. Since such a cabinet must have all the elements of protection required for radiography, and since the same x-ray generating equipment can be used for both fluoroscopy and radiography, it becomes unnecessary to construct a separate lead lined radiographic room provided, first, that cabinet be designed to be adaptable for either radiography or fluoroscopy; and, second, that the control do double service.

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THE enviable engineering tradition on which the foundation of the North American Philips Company, Inc., rests, is reflected in the superior quality and performance of electronic tubes bearing the NORELCO stamp. Contributing to the long life and uniform characteristics of these tubes are many exclusive manufacturing techniques and inspection methods developed over a long period.

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In the North American Philips Company, there is gathered together a team of outstanding electronic engineers, captained by one of America’s leading physicists, and coached by a group with world-wide experience resulting from fifty years of research and development in the electrical field. This new combination of technical talent has at its command many exclusive processes that insure electronic devices of the highest precision and quality. Today, North American Philips works for a United Nations Victory; tomorrow, its aim will be to serve industry.

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are involved. The first is a foot switch control for the fluoroscopic observer, a very simple addition to any x-ray control unit; and the second is to provide stepless control of kilovoltage to permit adjustment, to whatever value is required to penetrate the particular section under observation. Regarding the cabinet, the actual development has been from the radiographic side. For some time, it has been recognized that a cabinet has certain advantages in cost, convenience and flexibility over the construction of a lead lined room."

... ...

Ultraviolet Radiation Reduces Absenteeism

Use of ultraviolet rays in business offices to curb epidemics of respiratory diseases responsible for so much absenteeism is demonstrated by the experience of a company in Boston, Mass. The firm employs 70 men and women and protects them from germs with a constant daily radiation barrage from 15 carefully placed irradiators. Graph chart records kept from December 1 to March 1 reveal an average reduction of absenteeism due to illness of over 25 percent, while the decrease effected during the height of the influenza epidemic amounted to 66 percent.

In Boston, Dr. Richard Overholt has carried on extensive research in irradiation, particularly in relation to hospital operating rooms and the prevention of post-operative infection. His own office has been equipped with air sanitation by engineers of Hanovia Chemical and Manufacturing Co., Dr. Overholt was successful in reducing the overall infection rate by more than 30 percent.

Schirmer-Atherton Co. decided to try out a similar plan to prevent cross-infection in a business office. Twelve ultraviolet irradiators were installed 20 feet apart to protect a total space of approximately 60,000 cubic feet. Three other installations take care of an additional 20,000 cubic feet in separated offices. All irradiators are placed at an approximate height of eight feet from the floor and the rays are thrown upward to protect occupants' eyes from skin or eye redness.

To meet the demand for precision-functioning resistors, impervious to moisture, heat and other detrimental conditions, IN-RES-CO types RB and SB were developed. Non-inductive, and with standard tolerance of 1/2%, type RB has a maximum resistance of 500,000 ohms, and measures 9/16" high and 9/16" in diameter. It is rated at 1/2 watt. Type SB is rated at 1 watt, has a maximum resistance of 1 megohm, and is 11/16" high and 9/16" in diameter.

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FREQUENCY MODULATION receivers require linear discrimination against undesirable signals. Guthman engineers have developed precise DISCRIMINATOR COILS to discriminate equally on both sides of the resonance curve, providing maximum discrimination.

DO YOUR BEST . . .
INVEST IN WAR BONDS!

EDWIN I. GUTHMAN & CO. INC.
15 SOUTH THROOP STREET, CHICAGO
PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT
The demand for Wilco tubing, wire and other products used in various electronic applications for the Army and Navy has caused the H. A. Wilson Company to increase its manufacturing facilities and develop new products and techniques. Both present and future customers will find these new Wilco developments of great advantage.

The H. A. Wilson Company manufactures and is interested in receiving inquiries regarding the following products—

**WILCO RADIO TUBING**
- Silver Tubing (Fine, Coin, Sterling)
- Gold Tubing (any karat)
- Gold on silver (on one or both sides)
- Gold on bronze (on one or both sides)
- Silver on copper (on one or both sides)
- Tubing made to order from special materials or any combination of materials.

**WILCO RADIO WIRE**
- Silver (Fine, Coin, Sterling)
- Silver-jacketed Invar
- Silver-jacketed Brass and Bronze
- Silver-jacketed Copper
- Gold Wire
- Gold on silver
- Gold-jacketed Bronze and Brass
- Any other type of jacketed wire desired

*Let us analyze your problems. Write*

**THE H. A. WILSON COMPANY**
105 Chestnut Street, Newark 5, N. J.
Branches Detroit • Chicago
Again Johnson scores a first with newly designed thick plates which allow much higher voltages, particularly at high frequencies.

It has long been known that plates with rounded edges have higher breakdown voltages in variable condensers, but it remained for Johnson Engineers to work out ratios of plate thickness, design, voltage, and spacing for maximum advantage.

Greatly decreased length (as much as one-third in some cases) results in lower minimum capacity and lower inductance due to shorter frame rods and other metal parts, which is extremely important at high frequencies.

Corona is noticeably less with the new type plates and corona shields have been added where stator bars enter insulators, resulting in still further improved performance.

Despite these many improvements, in most cases prices are lower because of the saving in material.

Now available in Types A and B, both fixed and variable, this new plate shape and construction will be incorporated in other types as quickly as possible. Write Johnson today for more information and for recommendations on YOUR variable condenser application.

New Catalog 968D now ready.

JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA
The Radio Manufacturer Asked:

just why are these Pan-El people better?

He was given these two answers:

1. **Pan-El production is almost wholly mechanized**

   which means quantity production of control crystals on dependable schedule, and to the most precise specifications—from very-low to ultra-high-frequencies.

2. **Pan-El has developed a great technical staff**

   which means continuous development of the crystals themselves, and of new crystal applications which have solved a number of basic problems ... and may offer the answer to your own problem.

The Pan-El technical staff is ready to collaborate without obligation with your own electronic engineers in the fields of electronics, fm and other radio.

PAN-ELECTRONICS LABoratories Inc.
500 Spring Street, N. W. Atlanta, Georgia

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**Secondary Radiation**

(Continued from page 108)

(23) Tate, J. T., Phys. Rev., 17, p. 82, 1922.
(31) Copeland, P. L., Thesis in the Department of Physics, State Univ. of Iowa, July 1931.
(45) Schmidt, W., Diss. Berlin, 1923.

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**FACSIMILE AT SHAFF**

Radiotelephoto equipment at SHAFF Supreme Headquarters of the Allied Expeditionary Forces in England, when news and news of the invasion transmitted to the rest of the world.
### Quick-Reference Chart

**Miniature Tubes**

**Basic Data for Designers on RCA's Wide Miniature Line**

<table>
<thead>
<tr>
<th>Type No.</th>
<th>Description</th>
<th>Application Data and Suggested Uses</th>
<th>Filament or Heater</th>
<th>Max. Ratings</th>
<th>Typical Plate Ma</th>
<th>Transconductance</th>
<th>List Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b</td>
<td>H-F DIODE</td>
<td>For discriminator in FM receivers and in measuring equipment. Resonant freq., 1000 Mc.</td>
<td>1.4 0.15 H 330a --</td>
<td>0.5g --</td>
<td>--</td>
<td>$1.15</td>
<td></td>
</tr>
<tr>
<td>1f</td>
<td>R-F AMPLIFIER PENTODE</td>
<td>For use where sharp cut-off characteristic is required—no external bulb shield needed.</td>
<td>1.4 0.05 F 110 90 6.5 4.5c 1035c --</td>
<td>1.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1g</td>
<td>PENTAGRID CONVERTER</td>
<td>Has conversion transconductance of 300 microhms at 90 volts on plate.</td>
<td>1.4 0.05 F 90 67.5 5.5 1.6 --</td>
<td>1.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1h</td>
<td>POWER AMPLIFIER PENTODE</td>
<td>Has output of handling audio power output at 270 milli-watts.</td>
<td>1.4 0.10 F 90 67.5 9 7.4 1575 1.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1i</td>
<td>DIODE-PENTODE</td>
<td>Combined diode and a-f penteo providing high voltage gain.</td>
<td>1.4 0.05 F 90 45 4.5 1.6 625 0.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1j</td>
<td>SUPER-CONTROL R-F AMPLIFIER PENTODE</td>
<td>Useful as r-f or i-f amplifier—no external bulb shield needed.</td>
<td>1.4 0.05 F 90 67.5 5.5 3.5 900 1.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1k</td>
<td>THYRATRON (Gas-Tetrode)</td>
<td>For relaying. Will operate directly from high-vacuum phototube.</td>
<td>6.3 0.6 H 1300a --</td>
<td>100d --</td>
<td>--</td>
<td>3.75</td>
<td></td>
</tr>
<tr>
<td>1l</td>
<td>POWER AMPLIFIER PENTODE</td>
<td>Can handle a-f output of 700 milliwatts, or r-f output of 1.2 watts at 10 Mc.</td>
<td>2.8a 0.1 1.4p H 150 90 18 13.3 1900 0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1m</td>
<td>H-F TWIN TRIODE</td>
<td>Has Class C output of about 2 watts at 40 megacycles.</td>
<td>2.8a 0.11 1.4p F 135 --</td>
<td>5.5 AF 30 RF 3.7c 1800 1.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1n</td>
<td>POWER AMPLIFIER PENTODE</td>
<td>Can handle relatively high audio output of 270 milliwatts.</td>
<td>2.8a 0.05 1.4p F 90 90 12 9.5 2150 1.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1o</td>
<td>POWER AMPLIFIER PENTODE</td>
<td>Similar to Type 154 but has filament arrangement for either series or parallel operation.</td>
<td>2.8a 0.05 1.4p F 90 67.5 9 7.4 1575 1.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1p</td>
<td>H-F AMPLIFIER PENTODE</td>
<td>Has sharp cut-off characteristic and high transconductance—useful up to 400 Mc.</td>
<td>6.3 0.3 H 300 150 --</td>
<td>7.0f 5000 2.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1q</td>
<td>POWER AMPLIFIER PENTODE</td>
<td>Can handle a-f power output of 1.1 watts.</td>
<td>6.3 0.15 H 300 250 --</td>
<td>15f 2200 1.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1r</td>
<td>TWIN DIODE</td>
<td>High-performance detector for wide-band circuits. Tube drop, 10 volts at 50 ma. per diode.</td>
<td>6.3 0.3 H 420a --</td>
<td>9a --</td>
<td>--</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>1s</td>
<td>DUPLEX-DIODE HIGH-MU TRIODE</td>
<td>For use as a combined detector, amplifier and a-v tube.</td>
<td>6.3 0.15 H 300 --</td>
<td>2.15 1200 1.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1t</td>
<td>H-F POWER TRIODE</td>
<td>Has Class C output of about 5.5 watts at moderate frequencies and 2.5 watts at 150 Mc.</td>
<td>6.3 0.15 H 300 --</td>
<td>3.5 RF 10.5a 150 RF 2200 0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1u</td>
<td>U-F POWER TRIODE</td>
<td>For use primarily as grounded-grid amplifier at frequencies up to about 500 Mc.</td>
<td>6.3 0.4 H 300 --</td>
<td>20 15 12000 8.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1v</td>
<td>TWIN TRIODE</td>
<td>Used as mixer at frequencies up to 600 megacycles. Also useful as oscillator.</td>
<td>6.3 0.45 H 300 --</td>
<td>30 8.5b RF 5300e 1.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1w</td>
<td>DETECTOR AMPLIFIER PENTODE</td>
<td>A sharp cut-off pentode for use as an r-f amplifier or detector in u-f service.</td>
<td>6.3 0.15 H 250 100 --</td>
<td>2.0 1400 2.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x</td>
<td>DETECTOR AMPLIFIER TRIOIDE</td>
<td>Has moderately high amplification factor. Useful as u-f detector, amplifier, oscillator.</td>
<td>6.3 0.15 H 250 --</td>
<td>6.3 2200 2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1y</td>
<td>SUPER-CONTROL R-F AMPLIFIER PENTODE</td>
<td>Remote cut-off pentode useful as mixer or as r-f or i-f amplifier in u-f work.</td>
<td>6.3 0.15 H 250 100 --</td>
<td>6.7 1800 2.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1z</td>
<td>U-F DIODE</td>
<td>For u-f service as rectifier, detector, or measuring device. Resonant freq., 700 Mc.</td>
<td>6.3 0.15 H 730a --</td>
<td>5g --</td>
<td>--</td>
<td>1.50</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- Peak inverse voltages (I) at 90 volts on plate (and screen) — Per unit
- For an averaging period of 30 sec.
- -- 0 volts on plate
- D-C output Ma.
- Filaments connected in parallel
- Filaments connected in series

**My/Navy Preferred Type.**

**Here is a condensed story on the complete line of RCA miniatures—you will recall—we were an RCA development back in 1940 when that famous quartet, the IR5, 1S4, 1S5, and 1T4, put "personal" portables on the map. War demands have speeded the development of miniatures so that today 22 RCA types are available. Note that 18 of the 22 are on the Army/Navy Preferred Type List; of these 22 tubes, 21 were developed by RCA! When you have a tube application problem, turn to RCA engineers. Remember, the Magic Brain of all electronic equipment is a Tube, and the fountain-head of modern Tube development is RCA.**

**Copies of this advertisement for reference are available on request. Write to: RADIO CORPORATION OF AMERICA, 720 South Fifth Street, Harrison, N. J.**
Steatite Insulators
by STUPAKOFF
FOR TRANSMITTING ANTENNA

In AM, FM and Television broadcasting, Stupakoff low loss steatite insulators have proven their superiority for high frequency installations.

Illustrated are a few styles of precision made lead-in, strain and post insulators by Stupakoff. They provide unfailing service with the ultimate in electrical performance.

Laboratory control—years of engineering experience—modern production facilities—manufacturing skill—combined, enable Stupakoff to produce a complete line of dependable ceramic insulators of unequalled quality for the electronic industry.

Stupakoff engineers, supported by two generations of experience in the manufacture of ceramics, are at your disposal and are ready to assist you in planning projects in the transmitting field.

Do More Than Before—Buy EXTRA War Bonds

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.
Ceramics for the World of Electronics
THE RUBBER SHORTAGE INSPIRED
THIS AIRPLANE BOOSTER PLUG

Another Engineering Accomplishment of The Hubbell Development Laboratory

When the rubber situation became acute, an all-rubber plug was being used to supply a booster charge for aircraft motors. As a conservation measure, the aircraft industry asked the Hubbell Development Laboratory to re-design the plug using less critical material.

Working with plastic and metal, Hubbell engineers produced the external power plug shown here. Its principal advantages are described below. So completely satisfactory is this new plug that it has received wide acceptance and will unquestionably continue to be used after the war.

Hubbell Development Laboratory is an engineering organization serving all of industry. Its purpose is to produce electrical sockets, receptacles, switches and connectors to meet specific requirements. Most of these devices in general use today are either Hubbell-designed or Hubbell-improved. If you have some problem involving products of this nature, write to the Hubbell Development Laboratory. Whether the solution is a simple alteration of some standard unit or the creation of an entirely new design, you can count on complete satisfaction. One of our technical advisers will be glad to call on you to discuss your requirements. This involves no obligation.

APPLICATION SUGGESTIONS WELCOMED. If you believe that the modification of any electrical outlet receptacle, switch, or connecting device will give the product broader application, send your suggestions to the Hubbell Laboratory. Also, if you have any Hubbell products, the uses of which you think are unusual, we would like to know about them. Your ideas may help others solve a problem.

ADVANTAGES OF THE HUBBELL POWER PLUG

1. Heavy armor and impact resisting plastic make this plug practically indestructible.
2. Can be re-wired in case of power cable damage.
3. Non-current carrying reinforcing springs assure constant pressure indefinitely.
4. Insulation extends beyond armor eliminating danger of short circuiting.
5. Designed for use with standard AN cable clamps.

Photograph courtesy of Pan-American Airways
No matter how modern the electronic application

its performance depends on

BOLTS-NUTS-SCREWS-RIVETS-WASHERS

Obtain the rated performance of your electronic equipment by using fastening devices supplied by Sterling. Sterling Bolt Company products are accurate, uniform, with clean threads, uniform heads, true-centered slots, straight shanks, free from scale and burrs. These assure dependable performance, quick assembly and increased production.

Sterling Bolt Company is a reliable, single source of supply for bolts, nuts, screws, rivets and washers of every type and size, of every metal, plain or plated, for every fastening purpose. Try Sterling's prompt, dependable service for your fastening needs.

Write today for quotations.

PRECISION MADE FOR PRECISION FASTENING

STERLING BOLTS
STERLING BOLT COMPANY • 211 W. JACKSON BLVD., CHICAGO 6, ILL.
**M-R Friction and Sealing Tapes**

**M-R FASTHOLD FRICTION TAPE**

Double-Coated With Rubbery Compounds... Tensile Strength more than 44 lbs. — Adhesive Strength more than 50 lbs.

In the manufacture of FASTHOLD FRICTION TAPE the best procurable cotton sheeting (long staple 50/60) is first dried to eliminate moisture... then the fabric is thoroughly impregnated with a filler coat of insulating, waterproofing and preserving compound... after seven days of drying a second coat, exceptionally heavy in rubber content, is forced through the fabric by means of enormous rollers... then follows another period of drying out before cutting and wrapping in tin foil for protection. The materials used and the precision and control exercised in the manufacture of FASTHOLD FRICTION TAPE enables it to meet all known electrical tests and requirements... and to guarantee of against Unraveling or Dry Out. FASTHOLD FRICTION TAPE is New York warehouse stocked in widths of 3/4 1/4 1/4—1 1/4 and 2 inches.

**M-R ANHYDROUS SEALING TAPE**

**IMPROVES WITH AGE AND SERVICE**

25.82% Cotton Sheeting • 74.62% M-R Insulating Compounds Weatherproof, Waterproof, Acid, Alkali, Oilproof... Permanently Flexible... Will not Vulcanize or Dry Out... Tensile Strength 30 Pounds... Dielectric 1,000 volts

ANHYDROUS SEALING TAPE containing nothing which will injure fabrics or metals. It is made of the best procurable cotton sheeting and special M-R luminous Compounds. A wrapping of ANHYDROUS TAPE gradually becomes one solid mass (glass hard on the outside and soft inside) that excludes air, moisture, vapors, etc. It can be used to great advantage under conditions which disintegrate ordinary tapes; inside work where acids or alkali fumes or spray prevail, outside of cable joint insulation in conduits transformer connections, extreme high or low temperatures, etc., mines and damp places where atmospheric conditions and constant friction demand maximum wearing qualities.

A joint, properly taped with ANHYDROUS, is absolutely waterproof, even after complete submergence for many weeks.

ANHYDROUS SEALING TAPES are New York warehouse stocked in widths of 3/4 and 1 1/4 inches... other sizes are available, as ordered.

---

**MORRISON RAND INSULATION COMPANY, INC.**

1 Murray Street

Cortlandt 7-9264

NEW YORK 7, N.Y.

---

**FREE FOR THE ASKING**

Write today for samples of M-R Friction and Sealing Tapes... also your Free Card of Varnished Tubing with samples ranging from size 0 to 20 to fit wires from .032 to .325 inches... other valuable aids, are the M-R Guide Book of Electrical Insulation... the Wall Chart with reference tables, electrical symbols, allowable capacities of conductors, dielectric averages, thicknesses of insulating materials and tap drill sizes... and the M-R Wax and Compound Guide Book... they are full of valuable information... write for them on your letterhead.
Electronic Tester for Electric Cords and Cables

An electronic cable tester, designed and constructed by Consolidated Vultee Aircraft Corp., takes the guesswork out of checking the breaks in electric extension cords and those used on small power-driven tools.

The circuit of the unit is shown in the diagram. One electronic tube is connected as a self-excited oscillator operating on a frequency of about 400 cycles. The output of the oscillator is applied to the cord.

A small amount of the signal energy is picked off the cord by a metal ring through which the cord is passed. Fed to a high-gain amplifier, the signal amplitude is increased sufficiently to operate the output meter shown. When a break in the conductor passes through the ring, a sudden change in the meter deflection occurs and the broken spot can be quickly and accurately ascertained. Thus, the necessity of cutting the cord in more than one place to locate the break is eliminated.

The metal pickup ring is mounted inside an assembly of fiber insulation material that surrounds the cable during use of the instrument. A short shielded lead is provided for connecting the ring to the amplifier. The ring is mounted on top of the test unit.

Input and output potentiometers are provided to permit adjustment of the circuit so that the meter reading occurs at a convenient portion of the scale when a good cable of the type to be tested is inserted in the ring. Additional provision for this purpose is the use of different values of resistance in the output circuit. Besides the output terminals shown in the diagram, made and female receptacles for the cable plugs used in the Vultee plant are contained in the tester.

Cords and cables are tested for breaks by the amplifier and oscillator connected in the circuit shown above. The cord under test and the metal ring act as the coupling medium between the two units.
You know where you stand with the post-war STROMBERG-CARLSON!

First, you have the firm foundation of Stromberg-Carlson's widely recognized pre-war superiority. The quality of its FM and AM reception. The fidelity of its phonograph reproduction. Its pioneering effort in the development of television.

But Stromberg-Carlson has already gone far beyond this—and will offer you a post-war line essentially pre-tested in all its aspects.

Pre-tested in its appeal to dealers. For an exhaustive survey among the trade has developed clearly the features that our dealers are looking for at war's close.

Ad pre-tested in its appeal to the public. For a correspondingly widespread study of the post-war wants and desires of our prospects has permitted our engineers—in collaboration with some of the country's leading industrial designers—to create a line of new Stromberg-Carlson instruments that will set even higher standards of leadership in appearance and in performance.

STROMBERG-CARLSON’S sales story in a nutshell!

1. We will have—soon after Victory—a fine line of Stromberg-Carlson FM and AM radios, phonograph combinations, and television receivers in a wide range of prices.

2. We will have a policy of distribution planned to give every Authorized Dealer a good profit opportunity on the Stromberg-Carlson line.

3. And the Stromberg-Carlson name will be even more widely and favorably known than ever before.
THE MOST ECONOMICAL METHOD

GOVERNMENT specifications require that every part of a military aircraft be electrically bonded. This precaution eliminates the hazard of fire that might result from electrical energy built up in one section of the plane being suddenly discharged to another, creating an arc.

Disposable gas tanks, engine cowls and other accessory parts are fitted with a length of high-conductivity cable. When the units are assembled the jack on the cable is plugged into a receptacle on the plane. These jacks are made by MULTI-SWAGE at a fraction of the cost of other methods.

The BEAD CHAIN MULTI-SWAGE PROCESS forms small metal parts from flat stock. No metal is cut away and there is no drilling, thus no waste. Parts can be produced in volume and at high speed by MULTI-SWAGE while holding tolerances accurately. Our Research and Development Division will gladly assist you. Write for further information.

*Jack and complete disconnect bonding jumper designed and assembled by Aircraft-Marine Products, Inc.

BEAD CHAIN MANUFACTURING COMPANY
88 MOUNTAIN GROVE STREET, BRIDGEPORT 5, CONNECTICUT

BACK THE ATTACK
BUY MORE WAR BONDS

THE MOST ECONOMICAL METHOD OF PRODUCING SMALL METAL PARTS TO CLOSE TOLERANCES WITHOUT WASTE

THE MOST ECONOMICAL METHOD OF PRODUCING SMALL

September 1944 — ELECTRONIC
"Lord Mounts", as they are generally known, are being produced at the rate of many millions per year. A large proportion of this production is of synthetic rubber, which has proved in the main, to be as effective as natural rubber in flexible mounts for Vibration Control.

The entire facilities of the Lord factory are used to produce mountings and other bonded rubber products, and the energies of the research, development, and field engineering staffs, are devoted exclusively to the improvement of these products for industrial and military use. By specializing, Lord is producing mountings that are the criterion in the flexible suspension field.

The method of bonding rubber to metal, which Lord has developed, permits the use of the rubber in such manner that the stress is always in shear, thus providing the proper deflection for a given load. The final result is a mounting system which provides the greatest efficiency in vibration isolation.

Lord Mountings are small, compact, lightweight units, easy to install and load ratings range in small increments from a few ounces to several thousand pounds. They prolong equipment life, lower maintenance costs, insure greater accuracy of operation, reduce material weights by eliminating the necessity for inertia masses, increase personnel efficiency by eliminating nerve-wearing noise and vibration transmitted through solid conduction.

Send for literature on vibration control or call in a Lord Vibration Engineer for consultation on vibration problems. There is no obligation.
The G. E. Magnetic Wire Recorder

TURNER EQUIPPED

Model 50A G. E. Magnetic Wire Recorder has wide application wherever recording of sound for reference is important, or wherever analysis of speech is desirable. Today, these recorders are used extensively in military applications on land, on sea, and in the air. In the peace to come they may be applied in radio and entertainment, in business and industry, and in education and numerous specialized activities. Turner is proud to be associated with their performance.

Free
TURNER Catalog.
Write for your illustrated copy

Crystals licensed under patents of the Brush Development Company

THE TURNER CO.
CEDAR RAPIDS, IOWA, U.S.A.

It's Time to Turn to Turner for suggestions and applications in your Electronic Developments. Orders are being filled today for those whose needs meet priority requirements. But it isn't too early to start discussing your post-war plans.

Steel towers nearly two hundred feet high support the antennas at each terminal. Each transmitting and receiving antenna consists of two parallel arrays of half-wave elements, one behind the other. The front array contains twenty-four horizontal radiating or receiving elements, while the rear array contains twenty-four similar elements that act as parasitic reflectors.

A view of the Cape Charles

Two parallel arrays of half-wave elements mounted 200 feet high form each antenna in the radiotelephone link across Chesapeake Bay
A leak in a cathode ray tube is a disaster... so the time to stop is before precious man hours and material have been expended on final assembly. Tiny as it is, this terminal cap performs a vital function and must be structurally perfect if the vacuum is not to bleed through it. Routine x-ray examination sees to that by disclosing internal weaknesses, such as porosity or faulty welds, which would affect performance, before assembly.

In the electronic industries, radiography also provides spot-weld control... checks on accuracy of filament and grid alignments... discloses imperfect joints, broken leads, and similar common defects in condensers, resistors, assemblies. The Picker 150 KV X-Ray Unit, either stationary or portable, rated at 150 KV, 8 MA operation, has been found ideal not only for such inspection, but also in hundreds of other applications where continuous production x-ray inspection is required.

*For this inspection, quickly loaded tray jigs are used in conjunction with the Picker 150 KV Industrial Unit. This efficient operation was worked out by Picker engineers in collaboration with plant engineers.
A New
TWIST

... to CRYSTAL CLEANING

THIS is an actual photograph of the centrifugal air drier, or "spinner," used in Bliley production to facilitate clean handling of crystals during finishing and testing operations. Quartz blanks are dried in 5 seconds in this device which is powered with an air motor and spins at 15,000 r.p.m.

Little things like lint or microscopic amounts of foreign material can have a serious effect on crystal performance. The "spinner" eliminates the hazards encountered when crystals are dried with towels and makes certain that the finished product has the long range reliability required and expected in Bliley crystals.

This technique is only one small example of the methods and tests devised by Bliley Engineers over a long period of years. Our experience in every phase of quartz piezoelectric application is your assurance of dependable and accurate crystals that meet the test of time.

BLILEY ELECTRIC COMPANY - - - ERIE, PA.

Bliley Crystals
-DAY WILL HOLD A STOP WATCH...

THIS BOOK is designed to help you prepare for CONVERSION DAY . . . it presents the story of a unique institution that may have the answer to your production problem . . . it suggests a plan for putting your new product development in training for the post-war starter's gun.

When materials are no longer ear-marked for war . . . when civilian goods are price-marked for peace . . . there will be no glory or profit at the finish line for any but the winners!

"Cost-Plus" profits will be outlawed . . . wartime regulations will give place to time studies . . . the stop watch will take over control in the competitive race for manufacturing economies.

Lewyt has set the pace in contract manufacturing ingenuity through two post-war periods of business readjustment. We've had long training in cost-sensitive specialization. We're ready to partner with other manufacturers in producing their component electrical and electronic assemblies, chasses and housings . . . or complete units.

With our exceptional facilities and skills in electrical and mechanical parts manufacture carefully developed through 56 years, it will pay you to talk with us . . . at least write for this 48-page book. Ask for "Series B". There is no cost or obligation.

LEWYT CORPORATION, 62 BROADWAY, BROOKLYN II, N. Y.
We Are Busy

Operating 24 hrs. per day in the most modern, efficient crystal plant.

Every crystal finished individually to exact frequency mechanically, completely eliminating hand work, assuring highest uniformity and quality.

Petersen Radio Co.
Council Bluffs, Iowa
Crystals exclusively since 1924

tower and antennas is shown. The transmitting antenna is at the top of the tower, and the receiving antenna directly beneath it. Coaxial transmission lines connect the antennas to the radio equipment in buildings near the base of the towers.

The radio equipment is operated from commercial power lines but at each terminal a stand-by generator, driven by a gasoline engine, has been provided to insure adequate power in emergencies. These auxiliary generators start automatically on failure of the commercial supply.

Type-K Carrier

Although the radio link forms what is essentially a short type-K carrier line circuit, it differs from it in several respects. With the type-K carrier system, the group of twelve single sidebands resulting from the modulation of twelve speech bands is transmitted over the cable as a single sideband of the group carrier frequency.

Meter readings of the radio transmitter at Cape Charles are taken by D. M. Black

The radio transmitter, on the other hand, transmits a double sideband of the type-K carrier group, and thus requires a total band width of 120 kc, instead of the 60 kc transmitted over the cable. A double sideband transmitter was decided upon since it is simpler and less expensive to build.

Another difference is in the regulating scheme. The radio receiver employs automatic gain control to compensate for variations in loss over the radio path. Additional overall regulation is provided for the complete system.
Recent Formica research assisted by new developments in the glass industry which produced glass mat and glass cloth fabrics, along with the perfection of new resins suitable for laminating, has made possible new Formica grades with many important electrical characteristics.

Formica grade MF-66 is a low loss insulator at high frequencies, which retains the high mechanical strength of other laminated grades, and can be machined for rapid production.

Grade FF-10 made with glass cloth base combines good insulating qualities with very high heat resistance, and is just what is needed for such applications as motor slot wedges.

Grade FF-41 made with glass cloth has been especially developed to resist surface tracking and arcing.

These valuable qualities are available in glass base Formica to a degree that was never offered before in laminated plastic materials. Perhaps they can solve some of your problems. Samples for testing on request.

"The Formica Story" is a moving picture in color showing the qualities of Formica, how it is made, how it is used. Available for meetings of engineers and business groups.

THE FORMICA INSULATION COMPANY
4661 Spring Grove Ave., Cinti. 32, Ohio
TYPICAL OF

FOSTER TRANSFORMERS

IS THIS AUDIO OSCILLATOR TRANSFORMER PACK BUILT TO A RIGID NAVY SPECIFICATION. IT IS TUNED TO A FREQUENCY TOLERANCE OF PLUS OR MINUS .4 OF 1%. PERFECT HERMETIC SEALING IS ASSURED BY THE USE OF OUR NEW VITROSEAL TERMINAL CONSTRUCTION FOR THE ENTRY OF THE CONNECTIONS INTO THE CASE.

Yes, we are designing and building transformers for the armed forces to meet specific requirements. This skill of being able to create exactly the right transformer for the individual need will be of great value after the war in the new world of electronic equipment. Our experience covers close tolerance vibrator transformers, output transformers, microphone transformers, saturable reactors, power transformers, audio filters and reactors ... designed and custom-built to fit the most exacting individual requirements.
High altitudes... humidity condensation... thermal shocks... cannot affect the performance of Solder-Sealed apparatus. The 100% hermetic bond assured by the metal-to-PRESTITE seal assures trouble-free service of terminal bushings.

The bushing consists of a PRESTITE tube on which are Solder-Sealed a terminal cap and a stud. Similar bushings are available without hardware for Solder-Sealing to other parts on the manufacturer's own production line.

Solder-Sealed PRESTITE assemblies offer immediate help to manufacturers in many available tinned forms. They also open up many new and old possibilities in postwar uses. For complete information, send for booklet B-3244. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N.

PRESTITE is a dense nonporous ceramic compacted under high pressure and vacuum by the patented PRESTITE method of manufacture. This eliminates minute air pockets in the material, thus minimizing distortion in voltage gradients and eliminating internal corona discharges. PRESTITE is impervious to moisture and all chemicals except hydrofluoric acid. The quality of PRESTITE is consistently uniform, thus eliminating the need for the exaggerated safety factors common in other ceramics.
IT IS A matter of policy with STRONGHOLD that all orders or inquiries pertaining to fastening products are of EQUAL IMPORTANCE, regardless of the size of the order or the size of the company from which it comes.

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between Norfolk and Cape Charles to maintain a substantially constant net loss between terminals. This follows type-K carrier practice, in that the gains of the receiving amplifiers are controlled by means of pilot frequencies transmitted in the frequency space between speech bands. As a result, the net loss of each of the twelve channels is held constant to within ±0.5 db.

To check the frequency of the carrier of the distant transmitter, each radio receiver has an alarm circuit fed through a crystal filter. A deviation in carrier frequency of as little as 0.002 percent will operate this alarm. Alarms are provided to warn of excessive temperatures, power failure, and other conditions that might ultimately affect the satisfactory operation of the system.

Each receiver is also equipped with an oscillator of such a frequency as to permit the output of the local transmitter to be detected. This permits a "loop" test to be made through the local transmitter and receiver. Whenever the transmission alarm indicates a circuit failure, these loop tests are made at each end of the radio circuit to determine the location of the trouble.

Tropical Failures of Electronic Components

THROUGHOUT THE GEOGRAPHICAL belt called the wet tropics, electronic equipment gets its toughest test, not only in service, but even before it is unpacked for use. In this non-temperate climate, temp
In two quick steps, this little part is made. The head and the shank with projection are upset from Alcoa Aluminum wire in a rivet header. A blanking operation shapes the head, and the part is ready for heat treating.

Dimensions can be closely controlled in these heading and blanking operations. Parts, like the carriage bolts you see in the photograph, can be produced with well filled-out square shoulders without the need of expensive milling operations.

Where design and quantities warrant production by upsetting, this process develops sizable economies. In addition to being fast, it saves raw material. You use all the metal you start with, obtaining final shapes by upsetting.

Alcoa is equipped to supply you with aluminum parts produced either on rivet headers, on automatic screw machines or a combination of both. Recommendations are based, therefore, on the most economical method. ALUMINUM COMPANY OF AMERICA, 2136 Gulf Bldg., Pittsburgh 19, Pennsylvania.
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ALLIED CONTROL COMPANY, INC.
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• AIRCRAFT USE... designed to overcome altitude effects to 70,000 feet.

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• Impervious to dust, dirt, oil and other foreign substances normally responsible for over 90% of all relay failures.

• Can be subjected to 100% humidity—continuously.

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Radio Communications operate with greater efficiency with built-in Constant Voltage

The safety and convenience of two and a half million passengers, carried daily by the Chicago Surface Line, are guarded continuously by an elaborate, phase-modulated radio communication system by which all divisions of this vast transportation system are kept under constant surveillance.

Naturally, any communication system so important to human safety and well-being cannot take chances with its equipment. Line surges, voltage fluctuations that distort and interrupt signals or damage costly tubes and equipment, cannot be tolerated.

In this, and in many other radio communication systems, Sola Constant Voltage Transformers are playing an important role—constantly on guard against line voltage disturbances, instantly correcting fluctuations as great as 30% to less than ±1% of rated requirements. Sola Constant Voltage Transformers require no manual adjustments or supervision. They have no moving parts. They protect both themselves and their loads against short circuit.

When supplied as a built-in part of any type of electrical or electronic equipment Sola Constant Voltage Transformers insure longer tube life, fewer service calls and greater satisfaction to the user. Consider these transformers in your basic design.

Constant Voltage Transformers

To Manufacturers:
Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications. Ask for Bulletin DCV-74

SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.

ELECTRONICS — September 1944

201
Coto-Coil

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**RCA WIDE-RANGE AUDIO FREQUENCY METER**

**306-A**

**10 Cycles to 50,000 Cycles**

**A BASIC INSTRUMENT IN LABORATORY AND INDUSTRIAL WORK**

- Checks calibration of beat frequency oscillators or other generators.
- Indicates beat note frequency produced by a standard high frequency oscillator and a radio transmitter.
- Used extensively with recorders in crystal laboratories for checking crystal characteristics.
- Used with an accurate crystal oscillator and radio receiver for checking transmitters at distant points.
- Used with special generator as a highly accurate tachometer for indicating or recording rotational speeds.

**DESIGN AND OPERATING ADVANTAGES:**

**Quick,** accurate, direct reading. Has six-inch indicating meter with ten scales respectively calibrated for 50, 100, 200, 500, 1,000, 2,000, 5,000, 10,000, 20,000, and 50,000 cycles.

**Limiting** circuit makes readings independent of input voltage over a range of several hundred to one.

**Self-contained** regulated power supply compensates for changes in line voltage. Operated from 110 volts, 50 to 60 cycles.

**Wave form** errors practically eliminated by unique circuit.

**Operates** recording meter directly—with no additional amplifier.

**Accurate** to within 2% of full scale.

Please Note Deliveries are subject to the regulations of WPB Limitation Order No. 265.

WRITE FOR BULLETIN containing complete description and specifications. Address Engineering Equipment Department, Radio Corporation of America, Camden, New Jersey.

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September 1944 — ELECTRONICS
On the morning of D-plus-7 Day, Press Wireless made radio and wartime history when it sent and received the first news dispatch to be handled by a private agency direct from the beachhead in Normandy to America.

Transmission speeds of 250 words per minute and more are being regularly maintained. This fast, direct, close-to-the-battle-lines service of Press Wireless, authorized by the war theater command, has become the talk of the communications and newspaper worlds.

Press Wireless radio men are operating the transmitting and receiving stations. Press Wireless designed and manufactured the transmitter being used, a 400-watt set installed in a truck so that it can be kept close to the action, and the receiver, one of our "6019" series.

The last radio communications company to leave France at the time of the German invasion in 1940, and now, the first to return to help speed the liberation of France, Press Wireless is justifiably proud of the distinguished service its men and its products are rendering day and night through Station PX in Normandy. This achievement is brilliantly in keeping with the traditions of a company that has been performing outstanding feats in world-wide communications and engineering for more than 15 years.
干涸并密封于潮湿的环境中。其中，适用于导线的有绕组装配，它们可能在绕组中被浸渍有合成的这斯林并密封。这些装配在绕组中存在差异时，有时是可行的要防止电解作用，通过绝缘的线和提供一个漏电路径在最高的电压和情况下。然而，某些危险可能会被引入，因为附加的高电压区域将被暴露。电解作用只在差别模式的潜在存在时发生。

Capacitors

除非它们是正确浸渍的，电容器，因其在热带环境下的不良适用性，通常被用于热带环境。这些电容器，当新，有高泄漏电阻，通常在除以1000兆欧姆。但是，除非它们被正确处理，它们的电阻率，特别是在热带的几天前，可能会减少到一个兆欧姆。一个超过5兆欧姆的电阻率是不合适的，因为高电压的电容器并特别在单元使用，特别是在板和网格电路中。电网偏压被做为更正的积极影响，由于电压的平均的板电压。

模具化玉型电容器和焊膏直接打开，焊膏的路通过线和电路，这留下一个到外面的路径。在热带潮湿的地区，焊膏将流入并跟随这个路径并最终导致单元的失效。

这种问题可以通过防止焊膏与蜡接合来防止。如果正确处理，焊膏的模具化焊膏将防止焊膏的泄漏。如果焊膏的模具化焊膏和焊膏的焊膏是不弯或混乱，它们将防止焊膏的泄漏。如果焊膏的模具化焊膏，焊膏将流入并防止焊膏的泄漏。由于蜡具有相对低的熔点，蜡将流入并防止焊膏的泄漏。然而，这将不会对电容器的电路的影响，因为蜡将流入并防止焊膏的泄漏。然而，它将实际上改善这些而不是损伤它。然而，
Aesop's Fly

Trotting on the Axle of the Chariot as been Laughed at for Exclaiming, "WHAT A DUST I DO RAISE!"

The wheels of American enterprise geared to war-paced production have been raising a high dust for the past few years. But it would be both absurd and naive for any one industrial unit to claim a large share of credit for this great accomplishment.

As a part of the over-all effort, G. I. was assigned to break a bottleneck in its special field of electronics and radar. By official admission this has long since been accomplished.

Variable condensers, many with circuit applications never before possible, automatic tuning mechanisms, complete wired assemblies and sub assemblies are all part of G. I.'s story. What we have learned in the way of new techniques short cuts and cost cuts will be of high interest in our industry when the last gun cools.
There is a connection between a "snake" made out of rubber, today's planes that are wrecking the Axis, and your business and ours tomorrow.

A rubber "snake" made by the Johnson Rubber Company makes the variable pitch propeller possible. It's a little part you can't see... just one of the small parts that must operate perfectly to make Uncle Sam's war machinery unbeatable.

This particular part is molded to a tolerance of one thousandth of an inch... it is a precision part in rubber... and it must remain lively and resilient under extremes of temperature and high pressures... this is made possible by specifications rubber produced by Johnson formulas.

Thousands of such small parts make the efficient, unbeatable operation of America's war machines possible... all Johnson Rubber production today is for Uncle Sam.

There will come a day, though, when we all have to think about transferring the boys' names from the honor roll to the pay roll, and getting back to our regular job of supplying a peacetime market. To meet that great day with a minimum of time waste is important to the boys coming back... and important to you.

Lay your plans now. Let us help you. Johnson engineers and designers can help you solve problems in your post war products... and come up with the right answers in the right kind of rubber in the specific part you need... and this precision in rubber perfected in wartime will serve you well in peacetime.

We will be ready to supply you when the time comes... but the time to think about it and plan ahead is now... not then.

The JOHNSON RUBBER CO. * Middlefield, Ohio
MOLDED & EXTRUDED RUBBER PARTS FOR INDUSTRY'S VITAL ASSEMBLIES
Indispensable in War—Essential in Peace
A Good Firm to Connect With For Your Postwar Needs in:

CONNECTORS AND RELATED UNITS

Connector Division of IRC produces a comprehensive line of coaxial cable connectors, multiple contact connectors and cable plugs.

If your postwar products call for these or other small parts of a related nature, we suggest you avail yourself of our specialized knowledge, experience and volume manufacturing facilities. Inquiries are invited.

NEW COAXIAL ADAPTER

Adapts British to American Coaxial Connectors

Ever on the alert to meet industries' requirements, IRC offers this precision Adapter to fill a current need for this type unit. This Adapter is now available in production quantities.

HERE'S WHAT IT DOES

Connects British 10H/528 coaxial plug to the Navy 49195 plug and to the Signal Corps PL-259 plug.

Meets Navy Specifications RE493242

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*CONNECTOR DIVISION OF
INTERNATIONAL RESISTANCE CO.

401 N. BROAD ST., PHILADELPHIA 8, PA.

*FORMERLY CONNECTOR CORPORATION
heating a mica unit will change its capacitance permanently; this change generally decreases the value about 5 percent, but occasionally the decrease may be much as 20 percent.

For efficient operation in the tropics, paper capacitors should be of the metal-clad, hermetically sealed type. Ordinary paper cardboard-cased types are unsuitable for use in the wet tropics because they quickly develop excessive leakage resistance. Wax-impregnated paper tubes which are proper wax-impregnated will keep off moisture, the solid wax and sea used in many early types are not adequate to protect the dielectric of the capacitor.

A tubular capacitor may tropic-proofed by being placed in a second tubular casing of metal and then dipped in a potting-type compound which will not fracture easily when solidified.

Paper labels encourage the growth of mold and the accumulation of moisture. It is better to mark the value with paint or ink.

**Resistors**

Resistance values of carbon type resistors which are not hermetically sealed usually increase slowly with time and eventually the resistors become open. Resistor of the type which are encased in molded material can be treated effectively with impregnating compounds.

To ensure good operation and prevent breakdowns, resistor carrying current should have a wattage rating at least four times that called for under normal conditions.

Wire-wound resistors on giant ceramic bales hold up better than wire-wound types built on organic materials which are very susceptible to fungus growth. Failure in wire-wound resistors are generally caused by corrosion and by other factors which affect fine wire coils in general. Practically all low-wattage resistors can be impregnated successfully with a sealing compound. Here again paper labels should be avoided.

Carbon-type potentiometers operating in the tropics have a tendency to become noisy and develop dead spots. Frequent cleaning and drying is thus recommended.

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**Dependable Power..**
In the photographs shown here, only the square patch of filter paper in the center has been treated with Tropicalized Q-Max lacquer. The area free from fungus immediately surrounding the patch shows how effectively Tropicalized Q-Max controls fungus growth even on untreated surfaces adjacent to the treated part.

**Tropicalized**

**Q-MAX A-27 H.F. LACQUER**

Now safeguards Communication and Electrical Equipment against FUNGI

Fungus and mold are ever-present in humid atmospheres, especially in the tropics... ready to impair and destroy the fine precision performance of radio, electronic, signal detector, communication and other electrical equipment used by our armed forces.

To meet this vital need for adequate fungicidal protection of war material, Q-Max chemists spent many months in search of an ideal fungicidal agent to incorporate into Q-Max lacquer ingredients. Many highly effective fungicides proved to be unsatisfactory because they disturbed excellent electrical characteristics or caused corrosion of metals.

But the search is now over, thanks to the effective blending of a potent fungicide with the outstanding dielectric coating material, Q-Max A-27 H. F. Lacquer.

With Q-Max A-27 H. F. Tropicalized Lacquer, no mixing of fungicides and lacquer is necessary—all this is done at our factory. Look for the word TROPICALIZED on the Q-Max label.
When the push-button is pressed, this 42.8 KVA lamp bank is under finger-tip control for instantaneous adjustment of the 171 infra-red 250 watt lamps to the exact energy output required by each production demand. Controlling this installation is a type M1256L-6 wye connected, 3 phase, 440 volt input, POWERSTAT variable voltage transformer.

If your application is smaller or larger, our engineers will recommend a POWERSTAT to — control infra-red to produce a better job faster ... increase lamp life ... reduce operating costs and eliminate the need of adjusting cumbersome lamp brackets.

Send for Bulletins 149 LE and 163 LE

Superior Electric Co., 208 Laurel Street, Bristol, Conn.

SUPERIOR Electric Company
HIGH FREQUENCY PREHEATING

...in the molding of plastics

This message has one idea...to emphasize wartime progress in molding methods which enlarge the field for Durez compounds. In the post-war period, high frequency preheating, along with many other new developments, will provide your custom molder with the means for making his service even more appealing than ever before.

The use of high frequency preheating in the molding of phenolic materials has opened up a completely new field specially in heavy duty materials that are natural for Durez compounds. The principal advantages of this method consist of (1) a reduction in the molding time cycle and (2) a better molded product with greater density, improved electrical properties and a more uniform cure.

The illustration at left serves as an excellent example of the successful application of high frequency preheating in the production of a molded plastic part. The item pictured is a terminal board for military use which was molded from a preform of high-impact macerated-fabric-type Durez phenolic molding compound.

The basic operation of all high frequency preheating is shown in the simple diagram at right (notice the preform in position between the high frequency electrodes). Since the preform is never a perfect non-conductor, some leakage takes place through it. This leakage current manifests itself in the form of heat and thus the preheating of the preform takes place quickly and thoroughly. This method of preheating is particularly valuable when the preforms are of unusually thick, heavy duty material.

The use of high frequency preheating in the molding of plastics is still in the process of development and therefore is extremely limited at the present time. However, the fact that its usage results in a reduction of the molding time cycle and a better product, seems to indicate that it can be viewed as one of tomorrow's certainties.

This is but one of many developments in which Durez phenolics fill the bill. Because of their excellent dielectric properties, inertness to solvents, resistance to impact, high heat, climatic changes, mild acids and alkalies, Durez versatile phenolics have found a place in practically all fields of industry.

Perhaps there is some question in your mind about the inclusion of plastics in your post-war plans. Why not get a competent answer to that question now? Our staff would welcome the opportunity to discuss any plastic material problem with you. Durez Plastics & Chemicals, Inc., 89 Walck Road, North Tonawanda, N.Y.
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required. Provision of adequate ventilation is another help; unit without covers often exhibit better operation and longer life. Wound potentiometers used in current-carrying circuits suffer corrosion of the winding and of the sliding arm. Potentiometers of this type must be cleaned periodically. Filling with white vaseline improves their operation and prevents failure.

Insulators

In the damp heat of the tropics, ordinary sheet fibers and materials which absorb moisture will warp and yield. This characteristic, together with differential expansion, will result in misalignment of component assemblies and will cause changes in circuit constants.

For use in the wet tropics, insulating materials in sheet, block or molded form should be of phenolic composition which resists moisture. Acrylate and methacrylate resins are fair insulators and may be used in low-frequency circuits where a very high dielectric constant is not required, or where it will not be subject to extreme heat. Since this material generally cannot be obtained easily around airfield in scrap form it is often used to replace defective insulation.

Whenever plastic insulating material is cut or drilled, the edges of all holes and cut surfaces should be buffed and then sprayed or brushed with insulating varnish or lacquer. This treatment will prevent moisture absorption and prevent the support of fungus growth.

Wiring

The use of hook-up wire having rubber or cotton insulation should be avoided. Cotton braiding, even if waxed, will absorb moisture. If an organic wax is used, fungus growth will attack it. Even non-susceptible wax impregnation disappears in time and decomposition of the cotton will eventually result. Hook-up wire with Neoprene insulation in place of rubber, and wire with Celanese or Fiberglas insulation in place of cotton, are suitable.

When high-impedance leads are involved, surface wiring is more satisfactory than wiring laced into harness cables. If wires must be laced into forms, the lacing
ANNEALING OF POLYSTYRENE parts, mentioned in the opposite column, is done by Plax, which supplies polystyrene in sheets, rods, tubes and in the famous Polyflex * Sheet and Polyflex * Fiber — tough, flexible extruded forms with wide insulation possibilities. Machined parts such as those shown above are produced by Plax to your specifications. Plax also supplies a polystyrene cement.

Other Plax wartime production includes various forms of cellulose acetate, cellulose acetate butyrate, ethyl cellulose, methacrylate and styramic.

Write for "Fabricating Polystyrene," a bulletin containing full details of polystyrene's properties.

Vibration is a deadly enemy. Unless equipment and parts can withstand its destructive force, irreparable damage results at crucial moments.

Parts tested on Utah's Vibration Life-test Equipment have the "bugs" shaken out of them before they are ready for quantity production; are again proved by this "power dive" test of production runs...assuring unfailing performance.

Equipment being tested is subject to vibration up to 25G.

As a result of this and other tests, many engineers' "brain children" grow up in the Utah Laboratories and on the production lines to play their parts in today's war effort. Tomorrow, these war-created radio and electronic improvements will be adapted to peacetime needs—aided by these new and most comprehensive testing techniques.

Every Product Made for the Trade, by Utah, Is Thoroughly Tested and Approved

Keyed to "tomorrow's" demands: Utah transformers, speakers, vibrators, vitreous enamel resistors, wirewound controls, plugs, jacks, switches and small electric motors.

Utah Radio Products Company, 857 Orleans Street, Chicago 10, Ill.
New Insulator Design Possibilities for Radio

General Ceramics' successful surfacing of steatite with thin films of silver, fired at a high temperature and then built up with an electroplated metal (silver, copper or tin), opens up new insulator design possibilities for very high frequency equipment, as well as for certain applications in the lower radio frequency field.

The metallic film can be applied to the surface of insulators to eliminate corona effect. The use of this combination permits improvement in the design of airplane strain and lead-through insulators.

The addition of a thin metallic surface film also permits soldering of metal parts directly to the steatite insulators. Water-tight seals may be made in this manner where temperature ranges encountered in service are limited.

Your inquiry regarding Silver Surfaced Steatite is invited.
General Electric Deltabeston Radio Hook-up Wires are designed specifically for manufacturers of electronic equipment and devices. These wires are used extensively in aircraft radio and communication systems and are also ideal for electrical measuring instruments, ground communications and closely associated applications.

Deltabeston is constructed in two types—No. 57376 for low-tension, up to 1000 volts and No. 57371 for higher voltage services up to 3600 volts. Tinned copper wire shield can be supplied in either type. Sizes range from 22 through 6 and larger wires can be supplied. Twenty-one standard braid patterns are available. Others can be furnished to satisfy customers’ requirements. Deltabeston Hook-up Wires are treated with a special compound to inhibit the growth of fungi.

For additional information write to Section Y945-119, Appliance and Merchandise Dept., General Electric Co., Bridgeport, Conn. Deltabeston Radio Hook-up Wires are distributed nationally by Graybar Electric Company, G-E Supply Corporation, and other G-E Merchandise Distributors.

materials should be waterproof and inorganic in makeup so that it will not support fungus growth. Binders should not be drawn more tightly than is required to support the form.

In general, solid wire will hold up better than stranded wire for surface wiring. When dressing wire at terminals, care should be taken not to bend sharply, stretch, dress and redress lacquered or varnished wire unnecessarily; otherwise, the coating may crack and the insulation will absorb moisture. Wiring should be as straight as possible; bunching or knotting must be avoided. Fungus growth is heaviest where wires are crowded.

Plugs

Condensation attacks plugs; moisture gets inside, runs down on cables and is often the cause of failure due to electrolysis and final shorting of leads. Holes could be provided in the bottom part of the plug to drain off water.

Batteries

Dry cell batteries have a very short life in the wet tropics. Satisfactory service has been obtained from those in which both inner and outer cases are well impregnated with wax or sprayed with a moisture-proof coating.

Batteries which are mounted in cases should be well screened and separated from metal surfaces by a liner of high-quality moisture-resistant insulation. The battery case should not be allowed to come in contact with metal at any point, even though the battery case appears to be well-impregnated with wax. This precaution is especially important where fairly high wattages are used.

In the field, the life of dry cell batteries is prolonged by repacking them in tins—eight cells to a tin—and soldering the tins airtight. The batteries are left in the tin until needed.

Dynamotors

The failure of dynamotors has been reported in which the cause has been found to be the high-voltage output shorted to the case because of exposure of wire insulation to excessive moisture. Where there is excessive leakage.
Building a quality product calls for skilled engineering, superior materials and extra-fine craftsmanship. Building a quality product in quantity calls for all these things, plus a plant laid out and organized for maximum production efficiency. The streamlined and efficient assembly lines which have poured forth unrevealable numbers of the SCR 299 and 399 Mobile Radio Stations, Mine Detectors, Aircraft Radio Receivers and transmitters and other equipment are International Detrola’s promise of great quantities of the best in radio, television and electronics for a world at peace.

Most of the many hundreds of Detrola Radio Division workers are women, working under most modern conditions. Shown is one assembly line in the main building.

DETROLA RADIO

DIVISION OF INTERNATIONAL DETROLA CORPORATION • BEARD AT CHATFIELD, DETROIT 3, MICH.

C. RUSSELL FELDMANN

PRESIDENT
How to make your product Environment-Free . . . . Have it

Fedelco-Sealed by Federal Electric Company, Inc. Fedelco-Sealing Service

Environment can be the cause of defeating all your careful design...skilled engineering...conscientious manufacture...all your painstaking effort to assure the long, dependable operation of your product.

Fedelco-Sealing offers a sure means of sealing-in ideal working conditions...sealing-out moisture, dust, bugs, and tampering. This new method seals your electrical or mechanical device inside a housing which is proof against these common enemies. This sealing assures your customer of getting, for a long, long time, the reliable operation you built into your product.

We can Fedelco-Seal it for you...or you can Fedelco-Seal it yourself.

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The growing importance of Fedelco-Sealing is shown by its rapidly increasing use. You will want to know about it. Write Federal Electric Company, Inc.; describe your product and your problem; and ask for details of Fedelco-Sealing and how it can be applied to your product.

FEDERAL ELECTRIC COMPANY, INC.
225 No. Michigan Ave., Chicago 1, Illinois
8700 So. State St., Chicago 19, Illinois

Here's how we Fedelco-Seal a Clare Type "C" Relay

1. Base for enclosure, with bracket for mounting relay. Tube is for evacuating enclosure.

2. Glass-to-metal seals surround connections to relay, provide hermetically-sealed terminals.

3. Relay mounted on base assembly and wired to sealed terminals. Enclosure may be filled with dry air, or inert gas, after sealing.

4. Completed Fedelco-Sealed relay. Environment-free, because ideal working conditions are sealed in.
ONE ALWAYS STANDS OUT

IT'S THE QUALITY OF PERFORMANCE THAT COUNTS

ALSIMAG

TRADE MARK REGISTERED U.S. PATENT OFFICE

STEATITE CERAMIC INSULATORS

The chorus is good, but it's the lovely voice of the Prima Donna that stands out. Years of training and experience have produced the exquisite tone, range and color of a great voice.

Grand opera or electronic insulation—it's the quality of performance that counts. Custom-made to your design... formulated for specific characteristics... processed with the knowhow gained from 42 years leadership in the ceramic field... ALSIMAG Steatite Insulators lend stand-out performance to high frequency circuits.

AMERICAN LAVA CORPORATION
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42nd YEAR OF CERAMIC LEADERSHIP

There stability is an important requirement. ALSIMAG Steatite ceramics are surpassed for lending rigidity and permanence of alignment to electronic circuits.
Electronics and what it can mean to post-war sales

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- Where will you fit in the fiercely competitive markets that will come with the war's end? Your position can be determined now, by the methods you employ now, in the design and engineering of your post-war products. Right now, with the aid of seasoned electronic and mechanical engineers, your peacetime items can be started toward top-rank positions in their respective fields.

Alert manufacturers, with a view toward post-war sales and quick acceptance of their products, are urged to consult with National engineers now, on matters electronic, electrical or mechanical.

Write today — Your inquiry will receive prompt attention.

----QUARTZ CRYSTAL PROBLEMS----

Our engineers and crystallographers are ready and willing to help you on the following items:

Radio Receivers Crystal Oscillators Supersonic Devices
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Address your inquiry to — Crystal Division

Electrical and Mechanical Engineering

NATIONAL SCIENTIFIC PRODUCTS COMPANY
Designers and Manufacturers of Electrical and Mechanical Devices
5013-25 NORTH KEDZIE AVE., CHICAGO 25, ILLINOIS

arc-over will occur and the armature winding will burn out.

Occasionally, the insulation will test satisfactorily during a late inspection if the equipment dies out, but failures will recur whenever the same conditions of previous failure exist. The best way to eliminate such failure is to replace the insulation and to rearrange the high-voltage lead so that it is kept away from the dynamotor case and other areas of ground potential.

Test Instruments

In panel-type meters, corrosion attacks the leads to coils, especially near newly soldered joints, also attacks the pivots and armatures in meters which are not properly sealed.

Varnish or lacquer must be used to seal test instruments after they have been opened for repairs for any other reason. Meter glass should be sealed to the case, all other openings, such as screw holes and terminals need attention.

Edges of the back panel require sealing with tape and varnish over. The zero-setting adjustment screw is often a big source of trouble because it allows moisture to get in. After each readjustment, it must be painted over with varnish or lacquer.

Even after applying these measures, test instruments will still fail under conditions of high humidity.

It has been found practical to keep ohmmeters and other test instruments in heated storage boxes with batteries removed when the instruments are not in use.

Electronic Indicator for Detonation

By E. A. TRAYER
General Laboratories
Socony-Vacuum Oil Co.

The device whose circuit is shown in the diagram is essentially an detonation or knock indicator which was especially designed to indicate the intensity of the knock occurring in an automobile engine while determining the octane number of a gasoline. The conventional sound level meter and sound analyzer cannot be used for this purpose because of the transient nature of the sound.

Engine knock is a sound of short duration which dies out rapidly an
A nationwide organization of the Panelyte Division is a clearing house for authentic, up-to-the-minute information on structural laminated resinous plastics.

Our replies to your inquiries are founded — not on theory — but on basic experience in the mass production of fabricated and molded thermo-setting plastic parts for all branches of industry. Nor is this technical knowledge limited to knowledge gained within our plant. Our policy of working closely with customers' engineering departments enables us to give designing aid — and from performance data on hand, to make accurate estimates on the service life of proposed plastic applications.

New type plastics and improved molding and fabrication techniques, developed by our engineering staff, increase efficiency and cut costs on widely divergent applications.

We are always glad to answer any question regarding the design, production cost or use of molded and fabricated laminated plastic parts.

Write for factual "Data Book"

The structural plastic

Panelyte Division
St. Regis Paper Company
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Sales Offices: Atlanta, Boston, Chicago, Cincinnati, Cleveland, Dallas; Denver, Detroit, Kansas City, Los Angeles, Montreal, New Orleans, St. Louis, St. Paul, San Francisco, Seattle, Syracuse, Toronto, Trenton, Vancouver
Long before the war, "Cole Steel Equipment" had earned its reputation for quality. Tough assignments are part of our everyday job... instrument housings... boxes... and chassis. If your blueprints call for close tolerance sheet metal fabrication, send us your specifications.

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OFFICE EQUIPMENT
will again be available after the war
Don't Handicap Important Designs for Lack of a SMALL Electric Switch

THE G-E SWITCHETTE IS ONLY THIS BIG

WHEREVER you need a tiny contact mechanism in ratings up to 10 amperes at 24 volts d-c—an enclosed, self-contained unit that's light and compact, yet can withstand thousands of operations—there's a G-E Switchette to do the job.

This tiny switch weighs only 9 grams, and is suitable for use at altitudes up to 50,000 feet and in ambient temperatures from 200 F to -70 F. It's corrosion-proof—meets 50-hour salt-spray tests. It's vibration-resistant. The contacts will not chatter when subjected to mechanical frequencies of 5 to 55 cycles per second at 1/32-inch maximum amplitude (1/16-inch total travel), or to a linear acceleration of 25 g in any direction.

Two terminal arrangements are available—out the ends of the case as shown above, or out the top through the cover. This makes for easy mounting in any position.

More than 200 design modifications of the G-E Switchette are available to provide for a wide variety of electrical and mechanical arrangements.

SHIPMENT FROM STOCK

Some forms are now available from warehouse stocks in substantial quantities, to give you quick delivery for your important war jobs.

For your copy of our new catalog (GEA-3818B) which gives dimensions, ratings, and ordering directions for both standard and modified Switchettes, call our local office. General Electric Co., Schenectady 5, New York.

GENERAL ELECTRIC
MURDOCK RADIO PHONES

for WAR and POSTWAR

PERFECT reception and trouble-free performance of MURDOCK RADIO PHONES among our armed forces NOW, is insuring a tremendous postwar demand.

Remember, sensitive radio phones can be built in only one way — by precision methods — close tolerances and close inspection. That’s the secret of MURDOCK performance. Close limits eliminate any chance of loose parts or weak connections — this is due to Murdock’s molded construction. You are always sure of clear reception and permanently fine adjustment when you wear Murdock Headphones.

See these “Master Radio Phones!” Send for Catalogue of Murdock Radio Phones and accessories TODAY!

SUB-CONTRACTS Though very busy, our efficient production methods open opportunities for making more Radio Phones and parts for others through sub-contracts. WRITE US.

WM. J. MURDOCK CO. 138 Carter St., Chelsea 50, Mass.
Why coils should be VARNISH IMPREGNATED UNDER VACUUM

The photograph at the right illustrates tightly wound fine wire coils which have been treated with varnish under vacuum. Note the firmness at the points where the coils have been cut with a saw. This firmness was achieved by using the proper grade of varnish for deep penetration under vacuum. To further illustrate this point, it was necessary to use a hammer and a chisel in order to break apart a section of the large coil. For maximum penetration of varnish, impregnate coils under vacuum.

Here are some of the advantages:

First of all, it is possible through the use of a vacuum to remove air pockets between coil layers which under ordinary atmospheric impregnation would prevent the varnish from penetrating the interiors of the coils. Moisture which was not driven off during preheating will be removed under a vacuum due to the fact that at the boiling point of water is greatly reduced at sub-atmospheric pressure. The air and water in coils which are removed under vacuum will be replaced with varnish when the vacuum is broken and atmospheric pressure restored. Those are but a few of the advantages of treating units with varnish under vacuum.

Further information on the treating of electrical units with varnish is contained in DOLPH'S Booklet on "Application of Insulating Varnishes". A copy may be had by making your request on your company letterhead.

Coil Treatment Service

One section of our laboratory contains vacuum equipment having a 12 inch diameter vacuum tank and also modern electric thermo-control ovens. Through the use of these facilities, we are in a position to treat some of your newly designed electrical units which require varnish insulation. Upon completion of this experimental work, a report will be issued covering the several procedures followed and recommendations made accordingly. Of course, this service is offered without any obligation on your part.

MANUFACTURERS OF
CHINALAK BAKING VARNISHES
SYNTHITE BAKING VARNISHES

JOHN C. DOLPH COMPANY
Insulating Varnish Specialists
163A Emmet Street, Newark, New Jersey
For Your Present and Post-War Production

40th ANNIVERSARY
1904—1944

This year Lenz celebrates its 40th year of service to the communications industry.

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

Consider these Lenz Dial Sockets for your present and post-war production. Write for samples today.

LENZ ELECTRIC MANUFACTURING CO.
1751 N. WESTERN AVE.
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ELECTRIC CORDS, WIRES AND CABLES
Solve Your Capacitor Problem
with Oil Type EC
CAPACITRONS

PROMPT DELIVERY!

Phone Your Requirements Now!

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Telephone: MiChigan 9656-7

The CAPACITRON Company
318 West Schiller St. Chicago 10, Illinois
resistor combination is made somewhat longer than the expected interval between successive detonations so that the average voltage on the grid of the detector tube depends upon the more intense detonations while other sounds of the same frequency have very little effect. In this manner, the instrument tends to indicate an average of the loudest detonations and not an average of all sounds occurring at the filter frequency.

The meter circuit has been designed so that a decrease in current through the detector tube, which is caused by an increase in knock intensity, will be indicated as an increase in meter reading. In order to make it possible to read the intensity accurately, the meter is damped so that it averages the knock indication for a somewhat longer period of time than the detector tube circuit. The variable resistor in the plate circuit of the detector permits setting the meter to zero at any level of sound intensity.

The automobile is operated with a non-knocking fuel under normal conditions to determine the noise level incident upon such operation. This operation may be expressed by a curve as shown in the graph. Investigations of knocking at single speed are to be made, and the noise level at that speed need be determined, but in the usual case, knocking over an acceleration range is investigated. Then the auto is operated under knocking conditions and the meter adjusted to give a center-scale reading of the conditions of knock encountered. This adjusts the meter to the motor with which it is to

Circuit of the knockmeter used to show the relative intensity of two fuels

Permo-Flux Corporation
4916-22 W. Grand Ave., Chicago 39, Ill.
PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS

September 1944 — ELECTRONIC
This unit with a nominal output of 20 kw is designed to handle a wide range of induction and dielectric heating applications. It is designed for fixed installation. All controls and meters are located on the front panel. Dead-front construction safeguards operating personnel.

- Single unit construction
- Automatic operation and control
- "Long life" air-cooled tubes
- Shielded to minimize radio interference
- Substantially built housing
- High efficiency—simple maintenance

How fast? Well . . . with Westinghouse Radio Frequency Heating you start figuring a lot of jobs in seconds that now may be taking five to ten minutes—and more.

It will change your ideas about rejects, too. You’ll get unvarying uniformity of depth—area—time and temperature—on one or a million pieces.

By creating instant, uniform heat throughout the predetermined area, Westinghouse Radio Frequency Heating Units keep parts free from damaging internal stresses set up by uneven heating. And highly-developed automatic operation turns tricky heating operations into simple “push button” jobs—whether it’s annealing, hardening, sintering, brazing, soldering.

Westinghouse single unit design "packages" all the radio frequency generating and control equipment into a safe, compact unit. These units are available in output capacities ranging from 1 kw to 200 kw for every induction and dielectric heating application. Why not investigate Westinghouse Radio Frequency Heating immediately?

For more information write for Booklet B-3261-A and Descriptive Data 85-800. Or if you have a specific application in mind a Westinghouse engineer will be assigned to discuss your problem with you—write Westinghouse Electric & Manufacturing Co., P. O. Box 868, Pittsburgh 30, Pa.
A PORTABLE TESTING INSTRUMENT WITH NO PROJECTING PARTS

ROLLER-SMITH TYPE NP . . .

Roller-Smith Type NP Portable Testing Instruments are designed for general service where a highly accurate and extremely rugged instrument is required. The case is made in two parts: an outer walnut case and an inner two-piece metal case. This construction furnishes full magnetic shielding, protects the mechanism from external strains, and the movement from dust and moisture. The lid of the instrument is designed to completely cover the dial and all binding posts, so that when closed there are no projecting terminals or other parts. The window is of maximum area for high dial visibility; scale length is 5¼". Instruments are 8" square by 5½" in depth and weigh approximately 7 pounds. Ratings cover a broad range of testing requirements.

Roller-Smith Type NP Testing Instruments are supplied for the measurement of direct current in milliamperes, amperes and volts. Voltmeters can be supplied with single or double range. Catalog 4340 contains complete description and full information with prices. Write for a copy.

OTHER R-S INSTRUMENTS

Panel, switchboard and portable instruments of practically every standard size, shape, capacity, type and style are included in the R-S line of electrical instruments. Let us quote prices and deliveries on your instrument requirements.

ROLLER-SMITH BETHLEHEM, PENNA

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS OF EVERY TYPE

"Steel-Six" Portable Ammeter. Scale length 5½", Size 6" x 6½" x 1½". Accuracy ½ of 1%. Type T-3.5" Miniature Panel Ammeter. American War Standard type conforming with AWS 29.2-1941.

ROLLER-SMITH MARSLAND LTD., Kitchener, Ontario
What type Air Condenser will post-war radios have?

You can be sure of one thing. They will provide accurate and distinct tuning as never before!

Air condensers of Radio Condenser Co. are used today on radio apparatus of our armed forces and provide such accurate tuning that these men—your post-war prospects—will want the same type reception in their commercial sets. Give them this reception by using our condensers and push button tuning devices.

RADIO CONDENSER CO.
CAMDEN, N. J.
RADIO CONDENSER CO. LTD., TORONTO, CAN.

... Doing a war job today
Especially designed and built for the electronic laboratory

We have found these mobile Tea Wagons useful in our own electronic laboratory and are, therefore, offering them for sale to others.

- Well built of % plywood, will stand any normal abuse.
- Desk type slide for notes, etc.
- Composition castors 2½" in diameter.
- Available in two sizes, with or without doors to enclose lower compartment.

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Woodworking Division

TEMPELTEONE
RADIO COMPANY
Mystic, Conn.

Secret Military Tube has Elements in Parallel Plane

A LARGE NEW FAMILY of uhf electronic tubes, circuits and apparatus has been made possible by the invention of an electronic disc-set tube, called the "light-house tube," by radio engineers in the military services. The existence of the new tube, was acknowledged publicly early in April when General Electric was allowed to disclose that the tubes are available to make possible radio relaying of television and far radio programs post-war. Beyond that, no further information could be revealed.

The Army and Navy have now approved the release of further information on the tube, including the fact that it has given the Allies a decided edge over the Axis in the military radio field.

The new tube eliminates the conventional type of grid anode and cathode. Instead of components being fitted around one another as in the past, they are now constructed in simple, parallel planes or layers used in the contemplated test.

The knock indicator, when properly adjusted for the car engine and test conditions, will indicate knock intensities in much smaller increments than can be detected by the ear. The instrument will also reproduce the knock intensity comparison much better than the same observer on successive trials or on successive days.

...
The Basic Advantages of SUPERIOR SMALL METAL TUBING are the same in peace as in war

- In planning for tomorrow, make use of our experience yesterday and today...
  production in tubing from 5/8" O.D. down in seamless and drawn welded.

**"Weldrawn" Stainless and "Brawn" Monel**

SUPERIOR TUBE COMPANY, NORRISTOWN, PENNSYLVANIA

FOR EVERY SMALL TUBING APPLICATION FROM 5/8" OD DOWN

Seamless in various analyses, WELDRAWN Welded and drawn Stainless, "Monel" and "Inconel"

SEAMLESS and Patented LOCKSEAM Cathode Sleeves
Our Job is to be Ready for the Unknown

War is a time of sudden emergencies, of shifting needs and quick-changing requirements. In the field of metallurgy there’s only one way to keep pace with it, and that’s to keep ahead. That is the reason for the Mallory policy of continuous research and development.

Quite recently that policy was justified anew. The new 400 cycle electrical circuits for aircraft posed several problems to a manufacturer of interrupting equipment. Not the least of these had to do with the choice of a metal for contact facings.

Because Mallory engineers had consistently experimented beyond immediate requirements, they were able to meet the situation promptly. It was possible not only to prescribe a metal that would carry a high current load with a minimum amount of pressure, but to select one already in production—Elkonite® 35-S—a standard member of the Elkonite family. When tests were conducted, contacts made of this metal overcame all arcing and heating troubles, and actually were able to handle currents up to 5000 amperes with a lower contact pressure than any other material tested.

Our job is to be ready for the unfamiliar, the unusual and the unknown. If your design calls for contact applications that have no precedent, then ours is the experience most likely to serve you best.

*Registered U. S. Pat. Off. for electric contacting element

P. R. Mallory & Co., Inc., Indianapolis 6, Indiana

Enroll Your Dollars Buy War Bonds

P. R. Mallory & Co., Inc. Indianapolis 6, Indiana

Mallory Manufactures Contacts of Tungsten, Molybdenum, Silver, Platinum, Elkonite® and Special Alloys for Individual Requirements. Special Designs to Suit Your Applications

Electrical Contacts and Contact Assemblies
Non Ferrous Alloys and Powdered Metal Parts
Smooth Operation calls for Smooth Power motors

PLANNING a new or improved device of small size that will need low torque power? Then you’re going to need motors that will deliver it, smooth as velvet, with instant starting, quick pick-up and reliable operation.

GENERAL INDUSTRIES Smooth Power motors fit these specifications. For years, they’ve been driving such peacetime products as phonographs, record changers, control mechanisms and automotive devices. In the war, they’re on every front, doing their jobs day in and day out with the reliability of a United States Marine.

VERY LIKELY the motor you’ll need will come from our long line of standard Smooth Power motors. But if not, we can adapt a standard model or design a new one for your specific needs.

IF your new or improved products call for comparatively small metal fabricated parts or assemblies, that’s another way we can serve you. When our present war work is finished, our modern plant and capable personnel will be ready to go to work for you. We’d like to have you call on us.

THE GENERAL INDUSTRIES COMPANY
ELYRIA OHIO

THE GENERAL INDUSTRIES COMPANY
Smooth Power
This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. May also be used as a highly stable amplifier, 70 DB gain, flat to 150,000 cycles.

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY, U. S. A.
As applied to motion, electricity has been considered generally as a starting and moving force—but now, with Warner Electric Brakes, it is used for stopping as well.

This brake has another thing in common with many other products—the use of well-engineered springs to control important mechanical actions. Warner relies on Muehlhausen Springs to free the brake bands after the vehicle has slowed or stopped. On one grueling run after another, through heat, rain and crystallizing cold, Muehlhausen Springs perform this job automatically.

A big responsibility for a little spring! But, because of careful design by experienced engineers, it does its job unfailingly.

MUEHLHAUSEN SPRING CORPORATION (Division of Standard Steel Spring Company), 760 Michigan Avenue, Logansport, Indiana
ROCKBESTOS
Permanently Insulated Wires
solve wiring problems in
Electronic and Communications
Equipment

ROCKBESTOS ASBESTOS INSULATED APPLIANCE LEAD WIRE
Sizes No. 8 to 40 AWG solid or stranded copper, mangan or nickel conductors insulated with 0.010" or 0.012" of felted asbestos in black, white or colors.
This Rockbestos All-Asbestos Insulated Lead Wire will not dry out and crack under heat and vibration, won't rot, swell or flow as a result of contact with oil or grease, and has ample moisture resistance for most applications.

ROCKBESTOS TYPE CA LEAD WIRE
Sizes No. 8 to 20 AWG solid or stranded copper, mangan or nickel conductors insulated with synthetic tape and varying width thicknesses of felted asbestos in black, white or colors.
Rockbestos Type CA Lead Wire has the same general characteristics as mentioned above, plus additional moisture resistance and higher dielectric strength provided by the thin, tough, moisture-resistant synthetic tape next to the conductor.

ROCKBESTOS ASBESTOS INSULATED MAGNET WIRE
Round, square and rectangular asbestos insulated conductors finished to meet varying winding conditions and oil treatment requirements.
Designed for Class B windings and also suitable for use as insulated bus wire where high dielectric strength is not required. The insulation is non-checking and is unaffected by heat or aging.

ROCKBESTOS THERMOCOUPLE CONTROL WIRE
Sizes No. 14, 16 and 18 AWG in two to six conductors with 0.010", 0.012" or (for 115 volt service) 0.017" of felted asbestos insulation and plated steel armour.
A multi-conductor control wire for low voltage inter communications, signal and temperature control systems. Its life-time insulation and rugged steel armour will give you trouble-proof service.

ROCKBESTOS MULTI-CONDUCTOR FIREWALL INSTRUMENT CABLE
This unusually small diameter, light weight, high dielectric 3 conductor No. 22 AWG wire was designed for electronic device because three No. 22 AWG single conductor aircraft circuit wires were too bulky. It is made to a nominal diameter of 0.250" (smaller than a No. 14 AWG single conductor 1000 volt Rockbestos Firewall Radio Hookup Wire).

Permanently insulated wires designed for severe operating conditions, wires to meet unusual wiring problems — that's what Rockbestos builds for manufacturers of electrical equipment, electronic devices and apparatus.
122 standard constructions, each with the built-in permanent characteristics that provide resistance to heat, flame, moisture, cold, grease, oil and corrosive fumes, present a wide range of selection. A few of the wires especially adaptable for electronic and communications equipment are shown here. For information or recommendations phone or write nearest Rockbestos Products Corporation.
415 Nicoll Street, New Haven 4, Conn.

ROCKBESTOS S/C FIREWALL RADIO HOOKUP WIRE
Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt.
The first light weight, small diameter flame resistant hookup wire, designed in 1937 and widely used since in airborne and ground communication systems, electronic devices, instruments and apparatus. Operating temperatures range from 115°C to minus 50°C. Also with tin coated copper shielding braid and in twisted pair or tripled construction.

ROCKBESTOS MULTI-CONDUCTOR FIREWALL RADIO HOOKUP CABLE
This type of cable is made up of 1000 V. individual Firewall Radio Hookup Wires (see above) of required size and number of conductors, cabled, and braided or shielded according to customer's specification. For example, this spread 14 conductor 22 AWG cable was tapped, shielded with tin coated copper braid, then jacketed with a black, glazed cotton braid with a flameproof finish.

ROCKBESTOS RESEARCH
Solves Difficult Wiring Problems

NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, OR
INVEST IN BONDS • MAKE EVERY PAYDAY A LAY-AWAY DAY

September 1944 — ELECTRONIC
Always in the forefront of tube research and development, Federal makes another advance and now has added exhaust units of entirely new and original design to its production equipment.

This latest Federal achievement produces a tube that is substantially closer to the perfect vacuum—a tube with greater efficiency and longer life.

Arranged in banks of eight and operated with identical control equipment, these units exhaust uniformly every size of Federal tube assuring a consistent and high standard of quality.

For any communication and industrial power tube need, turn to Federal now to test its reputation that "Federal always has made better tubes."

Federal Telephone and Radio Corporation

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Federal Telephone and Radio Corporation
New Standards of Efficiency
for Many Types of Radio Equipment

THINK of all the places where you can use exceptionally rugged, finely made, light-weight little coils like this! Many types of mountings, pitches from 4 to 44 t.p.i., and any diameter from 5/8” to 1 ½” can be supplied. Q is amazingly high, due to the small amount of insulating material in the electrical field.

These B&W Miniductors can be equipped with either fixed or variable, internal or external coupling links, and many other special features. They are adaptable to every need from complicated band-switching assemblies and “tailor-made” coupling link units, to sturdy, easy-to-mount coils for any tuned r-f circuit. Send us your specifications. We’ll match them!

Control of Stills

(Continued from page 99)

twice the values indicated. The optimum value is determined by the current requirements of the control cell connected between T, and T2 and its maximum resistance. In any event, the sensitivity is influenced by the potentiometer setting.

When adjusting the unit, should the gas tetrode fail to conduct with the potentiometer set for maximum bias and T, connects together through the control cell having its electrodes immersed in a single-distilled water, the bias is reduced until conduction does take place. In the event that the tetrode conducts with the control circuit open and with the potentiometer set for maximum bias the value of is increased. A shield for the lead connecting the grid and the control cell has been found necessary in applications where considerable sensitivity is required.

Limiting resistor R, is selected to limit the surge current to the rated value. The two resistors, R, and R2 limit the average current to the required for reliable operation of the plate circuit relay. Capacitor C must be of sufficient capacitance to smooth the relay current for noiseless operation. Where variable conditions are present in the control cell, relay chatter can be reduced by increasing the value of C, as much as space factors permit.

The circuit described has the usual advantage over similar hard-tube circuits in that the gas tetrode will close the plate circuit relay with no uncertainty if it closes at all, regardless of some abnormal behavior of the control cell. The circuit described has been in operation without a single failure for nearly one year, No adjustments beyond those made during the original installation have been required.

Some System refinements

In some applications better performance may be obtained by connecting the grid lead to one side of the control cell rather than to the other. The control cell used in the present application, shown in Fig. 3, consists of a tubular unit with two platinum electrodes extending down to the level which determines
THE first high-power FM transmitter to be installed atop a skyscraper is the 50-kw. REL model 521 equipment, completed in October, 1941 for the Evening News Association in the Penobscot Building, Detroit — first FM station in Michigan.

To those who do not have suitable high ground available, and must therefore use a tall building to obtain sufficient antenna height, WENA (formerly W45D) is of special interest.

Primary power equipment is installed in the basement. The 3-kw. REL driver and the 50-kw. REL amplifier, together with the speech and control equipment, are on the 45th floor, where the studios and offices are located. On the 46th floor are the water circulating pumps, filament motor-generator, and gas tanks for the transmission line. Phasing and matching section for the antenna is on the roof. A 2-bay REL turnstile is mounted above the ball at the top of the tower, as the illustrations show.

This is probably the most difficult installation that any manufacturer of radio transmitters has been called upon to make. To REL engineers, it was another opportunity to apply our unequalled background of experience. The highly successful performance of WENA over a period of nearly three years is proof that the job was well done.

Such is the engineering service available to all purchasers of REL Frequency Modulation transmitters and associated equipment.

THE FORERUNNER
OF POSTWAR

HIGH-POWER FM
SKYSCRAPER
INSTALLATIONS

RADIO ENGINEERING LABS., INC.
Long Island City, N.Y.
For your applications requiring light weight, compact design, and maximum performance...

24 VOLT SHUNT CONTINUOUS DUTY IN 25° C. AMBIENT

<table>
<thead>
<tr>
<th>Maximum H.P.</th>
<th>1/12</th>
<th>1/16</th>
<th>1/25</th>
<th>1/35</th>
<th>1/50</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. P. M.</td>
<td>7500</td>
<td>5800</td>
<td>3800</td>
<td>2800</td>
<td>1750</td>
</tr>
<tr>
<td>Amps Input</td>
<td>3.8</td>
<td>3.2</td>
<td>2.2</td>
<td>1.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Starting Torque in % of F. L. Torque</td>
<td>200 min.</td>
<td>200 min.</td>
<td>200 min.</td>
<td>200 min.</td>
<td>200 min.</td>
</tr>
</tbody>
</table>

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  has the features that "fill the bill"

**HOUSING** — Die cast, open or totally enclosed.

**FINISH** — Black, baked enamel.

**BEARINGS** — Single, shielded ball bearings.

Bearing housing fitted with steel inserts.

**BRUSHES** — Furnished with metal graphitic or electro graphite brushes of ample size to assure unusually long brush life. Phosphor bronze or beryllium copper brush springs.

**WINDINGS** — Available for operation at 12, 24 or 115 volts, in shunt, series and split series types.

**MOUNTING** — Available for either base or flange mounting.

**MODIFICATIONS** — Motors can be furnished with special shaft extensions, finishes, leads, etc. Motors can also be furnished for operation in high ambient temperatures and high altitudes.

All ratings and data are approximate.

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John Oster Mfg. Co.

DEPARTMENT L-18
RACINE, WISCONSIN

September 1944 — ELECTRONIC
Klixon Disc-Operated Controls

use

Control or Protection

For Positive SNAP-ACTION
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the minimum level of the water in the boiling flasks. It has been found advantageous to set the electrodes at slightly different levels with the grid connected to the higher one. Electrolysis in the control cell has produced no difficulties, probably due to the use of a c. in the control circuit and the exceedingly small currents flowing.

The solenoid valve is placed in the water line leading from the single-distilled water storage tank to the reservoir and the control cell. The reservoir was added in order to lengthen the period between successive operations of the system. Since it is the minimum level that requires control rather than the maximum level, it is preferable that water be added in relatively large amounts at infrequent intervals rather than in small amounts at frequent intervals. The amount added is controlled by a self-starting siphon in the reservoir and by the rate of flow from the reservoir to the control cell. By partially filling the connecting tube between reservoir and control cell with glass wool, the rate of flow may be adjusted to the point where the reservoir fills just as the water level in the control cell reaches the electrodes and closes the electromagnetic valve. The glass wool restriction also serves to damp out level fluctuations due to boiling action as the water level approaches the operating point.

The sensitive electronic relay controls simultaneously the valve and electric heater circuits, opening the valve and turning off the heater whenever the system calls for water. In the event that the single-distilled water tank becomes empty or the valve fails to open, or any other condition prevents the normal supply of water, the still heaters are shut off. Similarly, most failures in the control itself will result in opening both the heater and the valve circuits, thus effecting turning off the stills. By inserting a time-clock switch in the line side of the control circuit the system may be set to operate automatically for a predetermined time.

The heater system as installed originally was provided with a three-phase electromagnetic switch operated from the usual "off-on-pushbutton station. To give the electronic control of the switch with a minimum amount of rewire
The thermistor has come of age during this war. Hundreds of thousands of Western Electric thermistors—of various types—are serving the armed forces and war industries in a constantly growing variety of ways.

Developed by Bell Telephone Laboratories, the thermistor (thermal resistor) is a small circuit element made from materials known as semiconductors. They are characterized by large negative temperature coefficients of resistance. The electrical resistance decreases rapidly as temperature rises—increases as temperature falls, providing a unique, simple, economical means of control.

At present, thermistors can be supplied only for war uses. However, in planning your post-war products, consider the potentialities of thermistors. Call on us if the thermal and electrical characteristics of thermistors would be of value to you.

By all the War Bonds you can! Keep all the War Bonds you buy.

Electronics — September 1944
This new Harvey development is bound to be a star, because it fills the need for a Regulated Power Supply in upper voltages. It may be operated in two ranges, 500-700 at ¾ of an ampere and 700 to 1000 at .2 of an ampere. Both ranges have accurate regulation to one per cent or less.

The new HARVEY Regulated Power Supply 206 PA is a model of efficiency and operating convenience. All parts are readily accessible to the operator. It is equipped with spare fuses, a 6 ft. heavy duty Tyrex cord with a handy two prong plug.

The HARVEY 206 PA is fused on the primary side and has both an overload relay and time delay relay. Two interlocks on the chassis afford the operator complete protection. A black, crackle-finish panel and copper plated chassis make the 206 PA an instrument of beauty as well as precision.

Although the HARVEY 206 PA is too new to picture publicly, it has been thoroughly tested and proved and is now in production. Made by the makers of the HARVEY 106 PA that is providing fine, dependable performance in the 200 to 300 volt range, the HARVEY 206 PA will provide equally fine performance in the higher voltages.

Now is the time to get the complete story on this important new contribution to the radio-electronics field. Write, phone or wire...
Assigned to
"Special Service"

In the electrical as in the electronic field, National Fabricated has engineered battery sockets and receptacles to meet every specialized need. High speed production soldering, rugged construction and positive electrical contact under severe conditions of corrosion and usage characterize National Fabricated Products Battery Sockets.

Courtesy U. S. Signal Corps.

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Manufacturers of SOCKETS, TERMINAL ASSEMBLIES, JACKS AND CONNECTORS for use in every field of electronics.
250

Shallcross SELECTOR SWITCHES

For quality selector switches—try Shallcross! Dozens of standard designs are available—and each of these is subject to many variations to suit individual requirements.

Shallcross Selector Switches are the logical outgrowth of our own need for dependable, high-quality units for exacting Shallcross electrical measuring devices and other equipment. You’ll find them unexcelled for use wherever the call is for switches of assured better performance.

MOISTURE, ANTI-FUNGUS PROTECTION
All Shallcross Selector Switch types are available treated with moisture- and fungus-proofing materials that meet Signal Corps’ specifications.

Write for Switch Bulletins C-1 and C-2

Shallcross MFG. CO.
ENGINEERING • DESIGNING • MANUFACTURING

ing, and to retain the original push button station, a simulated push button station, relay-operated, was devised. This station consists of a solenoid contactor in combination with a mercury switch. The mercury switch is fixed to the contact armature in such a position that the closing of the contactor causes the mercury to flow toward the end of the tube into which the contacts are sealed; however, the closed position of the contactor is such that the globule of mercury does not remain across the contacts. Closing of the circuit is dependent upon the inertia of the moving globule carrying it past the equilibrium position to make momentary contact before returning to the position of rest. This action simulates the pushing of the “on” button. Release of the armature by a signal from the automatic control unit is equivalent to pushing the “off” button.

In addition to its use in the signal system, the electronic relay described has been found ideal for use with sensitive thermo-regulators whose precision depends upon the maintenance of clean contacts. The exceedingly small current is drawn by the unit permit operation for long periods of time with mercury thermoregulators.

* * *

ACTRESS DRAFTED FOR RADIO BY ARMY

Virginia Robinson, Broadway actress, broadcasts messages over a U. S. Army radio net in Italy to German soldiers. She went to Italy to entertain Yankee and Allied troops; instead her excellent German was used to make propaganda speeches between musical numbers.

September 1944 — ELECTRONIC
The Case of the Flying Gull...

In the storm season of 1942, The Flying Gull ran into heavy seas in the Gulf of Mexico. Running before a terrific wind, she made port. Then, just as she was tending about near Hunter's Point, she foundered. But The Flying Gull in eight fathoms of Gulf water. salvaged operations were started. Later in the season her electrical equipment ripped a gigantic wave and foundered. Three days later, out of the blue, he hooked the transformers onto a bench and flipped on the current. amazement, they still showed signs of life. He then ran standard tests. To his astonishment, all twelve of them were working perfectly.

Harvey Stark, owner of the boat, had already ordered a complete new set of transformers from Thermador. He cancelled the re-order. And today The Flying Gull sails with her original Thermador transformers. Not designed for the briny deep—but they could take it!

Such stories of plus performance are not accidents, for Thermador transformers are built to perform beyond normal expectations. They are completely manufactured—not just assembled—under one roof on a vast array of modern precision equipment. They are made only from the finest materials, engineered by men of broad experience. The result is not alone quality but quality in quantity. If that meets your specifications, better discuss transformers with Thermador.

An actual case history from Thermador files; however names, dates, and location have been altered. Buy MORE War Bonds.

THERMADOR TRANSFORMERS

DEFEND HEAT • COLD • HUMIDITY

THERMADOR ELECTRICAL MANUFACTURING COMPANY

5119 SOUTH RIVERSIDE DRIVE • LOS ANGELES 22, CALIFORNIA
New Rotating Slide Rule with 24 Scales on Slider

A rotating slide rule that permits a wide range of applications by electronic and electrical engineers has been invented by Lt. Jerry Allinger, communications officer of the Boston Fire Alarm Headquarters. Called the "Rota-Vec-Trig," the new rule is designated as a log-log, vector and trigonometric slide rule.

In appearance, the instrument resembles the ordinary slide rule, but contains 24 scales on its slider, compared to a maximum of eight on usual rules. All 24 scales operate against each side of the body. The 24 scales are grouped four to each face of a rotating hexagon axially mounted in the slider, and are instantly interchangeable by means of a milled wheel protruding slightly from the rule face. The selected scale locks in place when the plane of the scale is flush with the rule surface.

These scales are rotatable through 360 deg, which permits all 24 scales to slide against each side of the ruler body without removing the slider to turn it over. The rotating hexagon, due to the great amount of space available, has scales representing the six leading functions of trigonometry, thus eliminating the need of converting certain functions by a primary solution involving identities, reciprocals, etc.

Rewriting a problem for slide rule solution is practically eliminated. The provision of scales of tangents greater than 45 deg and cotangents less than 45 deg allows the computation of tangents of any magnitude by the basic formula arc tan \( \theta = \frac{a}{b} \), rather than by reciprocal form; where \( \frac{a}{b} \) is greater than 1. Complements are present when needed.

All scales except \( A, B \) and \( KS \) are of full unit length for greater accuracy and ease of operation. The \( KS \) scale is like the \( K \) scale on other slide rules, but is on the slider. It provides automatic cube root extraction regardless of the number of times the radical appears in either the numerator or denominator, and does away with the need of grouping "like radicals". Another interesting feature is a radian \( \theta \) scale complementary to the \( C \) and \( D \) scales. This gives the angle subtended by \( N \) radians, or conversely, the equivalent radian value of \( N \) degrees.

A \( 2\pi \) scale provided is invaluable in calculating problems involving angular velocity. It gives the value of omega (\( \omega \)) in a single setting. Radio engineers find this useful in problems of resonant frequency and inductive reactance, and when used with the \( DF \) scale, the computation of capacitive reactance. Another innovation is the introduction of log-log scales on the sliding section for greater flexibility. There are also new log-log scales of decimal quantities of full unit length for greater accuracy, referred to the \( D \) scale, which give the value of negative powers \( (e^{-}) \) with a single setting. Besides folded and inverted scales on both body and slide, provision is made, when desired, for scales representing hyperbolic functions, also special scales for navigators, surveyors, chemists and other specialists.
What better assurance of these important benefits than the record itself! ... The record of Ohmite experience in pioneering new rheostat, resistor and tap switch developments—in producing the widest range of types and sizes—in meeting the varied requirements of innumerable applications with high quality units that have proved their reliability and long-service economy.

In designing for war or postwar ... remember Ohmite experience. Consult our engineers on your control problems.

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Foremost Manufacturers of Power Rheostats, Resistors, Tap Switches

The Right Rheostat, Resistor, or Tap Switch for Each Job

Consistently Accurate, Dependable Control

Long-Service Economy Under Varied Conditions
The ELECTRICAL INSULATING PARTS must be rugged.

CONTINENTAL-DIAMOND

Electrical Insulating Materials are engineered to meet specific mechanical, electrical and thermal problems. With many years of experience helping customers apply the 6 different C-D electrical insulating materials to specific problems...C-D technicians have accumulated a wealth of "Know How," which is at your disposal to help you solve your insulating problem. C-D technicians welcome an opportunity to help you with your post-war designs as well as with your immediate "What Material?" problem. Send for Bulletin GF today.

Micro Switches are responsible for the accurate operation which has made Lear Actuators ideal components for use in military aircrafts.

Lear Avia, Inc., Piqua, Ohio, who build these light, powerful-electro-mechanical devices, find Micro Switches provide the precise, instant control required yet keep within the required limits of small space and light weight.

The small Lear Actuator shown here weighs but 3.3 pounds. Yet is capable of moving 1200 pounds. Rotary type Lear Actuators are capable of operating torques from 400 inch-pounds to 6500 inch-pounds.

Lear Actuators must operate instantaneously. Micro Switches, used in pairs, cause the unit to start or stop at the end point of predetermined setting in the control box. The first Micro Switch limits the actuator travel in one direction, the second Micro Switch serves as the limit to travel in the other direction. Lear Actuators may be controlled by manual switches, thermostats, pressure switches, etc.

Micro Switches were selected by Lear Avia, Inc. because of the sensitive and precise limit switch was required to provide the accuracy of control necessary. The quick make-break action of Micro Switches was also found to assure long operation life on severe direct current loads. No unit failure due to faulty Micro Switches has ever been recorded.

Designers and production engineers who are letting pre-conceived ideas go by the boards . . . seeking a new way . . . will do well to investigate Micro Switch. This tiny, snap-action electric switch can be counted on for any application where a small, precise, sensitive switch is required that will respond accurately to actuating motion through millions of repeat operations.

Micro Switches provide over 2700 variations . . . combinations of housings, actuators and electrical characteristics. For complete information, send for Handbook-Catalog No. 60. If your application is for aircraft use, also send for Handbook-Catalog No. 70.

"Uns Unlimited"—a dramatic talking motion picture of Micro Switches, in color, is available to industrial groups, training classes, schools and colleges, through Y.M.C.A. Motion Picture Bureau, New York, Chicago, San Francisco. Size: 16 mm. Length: 40 minutes. Write us for details.

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A Division of First Industrial Corporation
Freeport, Ill., U.S.A., Sales Offices in New York, Chicago, Cleveland, Los Angeles, Boston, Dallas, Portland, (Ore.)
**What is it worth?**

Cannon Quality Control adds plenty to our cost of manufacturing Cannon Plugs. We can't hold to such high production standards without paying for it.

But what is it worth?

When a set of flying instruments go dead in a soupy fog, when a motor konks out in a power dive, when a plane crashes with a loss of life—it's worth a lot to us to know that a Cannon Plug didn't cause the trouble.

And if such assurance is worth the extra time and better materials and added inspection cost to us how much more is it worth to the men directly involved?

Your answer to that one is your best reason for using Cannon Plugs exclusively.

**Battery Connector Bulletin** lists a wide variety of Cannon Connector types for battery installation. Your copy free on request. Address Department A-120, Cannon Electric Development Co., 3209 Humboldt Street, Los Angeles 31, California.

**CANNON ELECTRIC**

Cannon Electric Development Co., Los Angeles 31, California

Canadian Factory and Engineering Office: Cannon Electric Co., Ltd., Toronto, Canada

**Fig. 1**—Circuit illustrating the principle of stabilization of oscillator output amplitude by means of a diode stabilizing diode D. The cathode of the diode is made positive by a battery B or other suitable means, and the biasing voltage is chosen to be slightly less than the desired maximum voltage to be generated in the tuned circuit. If the amplitude of the oscillations should tend to increase when the frequency changed, the diode D will begin conducting for the peaks of the positive half waves and will act as a load on the tuned circuits which increases as the amplitude increases. It therefore tends to limit the amplitude of the oscillation. However, experience shows that the stabilizing control is not very great and considerable amplitude variations still occur.

**Use of Triode**

The effectiveness of the control greatly increased by using the circuit of Fig. 2 which uses a triode to shunt the tuned circuit instead of a diode and which applies the control grid the amplified and rectified variations of the oscillating voltage by means of the detector amplifier connected as shown. This can be most easily appreciated in the following way. Let \( v \) be variation in the amplitude of the oscillating voltage. This will be detected and amplified and will be...
UNIQUE research, engineering, tool making and production skills combine, not only to build control devices that fulfill the most exacting requirements, but also to build special purpose devices for which no specifications exist. Our list of customers, the most exacting in government, aviation and manufacturing, attest to these skills.

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Use LEIMAN BROS.
High Speed STENCIL SAND BLAST PATENTED
RAPID CLEANING of Weld Joints

Cabinet Type—work done inside cabinet.

Cabinet Type—work done by pressing against top aperture on outside.

LEIMAN BROS.
155 CHRISTIE STREET, NEWARK, 5, N. J.

multiplied by some factor \( \mu_1 \) becoming \( \mu v \). This voltage is applied to the grid of the tube and produces the same damping effect on the tuned circuit as another voltage applied to the plate and equal \( \mu v \) multiplied by another factor thus \( P = \mu_1 \mu v \). It is evident that much greater load will be placed on the tuned circuit for the same value of \( v \) with the arrangement of Fig. 3 than with that of Fig. 1, and accordingly a much more effective stabilizing control is obtained. Most standard triode valves have an amplification factor \( \mu_1 \) as high as 5 and \( \mu_2 \) may easily be made equal to 10. A multiplication of 500 is therefore obtained. The result can provide a circuit in which the variations of the whole frequency band is less than 0.05 db.

Practical Circuit

Figure 3 shows a simplified diagram of a practical stabilizing circuit in which the variations of high-frequency oscillating voltage are detected by a conveniently biased triode \( D \), and amplified by a direct-current amplifier VT-1. The cathode of the diode is given a positive bias by battery \( B \), the voltage of which should be slightly less than the minimum amplitude of the uncontrolled oscillating voltage in the tuned circuit taken over the whole frequency range of interest. The diode \( D \) accordingly tends to produce a rectified output voltage in the load resistance, \( R_l \), proportioned to the excess amplitude. This voltage smoothed in the circuit comprising the resistance \( R_s \) and capacitor \( C \) and applied to tube VT-1 arranged as a direct current amplifier, producing an amplified continuous voltage across the load resistance shunted by the bypass capacitor \( C \).
Soon!

PANORAMIC RECEPTION WILL BE USED BY GI JOE WITH HIS "HAM" RIG

When GI Joe takes off his helmet, he will still remember many of the things he is learning in the Army. As a radio operator, he uses Panoramic reception for effective monitoring and for playing tricks in enemy field communications. He recognizes its value for peacetime as well as for wartime. On the basis of military experience, he will want to make use of Panoramic reception for many more pleasant hours at his own command. Because it SHOWS ALL SIGNALS ON A GIVEN END OF THE RADIO FREQUENCY SPECTRUM SIMULTANEOUSLY, GI Joe knows that Panoramic reception will tell him what stations are on the air, whether they are phone or CW, and what their signal strengths are when they reach him. Most important, he can be sure that he will miss very few calls in response to his CQ's.

Currently, Panoramic reception also is doing good work in laboratory development and industrial applications. Its ability to measure, interpret and compare variations in inductance, capacitance and resistance has created possibilities that are being utilized by far-sighted manufacturers. If Panoramic technique can be adapted to your present or future needs, ask our engineers for more detailed information.
and is applied to the control tube VT-2 which then operates as a very sensitive amplitude limiter.

Any increase of the oscillating voltage across the tuned circuit produces an equal negative voltage across capacitor C, and C, and a much greater voltage increase at the grid of VT-2. This greatly increases the load across the tuned circuit and reduces the oscillating voltage to very nearly its initial value.

The cathode of tube VT-2 is biased positively by suitable means shown as a battery B,, the voltage of which should be adjusted in order that the current flows in VT-2 only during the positive peaks of the oscillating voltage. When the adjustment is correct, the oscillating waveform becomes sinusoidal with a very small percentage of harmonics.

**Another Circuit**

The circuit of a practical arrangement with which the method has been tested is shown in Fig. 4. This circuit is slightly different from the circuit of Fig. 3. There is no diode, the grid-cathode portion of VT-1 being used as a diode, and there is no battery B,. Only a small fraction of the oscillating voltage is transmitted to the grid of VT-2 by means of the potentiometer divider C,C. The sensitivity is much smaller than the circuit of Fig. 3, but is still sufficient to give a perfect stabilization. Tube VT-3 is used also as an electronic voltmeter, and the oscillating voltage across C, is indicated on the meter M.

Adjustment for the best control is easy. The bias of the cathode of valve VT-3 should be adjusted until maximum stabilization is obtained. If the cathode should be given a positive potential greater than the maximum oscillating peak voltage, there will be no control at all as the tube will always have an infinite impedance. By making the cathode progressively more negative, the control increases until some point is reached at which the load on the tuned circuit, at the peaks, becomes so great that the control is maximum and the amplitude of the oscillating voltage starts to decrease rapidly. The best operating point will be just before this occurs. With the circuit as described and as adjusted in the man
You may have received this interesting series of booklets on Mica by Macallen.

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Macallen says "From the mines of India comes our mica... the mineral that possesses the vitally important properties for electrical insulation."

Macallen, by a special process, ingeniously cements extremely thin mica splittings into larger sheets of any desired thickness. From the sheets come numerous mica products to meet your needs.

Macallen mica has high dielectric strength, great inductive capacity, resists puncture, has low power loss, stands high temperatures, and is impervious to moisture, oil, and chemicals. In short, mica is immune to everything—but continued duty.

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India and Amber Segment Mica... India Moulding Mica Plate... Flexible Mica Plate—Mica Tapes... Mica Commutator Segments and Rings... Mica Tubes—Mica Specialties.

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Electronics gears must be accurate without exception for use in Army—Navy radios and instruments on land, sea, and in the air.

Accuracy cannot be compromised with in these war days of lightning speeds and world wide communications, all tuned into our present tempo by precision gears.

**Fig. 4**—Practical circuit used to hold output voltage constant on a multirange oscillator covering frequencies from 30 kc to 9 Mc. One grid and the cathode of VT-2 form the detector.

Inner just explained, it is possible to maintain the oscillating voltage constant within about one percent when it would vary by perhaps 200 percent without any control.

The circuit of Fig. 4 has been tried with five different coils in order to cover the frequency band from 30 kc to 9 Mc, and for each coil the stabilization was found perfect.

Although the control circuit employs three tubes, the total power necessary for operating them can actually be made small compared with the power necessary for the oscillator. For example, VT-2 could

**Bowl covers** used by housewives have been drafted by the Signal Corps to serve as covers for microphones in freezing temperatures. They prevent moisture from a speaker's breath from condensing and filling the small holes with ice.
Homeward Bound

Breeze Aircraft Armor Plate Brings 'Em Back Alive
In World-Wide Theatres of Warfare

Breeze Aircraft Armor Plate is in use today on Allied invasion fronts, providing dependable protection for pilots and gunners of American hard-hitting bombers and fighters. Produced in quantity by the Breeze Electric Heat Treating Process, the fastest known for the purpose, this Armor Plate helps to bring home not only trained personnel but valuable equipment as well.

Breeze Armor is manufactured in two types: homogeneous and face-hardened. Although light in weight, it possesses the highest ballistic qualities and resistance to shatter. Complete assemblies to designers' special requirements are a specialty. Aircraft Armor Plate supplements the well-known Breeze line of equipment which is now in service on land, on the sea, and in the air.

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CORPORATIONS, INC. NEWARK, N. J.

DUCTION FOR VICTORY • PRODUCTS FOR PEACE

ELETRONICS — September 1944
The New Home of Stewart Metal Stampings, outstanding in its architectural beauty, furnishes an appropriate setting for the Stewart "Quality" Line.

Announcing

THE REMOVAL OF OUR FACTORY AND OFFICES TO NEW AND LARGER QUARTERS

THE steady and consistent growth of our business has made it imperative for us to expand our manufacturing facilities. This fine modern fireproof structure, to which we hold title, furnishes the answer.

The new home of Stewart Stampings embraces every up-to-date construction feature—daylight windows and skylights—automatic heat regulation—high ceilings and scientific ventilation—and large loading platforms to facilitate shipping.

With greatly increased floor space now available, we have added many new units to our mechanical equipment, resulting in faster production—increased volume—and an all-around better service to our customers.

STEWART STAMPING COMPANY
TERMINALS LUGS BRACKETS CLIPS
630 CENTRAL PARK AVENUE YONKERS 5, N. Y.
a very low-power tube whose maximum current is not more than, say, 2 milliamperes; and tube VT-3, owing to the manner in which it operates, will generally draw a plate current of less than 1 ma, even if a power tube such as a 6V6 or 6L6 is used. The voltage divider arrangement can also be arranged so that the total current drain is not more than about 7 ma.

Electronics in AIEE

PAPERS on electronic subjects were presented at the summer technical meeting of AIEE in St. Louis during June than have been given in meetings in the past. Among those with electronic significance, one by N. D. Kenney and Perry H. We referred to design and testing of coaxial cables.

The first part of the paper presented a discussion of the variation of transmission line parameters, both basic and working, as a function of construction and frequency. The and approximate formulas were given for computing cable properties, with notes on applicability and limitations as well as practical methods of test.

Simplification of the analytical expressions for rectifier behavior was the objective of a paper by E. Christensen and C. C. Herskind of General Electric and C. H. Wilk of Princeton University. The paper gives the methods used in analyzing rectifier circuits, illustrates the application of new circuit concepts, provides standard procedure analysis of rectifier circuits, gives a standard form for the presentation of rectifier characteristics, and presents a comprehensive set of characteristic curves for the delta-delta-y rectifier.

Design and tests of a mercury-vapor rectifier with exciter anodes was summarized by H. Winograd of Eastman Kodak Co. He described the application to electrochemical service of a 12-tanks Electrolyzer unit rated at 5,000 amp., 650 volts d.c.

Control for Welding

Improved electronic control for capacitor-discharge resistance welding was presented by H. J. Bichsel and E. T. Hughes of Westinghouse. His paper describes a capacitor-
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IT'S FM . . . the clearest voice on the air—We'll all be hearing it soon.
And when this method of broadcasting, along with television, is adopted by the nation's networks, Blaw-Knox will be ready with proven types of Towers to give new developments in antennas the utmost efficiency... Our engineers will be glad to assist you now in experimental work.

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BLAW-KNOX FM AND TELEVISION RADIATORS

discharge welding control designed to give high-speed operation and low maintenance.

Basic elements include: (1) a capacitor bank in which energy for the resistance weld is stored; (2) a rectifier system with its charge control and blocking circuit for converting a-c to d-c power and for automatically supplying an exact quantity of energy to the capacitor bank; (3) a discharge system to convert the stored electrostatic energy into welding current; (4) a flux reset circuit to restore the welding transformer flux to the same value between welds, and (5) a sequence control system including a forge timer to coordinate the operation of (2) and (3), above, with the mechanical system.

Fundamentals of hearing-aid design were covered by W. D. Penn. He showed that frequency-selective amplification is usually beneficial and described a method of obtaining this type of action, with mathematical analysis to support the conclusion. Means of computing acoustical amplification were also described.

By combining the advantages of electronic tubes and symmetrical component filters, a new carrier relay results in a marked simplification over previous systems. It was described by T. R. Halman and A. F. Drompp of Detroit Edison Co. and S. L. Goldsboro and H. W. Lensner of Westinghouse. Not only has the number of relays been reduced but the number of operating elements per relay as well.

In an aircraft engine torque meter described by F. W. Godsey, Jr. and C. F. Langer of Westinghouse, resistance strainage elements and vacuum tube amplifiers are combined. The paper included an extensive survey of methods for measuring torque.

**Electronic Frequency Conversion**

In a symposium devoted to the subject of electronic power conversion, one paper referred to the installation of a 20,000-kw electronic converter to exchange power between 25 and 60 cycles. The converter was described by F. W. Cramer of Carnegie-Illinois Steel Corp. and L. W. Morton and A. G. Darling of GE.

Distribution of currents in various transformer winding and recti
Smied because you've just got
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Orders Accepted Now for Post-War Delivery*

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ONE KILOWATT

BROADCAST TRANSMITTER

An Example of How Gates Wartime Developments Create Higher Efficiency at Lower Cost . . .

Here is "tomorrow's transmitter—completely engineered today!" Combining these important features.

- Low initial tube cost
- Low operating cost
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- Extremely easy to install
- "Easy-view" meter panel

Yes! Gates is ready for your post-war equipment needs. This new, 1000 watt transmitter is completely designed and operating under rigorous conditions . . . ready for post-war delivery. The Model 1D is designed as a commercial broadcast transmitter, but is also available, on special order, for high frequency operation up to 20 megacycles.

*May we send you details regarding the Gates Priority System for prompt postwar delivery?

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MANUFACTURERS OF RADIO BROADCAST TRANSMITTERS, SPEECH EQUIPMENT RECORDING APPARATUS AND ALLIED EQUIPMENT IN THE ELECTRONICS FIELD.

flying elements under conditions of unbalance were considered by E. F. Christensen and M. M. Morack of GE. Effects of such unbalances on circuit duty and rectifier capacity were indicated.

Measurement of dielectric properties at uhf by the resonant cavity method was considered by C. N. Works, T. W. Dakin, and F. G. Boggs of Westinghouse. In this method a reentrant cylindrical cavity is adapted to measure the dielectric constant and power factor of small disks, samples, and insulating material. Methods of measurements, mechanical details, and electronic coupling and detecting circuits employ technique common to uhf. Because the cavity has a value of Q higher than 2,000, it is much more sensitive to low power-factors of samples than any conventional coil- and capacitor-resonant circuit.

Furnace Regulation

Electronic motor control for regulating arc furnaces was covered in a paper by J. E. Reilly and C. E. Valentine of Westinghouse. The method has proved successful on many applications where a wide range of speed control and quick response are desired. Many combinations of acceleration and speed range can be obtained with a minimum of apparatus and almost instantaneous response. In the electronic system, the field is held constant and the armature voltage is varied to give the desired speed. Moving parts are eliminated from gear ahead of the motor.

- - -

D-F IN FCC CAR

A mobile direction finder used by the FCC to trace outlaw stations is explained to Congressmen Hart and Wiglesworth by J. B. Lewis (right) monitoring officer in charge of the mobile unit.
HERE'S HOW TOLERTON LUMBER CO. MET INCREASED PRODUCTION DEMANDS

BEFORE December, 1941, wood aircraft manufacturers were using spars cut from solid wood planks. But the supply of soft spruce for such spars was also limited. Thus spars laminated from thin strips came into the picture; next, to further conserve lumber, short lengths were self-jointed; and finally narrow widths to be edge-glued in order to meet demands.

As a result of these many operations, costs and production time increased sharply. The Tolerton Lumber Company, applying electronic heating to speed the setting of the glue, found that edge-glued joints could be “set” in 2 minutes; that scarf joints could be “set” simultaneously—in about 10 minutes; and that a 6" x 6" x 16½' beam could be laminated from several planks in about 20 minutes by electronic heat (former time in hot-platen press was 4 hours).

The aircraft spars are cut from these cold feet beams. Tolerton uses an RCA 15-kw electronic generator.

Results:

Because electronic heating shortened time so greatly, the Tolerton plant output was increased from 25 spars per day to 200!

The setting of the glue is complete because electronic heating produces uniform temperature throughout the glue line.

Lumber costs were cut about 40% bringing odd pieces!

In tests of these glue joints, wood flake runs 100%—considerably above the 80% acceptable under Government specifications.

For more complete information on this application, send the coupon below.

Other Applications by Tolerton: “In addition to manufacturing spars and other aircraft parts such as ailerons, fairings, fins, capstrips, etc., at a big saving in time, lumber, and expense,” wrote Mr. R. I. Tolerton, vice-president of the Tolerton Company, “we are also using this electronic method of gluing in the manufacture of lithograph backing blocks and steelmill hammer boards.

“The manufacturing rate has increased greatly, and the products are more accurately made because of the added glue adhesion obtained by electronic heat. We also laminate 6-inch square maple blocks which are later turned to make wheelbearings for bombers. Electronic heat has made these blocks the most satisfactory material yet found for the purpose.”

Want More Details? The complete story of the Tolerton operation—together with pictures, drawings, diagrams, and curves—is contained in a free 8-page article “Electronic Heating Sets Glue in Laminated Aircraft Spars.” Write for it, or send the coupon. If you have a problem electronic heating might solve, write us the details; our engineers may be able to help you. Address Radio Corporation of America, Electronic Apparatus Section, (70-40H), Camden, N. J.

RCA ELECTRONIC HEAT

BUY WAR BONDS

RCA 15-B Electronic Power Generator which supplies about 50,000 B.T.U. per hour. (Send coupon for bulletin.)

SEND FOR DETAILS! RCA, Electronic Apparatus Section, Camden, N. J.

Gentlemen: I want more information on how Tolerton Lumber Co. increased output 700% with electronic heat. Please send me “Electronic Heating Sets Glue in Laminated Aircraft Spars.” Also booklet on the “RCA 15-B Electronic Power Generator.”

☐ I would like an RCA sales representative to call.

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269
Remote Amplifier:

(Continued from page 131)

visible indication of field intensity in the null point of the radiating pattern. In contrast to a method in which a reading must be taken periodically by a comparison balancing method, this continuous indication will give immediate warning of an increase in the signal in the unwanted direction and could of course be readily adapted to operate a relay sounding an alarm.

Regulation of Voltages

Development of the remote monitor system involved dealing with several variables which affect its indications. Voltage variations were taken care of by a regulator in the line, and by gas-tube voltage-regulators in the receiver high-voltage supply.

Fluctuations in the receiver self caused most of the trouble encountered. These were found to be due to frequency drift of the local oscillator of the superheterodyne type receiver originally used, which caused it to become detuned sufficiently to reduce the detector current. Attempts to deal with this particular variation by means of temperature-compensating capacitors were less successful than the adoption of a Bragg type receiver such as the one shown schematically.

Extreme changes in ambient temperature occur in the semi-desert valley location of the transmitter. Because of the d-c indication method used, changes in resistance of the telephone line were anticipated as a factor which might have to be dealt with. On a typical hot summer day, temperature ranges from 64 to 102 deg F, between 4 a.m. and p.m. Measurements of the resistance of the line, totaling as a loss of 11,485 ft, showed a change with this temperature range of about 14 ohms in the total resistance of 413 ohms at the low temperature point. This variation in line resistance is sufficient to cause only a barely noticeable change in the reading of the microammeter. This system is otherwise stable enough.
Wrapseal construction, developed a number of years ago by Anaconda coil engineers, has proved highly acceptable where cost is a factor and, at the same time, good moisture-proof properties are essential.

The winding usually consists of a standard paper section coil, varnished where desired. The balance of the construction is markedly different from ordinary practice.

The entire outer surface of the coil is encased in one piece of insulation which not only completely covers the coil, but extends into the core of the coil between the winding and the core tube.

After this wrapseal is applied, the entire coil is treated with a thick coating of special varnish.

These coils are excellent for applications where considerable moisture is present—for example, in solenoid operated water valves, in laundry equipment, etc. Additional information may be obtained from any of our sales offices.

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To Meet Your Specifications

PERFORMANCE is the real measure of success in winning the war, just as it will be in the post-war world. New and better ideas—production economies—speed—all depend upon inherent skill and high precision... For many years our flexible organization has taken pride in doing a good job for purchasers of small motors. And we can help in creating and designing, when such service is needed. Please make a note of Alliance and get in touch with us.

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Built with greatest precision and “know how” for low ripple—high efficiency—low drain and a minimum of commutation transients. High production here retains to the highest degree all the “criticats” which are so important in airborne power sources.

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Incorporate precision tolerances throughout. Light weight—high efficiency—compactness. An achievement in small size and in power-to-weight ratio. Careful attention has been given to distribution of losses as well as their reduction to a minimum.

Remember Alliance!
—YOUR ALLY IN WAR AS IN PEACE

ELECTRONICS FOR CHINA

Two Chinese engineers remove the anode coil from a high-power broadcast transmitter made in England for China, while the third examines a band-change unit mounted on a turntable. Young Chinese are being trained in Britain for postwar reconstruction in their own country.
The development of G-E mycalex, the superior insulator possessing low dielectric power losses at high temperature, is of particular interest to the radio, electronic, industrial control and heating industries.

G-E mycalex has superior electrical characteristics and good mechanical strength. It has a low power factor, high arc resistance, chemical and dimensional stability and a low coefficient of thermal expansion. It is impervious to water, oil and gas and is unaffected by sudden temperature changes. Metallic inserts can be readily molded into the parts.

General Electric is molding mycalex for rectifier seals, brush holder studs, tube bases, switch insulation, structural parts in radio transmitters, arc chutes, relay insulators, terminal insulators and as inserts in die castings and organic plastics. For further information write Section N-252, Plastics Divisions, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

Hear the General Electric radio programs: "The G-E All-girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news, every weekday 6:45 P.M. EWT, CBS.

FIFTY YEARS IN THE PLASTICS INDUSTRY

GENERAL ELECTRIC

BUY WAR BONDS
NEWS OF THE INDUSTRY

Conventions to come; Canadian radio; Electronic Conference program; D. C. Bias, words from Washington; television and electronic instruction; transmission facilities; military communications

Radio on Maneuvers with the Airborne Artillery

THROWING OUT RADIOS and other equipment to float down on color-coded parachutes, 500 men of the 541st Parachute Infantry Regiment and the 467th Parachute Field Artillery Battalion dropped near Camp MacArthur, Long Island, recently to show visiting Army and Navy dignitaries with an air strip is captured by airborne forces.

From bomb-racks on the C-47 transports which brought the paratroopers in, so-called daisy chains of 75-mm pack howitzer parts were released. Each demountable piece of the gun is provided with its own parachute but all the parts of a single gun are tied together with a long streamer of cord which keeps them from separating on the descent and facilitates finding the individual bundles on the ground. Colored lights on the bundles also aid in detection and identification of dropped equipment after dark.

Each battery of artillery includes four transmitter-receivers, each with two standard channels, crystal-controlled. Channel A is the basic use channel with B as a standby. Battery commanders are kept in touch with battalion command through a separate radio net which is tuned to a K channel. Besides the crystals in the transceivers, a large supply of additional units are carried along for frequency changeover.

In actual combat, one-man sets in the 500 series are used but for these exercises, type BC-659-A combinations made by Galvin Mfg. Corp., were dropped. Requiring a two-man team, they consist of radio and batteries in separate containers which are coupled together mechanically, with trunk-type hasps and electrically with plugs and cables. The telescopic antenna is demountable and carried in clips on top of the radio cabinet.

Although normal communication is carried on with a push-to-talk, hand-held microphone and a speaker in the panel, provisions exist for earphones at points close to enemy lines where silence must be maintained. For use at a forward observation post where the operator wishes to conceal the antenna mast by placing the set on lower ground, microphone and earphone extensions permit remote operation.

Equipment bundles include form-fitting protective pads of mattress-like construction, but one zealous crew had borrowed the sofa cushions from their day room for extra security against damage. In spite of the standard precautions, one of the units suffered considerable physical distortion but operated perfectly. Another, with no outward sign of injury, went dead after a few minutes of use.

Book of Electronic Standards

IN A BOUND COMPILATION of results of the standardization program in WPB's radio and radar division, 21 American war standards for electronic components are brought together in a single, convenient reference.

Because the standards were developed in cooperation between the armed forces and industry, they satisfy the extremely critical requirements of the armed forces without going beyond the capabilities of industry regarding large scale production. Thus it is anticipated that besides constituting a sound basis for war standardization, they may also serve as a nucleus for postwar development.

Contents include ceramic insulating materials, fixed mica-dielectric capacitors, meter resistors, glass-bonded mica insulators, fixed composition resistors, glass insulators, wire-wound resistors, crystal units, fixed ceramic-dielectric capacitors, dynamotors, porcelain radio insulators, toggle switches, fixed paper-dielectric capacitors, method of noise-testing fixed composition resistors, electrical indicating instruments, shock-testing mechanism for indicating instruments, external r-f thermocouple converters, external ammeter shunts, and fixed molded paper-dielectric capacitors.

Search for Scientists

REQUESTS FOR INDUSTRIAL and government laboratories, for research personnel; from colleges, for teachers; and from industrial establishments, for miscellaneous scientifically trained persons, are reaching the office of scientific personnel of the National Research Council in large numbers. The supply of able scientists has never seemed so small in relation to the demand.

One of the functions of this office is to assist in the recruitment of scientists for positions in war supporting activities. Since it is in touch with demands from all types of activities, it is in a position to refer an able scientist to employers engaged in urgent work. Demand is particularly heavy for people trained in electronic and communication engineering, in physics, and in mathematics. Individuals who are or may become available should write to Dr. M. H. Trytten, director, 2101 Constitution Ave., Washington, 25, D. C.

Convention Coverage by Television

SCENES FROM the recent Chicago conventions were put on the air from film within 18 hours of their actual happening. Television set owners in 5,000 homes in New York, Philadelphia, and Schenectady were able to see important interviews and actual deliberations on the convention floor through television network facilities. Films for exclusive television use have never before been produced on so extensive a scale.

Production at the Stadium in Chicago.
4 REASONS WHY...

the New LAVOIE C-200 Calibrator

EASILY Establishes CRYSTAL-CONTROLLED Frequencies at UHF Up to 2000 Megacycles!

1. BEAT DETECTOR UNIT provides easy calibration of signal generators or oscillators with either aural or visual indication of zero beat.

2. OUTPUT and ADJUSTMENTS give crystal-controlled harmonic frequencies up to 2000 megacycles.

3. MODULATION CONTROLS permit selection of either modulated or unmodulated output as well as degree of modulation.

4. MILLIAMMETER and SELECTOR SWITCH facilitates easy adjustment of output controls.

Write for detailed information.

Lavoie Laboratories
RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

specialists in the Development of UHF Equipment
CONANT RECTIFIERS

Still
The Standard of Perfection

In the manufacture of Conant rectifiers, the layer of copper oxide is formed in the usual manner but it is then caused to alloy with the underlying copper to form a copper-copper oxide eutectic. Then by careful control of timing and temperatures, the eutectic alloy is caused to crystallize in a form resulting in a very stable asymmetric junction especially suited for instrument applications. The molecular structure of the junction so formed required the development of new and unusual processing methods.

Every step in the Conant process has been correctly developed. From the precision lapping of the discs, through the application of the contacting layers and chemical treatments, to the final assembly, each careful operation assures a rectifier assembly that will give the utmost satisfaction in instrument service.

Yes, Conant rectifiers are different, because of the extra care and the plus precision that go into their manufacture. Their enviable record of service is the proof.

Instrument Rectifiers

ELECTRICAL LABORATORIES

6500 0 STREET, LINCOLN 5, NEBRASKA, U. S. A.

Chicago was handled by Pathe News. Due to differences in television technique, it was necessary to instruct the veterans newsreel cameramen to make certain changes in their normal procedure. For one thing, far greater footage of each scene was required. Also, because of the small size of the television screen, a greater percentage of closeups was used, with long shots serving only for background or atmosphere.

The shooting supervisor maintained a schedule of every airplane flight from Chicago for New York. As each zero hour neared, film was unloaded from the camera magazines, labelled, and rushed to the plane with police escort. At New York, the films were rushed to the laboratory and developed. National Broadcasting Company, from whose WNBT the presentation originated, televises negative instead of positive film. This saved considerable time in finishing and made it possible to edit the reels quickly.

CONVENTIONS TO COME


Sept. 11–16. American Association for the Advancement of Science, Cleveland, Ohio. F. R. Moulton, secretary, Smithsonian Institution Bldg., Washington 25, D. C.


Machine designed by Remler to perform multiple operations: automatic slotting, indexing, drilling, milling and reaming.

**Remler Engineers** design and build robots with "rains" to improve production techniques. Ingenious jigs and gibs, and in many instances entire machines are constructed to combine intricate operations. These innovations contribute to the precision accuracy of Remler products; release manpower for other tasks; reduce costs and speed up deliveries. For complete sound transmitting systems; radio; plugs and connectors and other electronic components in metal and plastic, consult . . .

**Remler Company, Ltd.** - 2101 Bryant St. - San Francisco, 10, Calif.

**Remler**

**Since 1918**

Announcing Communication Equipment

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**Plugs & Connectors**

Signal Corps - Navy Specifications

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READY FOR SHIPMENT FROM
LAFAYETTE RADIO CORPORATION
CHICAGO OR ATLANTA

FRACTIONAL H.P. MOTOR
For use in model work, or in any usage where a small, powerful, slow speed motor is required. Compact, 1/20th horsepower induction type. Operates from 25 to 30 volts AC, 60 cycles. Motor speed 2400 RPM, with gear train driving 3/8" shaft at 24 RPM. 2" x 1 3/4" x 3" overall, excluding shaft.
M14699. Specially priced $2.50

RCA FACSIMILE BROADCAST RECEIVER
RCA MODEL FAX-2A
Fully automatic pre-tuned high fidelity radio receiver, facsimile printer amplifier, facsimile printing unit, and Telechron time switch clock. This instrument has many uses in the laboratory. The printing unit utilizes carbon paper in contact with white paper as a recording medium. Complete with tubes and operating and service instructions, but less recording paper.
M25749 $99.50

MEISSNER 9" SLIDE RULE DIAL
Single speed vernier dial mechanism. Fits 3 7/8" shaft 8.25-18.2 mc and 17.6-42 mc. Includes escutcheon and bayonet type dial-light sockets. Ratio 17:1.
M9977. Type 23-8232 $4.70

OHMITE RHEOSTAT
2-section unit. 1375 ohms each section. Each covering approximately 40 degrees rotation, and insulated from each other. 3/4" shaft.
M8168 $1.39

LAFAYETTE DYNAMIC SPEAKER
5-inch. For call systems, hearing aids and midget radios.
M19262. 450 ohms $1.39

FREE! The country's most valuable catalog of RADIO AND ELECTRONIC COMPONENTS AND EQUIPMENT—104 PAGES PACKED WITH ITEMS AND VALUES OF HIGH INTEREST TO INDUSTRY, GOVERNMENTAL AGENCIES, DEALERS, SERVICE MEN, RADIO SCHOOLS, ETC. THE ONLY 1944 VOLUME OF ITS KIND. COPIES ARE GOING FAST. MAIL COUPON IMMEDIATELY.

Lafayette Radio Corp.
901 W. Jackson Blvd., Chicago 7, Ill.

Nov. 2-3. National Time and Motion Study Clinic Chicago, III. Industrial Management Society C. S. Becker, vice president, 204 West Wacker Drive, Chicago 6, Ill.
Nov. 9-10. Fall Meeting, Dayton, Ohio. Institute of the Aeronautical Sciences, Robert R. Dexter, secretary, 1505 RCA Bldg. West Rockefell Center, New York 20, N. Y.

Naval Electronic Production
DELIVERIES OF RADIO and other electronic equipment for the Navy are currently reported to be well in excess of $100,000,000 monthly. This figure is five times the total production for all purposes in 1940.

Electronic Conference Program
SCIENTIFIC DEVELOPMENTS in electronics and electronic applications in industry and medicine are to be emphasized at the National Elec-
Precision Built...by the Million!

Few products require more exacting manufacturing skill than permanent magnets. Yet this company, one of the armed forces' vital sources of supply, is producing them in almost unbelievable numbers.

The

INDIANA STEEL PRODUCTS

Company

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

Specialists in Permanent Magnets Since 1910 *

Our engineers have rendered important service to many manufacturers by solving their permanent magnet designing problems. They will be pleased to consult with you. Write for a copy of our "Permanent Magnet Manual".

Help Win the War in '44 — Buy War Bonds!
Telex Receivers in the first wave!

Telex in the Aleutians

Yes! Telex Receivers played a vital part in 1943 during the occupation of Attu Island in the Aleutians. When this picture was taken the first wave of occupation forces were just landing on the rocky beaches of Attu Island.

Telex magnetic receivers bring each vital message with crystal clearness to the anxious ears of the radio operator. Tireless preparation by Telex engineers guarantees our boys dependability—the best that American engineering can produce.

The prolonged hours of careful research and analysis which the engineers of Telex Magnetic Receivers are making in creating the first wearable Electronic Hearing Aid and in serving the U.S. Army Signal Corps are to be invaluable in helping you solve your electronic development problems. Write us today.

TELEPHONE EXPERIENCE OFFERS

Magnetic Receivers:
Cu. Vol.—Approx. 0.3 cu. in.
Impedance—Up to 5000 ohms.
Sensitivity — 18 dynes/sq. cm. for 10 microvolt input.
Construction—Rugged and stable, using only finest materials, precisely machined—no diaphragm spacing washers in Telex receivers.

Transformers and Chokes:
Cu. Vol.—Down to .15 cu. in.
Core Material—High permeability steel alloys.
Windings—To your specs. (Limit of six outside leads on smallest cores.)

Electronic Products Division

TELEX PRODUCTS COMPANY

TELEX PARK • MINNEAPOLIS • MINNESOTA
This diagrammatic illustration shows how conventional cores, molded by applying pressure to the ends, results in a dense grouping of iron particles at these points. In side-molded cores, however, any density resulting from molding pressure extends evenly along the entire length of the core, assuring uniform permeability with respect to length.

Use in many applications has shown Stackpole side-molded iron cores outstandingly superior to conventional end-molded cores for permeability tuning in the broadcast bands. Similar side-molded units are now available for short wave frequencies including television and frequency modulation.

As the name implies, cores of this type are molded by applying pressure from the sides rather than from the ends. The resulting units show very little variation in density or permeability with respect to length, thus assuring a high degree of uniformity.

WRITE FOR CATALOG! Other Stackpole Iron Core types include both standard and high-frequency types; insulated types; iron cores for choke coils, etc. Our new Catalog RC5 describes these as well as fixed and variable resistors, and our complete line of inexpensive line, slide, and rotary-action switches.

STACKPOLE CARBON COMPANY, ST. MARYS, PA.
**ARPIN RECTIFIERS**

**MERCURY VAPOR**

**HALF WAVE**

**575-A**

**FOR HIGH VOLTAGE**

**FULLY GUARANTEED**

$35.00

**TYPICAL CIRCUIT CONDITIONS**

| Single phase full wave | (2 tube) | 5,000 | 3 amps |
| Single phase bridge | (4 tube) | 10,000 | 3 amps |
| Three phase half-wave | (3 tube) | 7,500 | 4.5 amps |
| Three phase par. Double Y | (6 tube) | 7,500 | 9 amps |
| Three phase full wave | (6 tube) | 14,500 | 4.5 amps |

**CHARACTERISTICS:**

In single phase circuits, full wave rectification can be obtained with good regulation with a circuit that supplies 5000 volts D.C. at 3 amperes, with no indication of arc back.

**PEAK INVERSE VOLTAGE:**

Cond. mercury temp. 20° to 50°c = 15,000 v

Cond. mercury temp. 20° to 60°c = 10,000 v

Max. peak plate current—amps—6. Max. Average Plate current—amps—1.5 Filament—5 volts—10 amps

**We SPECIALIZE in INDUCTION HEATING TUBES**

**IMMEDIATE Delivery**

In addition to the ARPIN 575-A, we recommend four additional tubes for industrial heating applications which have met with widespread approval. These are the ARPIN Nos. 875-B, 892, 869-B and 95-T. Write for Characteristic Sheets of these tubes, or write for the NEW ARPIN CATALOG illustrating and describing all new, current ARPIN Tubes.

**ARPIN MANUFACTURING CO.**

422 ALDEN ST. ORANGE, N. J.
The Triplett Line of Instruments—a complete line from one source and better than ever before—is now ready for the demands of "regular" business. Naturally, standard catalog numbers ready in the stock room can be shipped promptest, but all our instruments, through increased production facilities, are being delivered with gratifying speed. You can count on quick deliveries so place your orders now.
The Smallest Fully Enclosed SWITCH IN PRODUCTION AND USE!

Rd longer than eliminates friction, maintains known patented action switch smallest. This NEW ACRO MINIAC—the smallest fully enclosed snap-action switch in production and use—is built with the well-known patented ROLLING SPRING that eliminates friction, maintains higher contact pressure and prolongs life.

Built with a bakelite case, it is only 1-3/16" long, 13/16" wide and only a trifle over 1/4" thick. Designed with 4 mounting holes 3/32" diameter. Unusually well adapted for stacking in multiple assemblies. Stainless steel pin actuator. All parts are non-corrosive. All contacts are of fine silver. Blades and rolling spring of beryllium copper. Single pole, normally open or normally closed and double throw. Available with air gaps, .010" to .040". Standard operating pressures in 3 ranges from 5 oz. to 20 oz.

RATED AT 15 AMPS., 115 VOLTS, A.C.
Write for details today.

ACRO ELECTRIC COMPANY
1316 Superior Avenue, Cleveland 14, Ohio

New York, Chicago, Buffalo, Detroit, Dallas, Omaha, St. Paul, Kansas City, Memphis, Tampa, Baltimore, New Orleans, Phoenix, Los Angeles, Dayton, Toronto, Canada

whom will return to his local union as an instructor to pass the information along to some 25,000 members per year. Tuition costs of the electronics school amount to about $30,000 a year, which will be taken care of by the international union. Locals will bear the expense of transporting and lodging their member students.

Tubes for Civilians

AT LEAST ONE HUNDRED and possibly 200 percent more civilian radio tubes will be delivered in the last half of 1944 than in the first half according to an estimate of Arthur Stringer, director of circulation to the National Association of Broadcasters. Increased production is actually in effect and between 35 and 40 percent of the increase is expected to be shipped during the third quarter of the year.

Listing of Licensees

NAMES OF 600 HOLDERS of first- and second-class radiotelephone license comprise a list released by FCC in a third report on its survey of manpower. These licensees have indicated availability for employment in the communications industry.

Besides the names and addresses of the individuals, their present draft status, the nature of their present employment, the class of license held, and other particulars are listed. The compilation is broken down by state of residence and by census regions.

Radio Telephone for Emergency Airport Vehicles

CONSTRUCTION PERMITS for low power experimental radiotelephone stations in crash trucks, ambulances, and fire trucks have been granted by FCC to Lockheed Air Terminal, Inc. Authorized for transmission above 100 Mc, the installation will be in the vicinity of the company's airport at Burbank, Calif.

Communications on Attu

U. S. FORCES OCCUPYING the Aleutian Island of Attu found no evidence of the use of radio there by the Japanese. Stories to the effect that the Japs used high-pitched bird-call whistles to give signal...
GIVE SENSITIVE EQUIPMENT AN IMPENETRABLE DEFENSE WITH Sperti Hermetic Seals

Volume production! Prompt deliveries!

Peck the only points of entry for dust, fungus, moisture and other external elements that threaten the efficiency of equipment under tough military conditions. Adopt Sperti Hermetic Seals for capacitors, condensers, inductances, diodes, vibrators, transformers and other component parts.

PIECE. Glass and metal are fused into one piece to form a vacuum-tight hermetic bond. Resist corrosion. Have a thermal operating range of -70° C. to 250° C. Insulation leakage resistance, 30,000 megohms, minimum, after Navy immersion test.

SOLDERING TEMPERATURE NOT CRITICAL. Simple, easy to attach by means of high frequency, oven-soldering or standard soldering iron.

WRITE OR PHONE TODAY for information. Full details of planned use of Sperti Hermetic Seals will bring proper recommendations and desired samples promptly.

Sperti INCORPORATED

Electronic Division, Dept. E-4
RESEARCH · DEVELOPMENT · MANUFACTURING · CINCINNATI 12, OHIO

ELECTRONICS — September 1944
Do You Make...

TEMPERATURE RESPONSIVE DEVICES

for

* AIRCRAFT OPERATION
* INDUSTRIAL APPLICATIONS
* AUTOMOTIVE INDUSTRY
* DOMESTIC APPLIANCES
* HEATING SYSTEMS
* OR OTHER PURPOSES?

If you make temperature responsive devices for any purpose, then some one of the 35 different types of Chace Thermostatic Bimetals will exactly meet your needs for the actuating element. Each type of Chace Thermostatic Bimetal is especially engineered to meet specific conditions... each will produce known action at a predetermined temperature... all are very economical... and always dependable.

Let Chace help you select the most efficient type of bimetal for your control.

W.M. CHACE CO.
Manufacturers of
Thermostatic Bimetals and Special Alloys
1630 BEARD AVE • DETROIT 9, MICH.

have not been substantiated and such sounds are now thought to have been actual bird calls which are still heard daily. These facts were contained in a report recently received by Major General H. Ingles, Chief Signal Officer.

New Coaxial Run

Among facilities which may be available for a postwar television network is a new coaxial cable link authorized by FCC between Terre Haute, Ind. and St. Louis, Mo. Permission was granted to AT&T for construction of this new circuit which will contain six coaxial conductors. Cost of the overall project is $4,032,000, including carrie equipment to be installed at point between Kansas City and New York. The installation will provide 226 additional telephone channels which are now urgently needed for war messages.

Supplementary Service Survey

All domestic broadcast stations, including FM and television are being circularized by NAB (National Association of Broadcasters) to obtain information which will aid in estimating present and future needs for frequencies devoted to relay studio-transmitter link, experimental, and emergency use. Resulting information will be tabulated and made available to the various RTPI panels dealing with allocation problems. Individual information will be kept confidential.

Radiation Patents

At the Radiation Laboratory, Massachusetts Institute of Technology, the Signal Corps has established the Cambridge Signal Patent Agency with responsibility for the preparation of patent applications related to work at the Radiation Laboratory and at the Radio Research Laboratory of Harvard University.

Canadian Radio

Power increases have recently been approved by Canadian Broadcasting Corp. for a dozen or so transmitters. Lack of material is delaying the approved changes. Other applications have been made and approved for a number of
ADAPTABLE...

FOR MANY PURPOSES

The Ward Leonard Midget Metal Base Relay has proven so satisfactory and dependable that several adaptations have been made in it to give it even wider application. The relays shown above are the original relay, one with auxiliary contact and one with porcelain insulation. These relays may be furnished with studs in place of metal bases.
When Mark Twain said "lots of folks complain about the weather but no one does anything about it," he was right. That was quite some time ago. But something has been done about it since.

In a Kold-Hold Altitude Chamber, any kind of weather known on the face of the earth can be developed at will for testing and/or calibrating both aircraft and electronic equipment. The temperature range available is from 176 deg. F. to minus 94 deg. F. Pressure range is from sea level atmospheric pressure to 1.25 inches mercury and any degree of humidity from 25% RH to 95% RH.

The weather inside the chamber can be changed from that of a tropical jungle to the intense cold of the stratosphere as rapidly as a plane can climb from sea level to its ceiling.

Write for Bulletin AC-441.

local private stations and a new CBC station.
Two 50-kw shortwave transmitters are announced as being installed in New Brunswick for transmission to South America, Africa, Australia, and the Far East. One of these stations, which represents Canada's first venture into overseas broadcasting, programs will be brought from Montreal, 60 miles away.

Jeep-Mounted Mobile Cinema

For showing motion pictures in battle areas, Warrant Officer A. Hinchey established a workshop in New Guinea where projected equipment could be serviced. He also combined equipment with the necessary power supply so it could be mounted or a jeep for transport by plane to troop concentrations in areas inaccessible by road.

As a result of this activity, jeep mounted RCA equipment was showing movies on Lae 48 hours after the island had been captured from the Japanese.

D.C. BIAS

Communications Construction. An amendment has been issued by the FCC extending the time limit prescribed for facilities which have been authorized. Section 63.05 of the rules and regulations now state that "Unless otherwise determined by the Commission upon proper showing in any particular case in the event construction shall not have been begun upon a project involving an expenditure of more than $50,000 within 18 months from the date of the Commission's authorization, or all or part of the proposed facilities shall not have been placed in operation within 36 months after such date, such authorization shall terminate at the end of such 12 or 36 month period . . . .". For projects involving $50,000 or less, the time period are 9 months or 18 months.

Production Deficit. Since the principal deficits in deliveries of military products are in those items most urgently needed in combat areas, the Army has asked for increased efforts by management and labor to bolster up lagging pro
An Army that Travels on its Ears

CERTAINLY, today's armies have Stomachs, but they have something Napoleon's armies did not have... Ears. Ears that can hear, not for just a few feet, but over any distance on Land, in the Air and on the Sea. Electronic ears that link every unit of our fighting forces in instant and complete Communication... that spell the difference between success and failure.

As a pioneer designer and manufacturer of THE ROLA COMPANY, INC. • 2530 SUPERIOR AVENUE • CLEVELAND 14, OHIO

Let's do more in forty-four!

AKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

ELECTRONICS - September 1944
Performance

Comco Receiver
MODEL 132

Frequency Range:
100 - 156 Mc.

Image Ratio:
300 to 1 (50 db.)
at 100 — 128 Mc.
100 to 1 (40 db.)
at 128 — 156 Mc.

A.V.C. Action:
Constant within 3 db.
from 100 microvolts
to 100,000 microvolts

Sensitivity:
7.5 microvolts 30% modulated for 6 mw.
output

Signal-to-Noise:
13 db. at 7 microvolts
Input 30% modulated

Comco Receiver
MODEL 82-F

Frequency Range:
2.0 to 8.0 Mc.

Image Ratio:
50,000 to 1 (94 db.)
at 2.5 Mc.
55,000 to 1 (96 db.)
at 3.6 Mc.
45,000 to 1 (93 db.)
at 4.8 Mc.
10,000 to 1 (80 db.)
at 6.5 Mc.

A.V.C. Action:
Constant within 3 db.
from 10 microvolts to
1 volt

Sensitivity:
3 microvolts 30% modulated
for 50 mw.
output

Signal-to-Noise:
9 db. at 3 microvolts
Input 30% modulated

The radio telephone receivers illustrated above are
of the fixed tuned, crystal controlled, superheterodyne type, for
aeronautical ground stations, airport control towers, police
radio stations or point-to-point service.

We invite your inquiries as to use of these receivers in con-
junction with your present or post-war planning. Our facilities
are at your service, whether you need complete transmitters,
receivers, or some electronic component which we can help
design and manufacture for you.

COMMUNICATIONS COMPANY, Inc.
Manufacturers of Radio and Electronic Equipment
CORAL GABLES COMCO 34, FLORIDA

duction. Radio and electronic
equipment is in this category.
Materials in production today are
required to meet expenditures on
the battle front, and failures now
to meet schedules mean delays in
military operations which may be
costly in loss of lives and in pro-
longing the struggle.

Meanwhile, WPB has made in-
creased efforts to channel idle and
excess electronic components back
into the production stream. Forms
have been sent to all radio prime
contractors and component man-
ufacturers, so that they can report
excess and idle stock. The com-
ponent recovery section of WPB
will maintain distribution of pub-
lished idle-and-excess-component
listings.

Surplus Disposal. An orderly
method of handling future huge
quantities of electronic surpluses
is expected to result from present
tests on ways of handling cur-
rently small amounts of products
by Defense Supplies Corp. Among
specific problems anticipated are
those surrounding the disposition
of obsolete walkie-talkies and
similar equipment which, unless
care were exercised, might end up
in the hands of criminals or other
subversive elements.

Mica. At recent meetings of the
raw mica fabricating industry ad-
visory committee, methods were
discussed for obtaining and con-
serving the better qualities of
mica, for manufacture of block
mica into film, and for establish-
ment of standards. Questions cov-
ered included the advisability of
changing the dividing line between
strategic and non-strategic block
mica, while relaxation of unneces-
sary controls was advocated by in-
dustry representatives.

It was reported that large stocks
of No. 6 mica of better qualities
(good stained, fair stained, clear,
and slightly stained) are now
available for all purposes. Radi-
tube manufacturers were urged to
use the better quality even though
prices of finished tube parts might
increase. Greater consumption of
No. 6 mica would be beneficial in
relieving pressure on No. 5 and 5i
for radio and radar capacitors.

To help the industry acquaint it-
self with the various micas avail-
able, tentative plans call for 100-lb
samples of each quality to be made.
They wanted to
LOOK inside METALS

...and DuMont Laboratories found that pure Nickel and Nickel alloys provided all the properties they sought to make the electronic eyes of their Cyclograph.

The Cyclograph gives an immediate electronic view of the inner make-up of metals.

Its cathode-ray tube reveals differences in magnetic and electrical properties of metals which may be correlated with differences in one of the following: chemical composition, hardness, toughness, internal stresses, case depth, thickness of plating or cladding, and other characteristics.

These readings, to be accurate, require cathode-ray tubes free from tube-caused errors which might affect the Cyclogram.

Naturally the cathodes of DuMont cathode-ray tubes—as in the majority of modern tubes—are pure Nickel.

For Nickel provides the combined mechanical, electrical and electronic properties which give the DuMont cathode-ray tube its long life.

This use of pure Nickel and other Nickel alloys in the DuMont cathode-ray tube is typical of the unique service given by Nickel and its alloys, for Nickel alloys offer the electrical, expansion, magnetic and non-magnetic characteristics required in electronic devices.

If you have a problem involving the selection of the right metal for an electronic application, you are invited to consult INCO Technical Service. Address: The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.
Kester, The Right Solder for an Exacting Job

- Solder used in building and assembling electronic equipment must be right. The successful operation of the unit as a whole often hinges upon this important factor.
- Kester Rosin-Core Solder is right for safeguarding electronic circuits. The patented, plastic rosin flux, especially compounded for this type of soldering, is self-contained in the core of the alloy in proper amount for perfect results. It will not cause corrosion or injure insulating material.
- In the wide range of Kester core and strand sizes, there is one combination exactly suited to your requirements. Consult Kester engineers—they'll gladly assist you in working out the right solder formula for your plant operation. Write fully—there's no obligation.

Kester Solder Company
4204 Wrightwood Avenue
Chicago 39, Illinois

Kester Solder Company
Canadian Plant: Brantford, Ontario

★ BUY WAR BONDS ★

Kester Cored Solders
Standard for Industry

Dry Cell Batteries. Consumers durable goods division of WPB is pointing out to distributors of farm radio batteries that such products have, within the past year, become one of the most urgent and critical products in our war production program. Military requirements were described as exceeding production by an estimated 30 percent. Because fifty or more military items such as radios, buoys, submarine detectors, direction finders, bazookas, and field telephones require dry batteries, it is unlikely that the industry will be able to do any more than maintain the present inadequate civilian production. The production bottleneck was indicated as being a shortage of workers rather than a shortage of materials or machines.

BUSINESS NEWS

In the theater equipment business, RCA Victor Div., Radio Corp. of America, plans postwar distribution on a worldwide basis not only of sound reproducing equipment but also related theatrical apparatus.

Illinois Condenser Co. increases its production to a point 300 percent above activities a year ago by addition of a floor to its Chicago plant.

Two department heads at Kollsman Instrument Co., Flushing, N. Y., found themselves in court recently for breaking an obscure ordinance which prohibits working on Sunday—even for an Army-Navy E.

Labor-management committee members at Hallicrafters Co., Chicago, Ill., turned over to the Army's new Vaughan General Hospital the $2500 that employees would have been paid for working
YOU SHOULD KNOW ABOUT RELAY SENSITIVITY

SO YOU would like a sensitive relay for that remote control circuit!

Sensitivity is important for many relay applications. And if that is all you want, there’s no problem. It’s easy to build a relay that will “operate” with a small amount of power.

But sensitivity without contact reliability is useless. So what you really want is a relay that is not only sensitive, but also has the contact pressure needed for reliability under actual service conditions.

Sensitivity and contact reliability are opposing factors. To get a high measure of both qualities in one relay calls for an exacting balance between electrical, mechanical and magnetic design factors. We’ve been building such relays for years - to meet hundreds of requirements, from complex telephone switching circuits to simple control functions on aircraft and radios.

Next time you need a sensitive relay, let the Automatic Electric field engineer show you how to get sensitivity plus contact reliability. No matter what the nature of your problem, there is an Automatic Electric relay that will give you both.

The Automatic Electric Class B Relay shown here combines high sensitivity and contact reliability. It has a highly efficient magnetic circuit, long wearing mechanical structure, independent twin contacts, and capacity for any number of springs up to 26. Contact pressures average 20 grams per contact. Compare this with "sensitive" relays having contact pressures of less than five grams.

For high sensitivity and contact reliability in small space, your best bet is the Class S Relay shown here. Especially designed to meet the severe conditions of operation on fast modern aircraft, it is also recommended where space is at a premium. Because of the great demand for Class S Relays for vital war products, we urge that you avoid its use except where no other relay will serve.

AUTOMATIC ELECTRIC SALES CORPORATION
1033 West Van Buren Street  *  Chicago 7, Ill.

In Canada: Automatic Electric (Canada) Limited, Toronto

PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED
One Palnut replaces a regular Nut and Lockwasher

Provides unfailling security with Savings in Time, Cost, Weight, Space

Years of successful use on Radio and Electronic equipment have proved that the double-locking action* of PALNUTS holds tight under vibration, eliminating need for slower, heavier, more expensive nut-and-lockwasher assemblies.

With this dependable security of PALNUTS, you also cut the cost of fastenings in half—reduce assembly time 50%—save up to 90% in weight—require less space.

PALNUTS are single thread locknuts, made of spring tempered steel. Speedily applied with Yankee or Power Drivers. Available in a wide range of types, sizes and finishes.

Send details of your assembly for samples. Write for Palnut Manual No. 2 giving complete engineering data.

The Palnut Company, 77 Cordier St., Irvington 11, N. J.

Extra time on D-day, plus $2500 they would have spent on a company picnic they cancelled.

Madison Electrical Products Corp. is a new company in Madison, N. J., devoted to manufacture of resistors, electronic assemblies, coil windings, and special components.

By producing in a single plant more than 4,178,000,000 single-conductor-feet of wire, during the last 2¹⁄₂ years, United States Rubber Co. exceeds the combined industry figure for building wire in 1941.

West Coast Electronic Manufacturers Association accepts for membership six new concerns, bringing the roster above the fifty mark. The companies are Brittain Sound Equipment Co., Los Angeles; Merle F. Faber, San Francisco; Harvey Machine Co., Los Angeles; Howard Pacific Corp., Los Angeles; The Lake Mfg. Co., Oakland; and Special Electric Laboratories, Los Angeles.

Electronic equipment for the armed forces will be manufactured by approximately 2000 workers of Western Electric Co., in newly leased space at 529 West 42 St., the company's fourth manufacturing plant in metropolitan New York.

Universal Microphone Co., Inglewood, Calif., purchases the entire plant in which it has been operating under rental for the past 12 years. Included are two two-story buildings, an annex, and two stores.

Home receivers are reported to be planned as part of the postwar line of the radio division of Bendix Aviation Corp.

Under a system referred to as the PDQ plan, Emerson Radio & Phonograph Corp. is establishing preference delivery quotas for home receiver sales after production is resumed. Priority certificates are issued without cash deposit to would-be consumers who register with dealers throughout the country.

National Broadcasting Co. is starting a 50-week course in television for the engineers in its central division. Instruction will be in charge of Clarence Radius, and will parallel that previously made...
Built to take it . . . anywhere . . . anytime!

Techrad LRR-4 is built to take it under any and all conditions. This Techrad receiver has F.C.C. approval for low radiation, but there are many more reasons why it is winning such general acceptance.

Techrad LRR-4 is built to insure uninterrupted performance under the most drastic conditions of service . . . anywhere in the world. Because of its massive and rugged construction, it can be counted on to get there, and to get there intact. It will stand transshipment on the bang-slam carriers bound in remote places and be ready to go into service upon arrival at its destination.

Techrad LRR-4 will work in any climate. It offers a high degree of resistance to tropical humidity and to tropical organisms because LRR-4 transformers are hermetically sealed . . . and LRR-4 wiring and terminal boards are completely Anti-Fungus treated. It will also stand up under severe duty at sea, because LRR-4 is capable of withstanding the Salt Spray Test.

Techrad LRR-4 is available in a number of different models which cover a variety of frequency ranges.

TECHRAD

TECHNICAL RADIO COMPANY

275 Ninth Street • San Francisco 3, California

Export Agents: Frazer & Hansen, 301 Clay St., San Francisco 11, California, U. S. A.
ONE PALNUT replaces a regular Nut and Lockwasher

Provides unfailing security with Savings in Time, Cost, Weight, Space

Years of successful use on Radio and Electronic equipment have proved that the double-locking action* of PALNUTS holds tight under vibration, eliminating need for slower, heavier, more expensive nut-and-lockwasher assemblies.

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THE PALNUT COMPANY, 77 Cordier St., Irvington 11, N. J.

Self-Locking PALNUTS

extra time on D-day, plus $2500 they would have spent on a company picnic they cancelled.

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Built to take it... anywhere... anytime!

Techrad LRR-4 is built to take it under all conditions. This Techrad receiver has F.C.C. approval for low radiation, but there are many more reasons why it is winning such general acceptance. Techrad LRR-4 is built to ensure uninterrupted performance under the most drastic conditions of service... anywhere in the world. Because of its massive and rugged construction, it can be counted on to get there, and to get there intact. It will stand shipment on the bang-slam carriers and in remote places and be ready to go into service upon arrival at its destination.

Techrad LRR-4 will work in any climate. It offers a high degree of resistance to tropical humidity and to tropical organisms because LRR-4 transformers are hermetically sealed... and LRR-4 wiring and terminal boards are completely Anti-Fungus treated. It will also stand up under severe duty at sea, because LRR-4 is capable of withstanding the Salt Spray Test. Techrad LRR-4 is available in a number of different models which cover a variety of frequency ranges.

MASTER ENGINEERING TAKES NOTHING FOR GRANTED.

Technical Radio Company
Over ten years of continuous experience
275 Ninth Street - San Francisco 3, California
Export Agents: Frazier & Hansen, 301 Clay St., San Francisco 11, California, U. S. A.
Ingenious New Technical Methods
Presented in the hope that they will prove interesting and useful to you.

Amazing New Four Spindle Turret Attachment for Drill Press!

Now one drill press can do the work of four and, at the same time, effect a savings of up to 75% in floor space, with the "Quadrill" attachment. This rotary device will accommodate four boring or cutting tools at the same time, yet one tool only is in motion when the head is in operating position.

The entire unit is assembled to the quill of the drill press and is driven from the drill press spindle. Accuracy and rigidity of alignment of the "Quadrill" are assured by the special construction of the driver and spindles, thus efficiency is only limited by the accuracy and power of the drill press itself.

Foolproofing in indexing is accomplished by visual markings and by the relationship of the index pointers on the index disc, as well as the extension of the spring retainer. Four hardened and ground spindles are fitted for No. 32 Jacobs chucks or their equivalent. To provide correct positioning at all times, the entire spindle assembly is located by means of an accurate fitting of recess and undercut, between turret and bearing housings. The hardened friction starter and driver have been so constructed that at any speed proper synchronization of the driver teeth is accomplished without clashing.

It goes without saying that our fighting men must have the finest possible quality materials home industry can produce. So, although the stock of quality raw materials from which Wrigley's Spearmint chewing gum is made is growing steadily smaller, they are still maintaining pre-war standards. However, they can now make only a portion of their former output, so all of this limited production is going to our fighting men and women overseas only . . . where it is an "on-duty" need.

You can get complete information from Chicago Drillet Corporation, 919 North Michigan Avenue, Chicago 11, Illinois.

available to the company's eastern personnel.

Reorganization changes Amperex Electronic Products to a Delaware corporation, Amperex Electronic Corp., gives it an affiliation with North American Philips Co. Personnel, management, and policies are unchanged except that former senior partner N. Goldman has retired.

A limited partnership, Pioneer Gen-E-Motor transfers all its assets and liabilities to a Delaware corporation, Pioneer Gen-E-Motor Corp.

RCA Victor Div., Radio Corp. of America is using 17,000 new procedures suggested by efficiency-conscious workers since Pearl Harbor. This represents 35 percent of all ideas submitted.

In a new building at Minneapolis, Minn., Audio Development Co. now houses its general and engineering offices, experimental and design laboratory, and model shop. Space formerly occupied by these units is assigned to production for a 25 percent increase.

PERSONNEL

Director of communications J. R. Cunningham rejoins United Airlines after more than two years of active duty with the AAF.

At newly-organized Grayhill, Chicago, Ill., W. S. Lewis fills the post of chief mechanical engineer, while Arnold Wassell heads up plastic design engineering.

W. C. Walsh, formerly electrical design engineer for the Department of Agriculture, becomes district representative of the General Electric electronics department in San Francisco, Calif.

If "skill to do comes of doing," this thirty-eight year old commentary explains the record of Connecticut Telephone and Electric in manufacturing telephones, switchboards, and electrical supplies for the military needs of this war.

We look forward to the next thirty-eight years, confident that this is the dawn of the most important era yet, in the development of communications, and every other branch of electrical science.

If our seasoned, but progressive, experience can be of help to you in connection with your communications requirements or the development and manufacture of electrical or electronic devices, we shall be glad indeed to talk with you.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION
GREAT AMERICAN INDUSTRIES, INC.
MERIDEN, CONNECTICUT

TELEPHONIC SYSTEMS • SIGNALLING EQUIPMENT • ELECTRONIC DEVICES • ELECTRICAL EQUIPMENT • HOSPITAL AND SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS • IGNITION SYSTEMS
This switch design required not only the characteristics of a laminated plastic, but also the desirability of molding it. Thus, the arc chamber is composed of four units of INSUROK—laminated and molded laminated, fiber faced. INSUROK was used because of its constant dielectric and physical characteristics; its resistance to corrosion and ability to withstand continuous hard usage.

How INSUROK helps a Bull Dog control arcs

By keeping the amount of oxygen necessary to support combustion out of the arcing chamber, the Bull Dog Vacu-Break Safety Switch eliminates destructive arcing—secures better rupturing performance, conductivity and safety.

The four INSUROK units in which the contacts "make" and "break" comprise a partitioned arc chamber. Because INSUROK Precision Plastics assure close fitting; because of their high strength and dielectric qualities; they protect and make an important contribution to the efficiency of this Vacu-Break Safety Switch.

INSUROK Precision plastics are available in a host of grades—in sheets, rods and tubes for fabrication in your own plant, or in completely finished molded or laminated parts or products. Perhaps it can solve one or more of your design problems, as it has thousands of others. For further information, consult Richardson Plasticians—without obligation, of course.

INSUROK Precision Plastics

The RICHARDSON COMPANY


At Webster Products, Chicago, Ill., R. J. Keogh joins the engineering staff. He has been with Colonial Radio Corp. in a similar capacity.

A. Warren Norton, new president and general manager of Press Wireless, Inc., was previously manager of the Christian Science Publishing Co. He succeeds Joseph Pierson, founder and former president.

Sylvania Electric Products Inc. puts Curtis A. Haines in charge of plants at Mill Hall and Altoona, Pa.; Huntington, W. Va.; and Lexington, Ky., as general manufacturing manager. American Institute of Electrical Engineers elects to presidency

Charles A. Powel, manager of headquarters engineering at Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. His predecessor was Dr. Nevin E. Funk.

T. H. Mitchell, lieutenant colonel in the Army Communications Service, is to succeed William A. Winterbottom, deceased vice president and general manager of RCA Communications Inc.

At Operadio Mfg. Co., St. Charles, Ill., Harold H. Kingsbury is made production-control manager over the company's three plants there.

Formerly chief of the audio and industrial section of the radio and radar division of WPB, Glenn C. Henry joins the sound equipment
The field of Electronics broadens and new, more complex equipment goes into service the need for more accurate test measuring instruments becomes greater. The war has lent impetus to the progress of Electronics and has accordingly accelerated the development of Electronic instruments. In the past two years have been crowded a normal ten years technological progress.

Today most advance developments are not being released for general use. However, today is not too soon for you to make your plans for post-war activity. And, along that line, you should make note of the fact that -hp- engineering is in the guard of electronic instrument developments.

Oscillators to test wide range television channels, new high frequency signal generators, special signal generators for F. M. use, new vacuum tube voltmeters... all providing split-hair accuracy for more exacting measurements and ruggedly constructed to perform in the field under circumstances of war, are examples which merely hint of the better things to come.

-hp- engineering is at your service, whether your problem is immediate or for post-war. Write today, there is no cost or obligation. Direct Canadian inquiries to Atlas Radio Corporation, 560 King Street West, Toronto 2, Canada.

HEWLETT-PACKARD COMPANY
Box 927A Station A - Palo Alto, California
CRYS\TALS... Not Crystal Balls

Making crystal pickups and cartridges has made Webster Electric Company outstanding in an industry that is never satisfied... always striving for something new... something better.

Dreams of tomorrow, like gazing into crystal balls, Webster Electric leaves to others. Our factories are busy with developments and research for victory. We need no crystal ball to know that Webster Electric will be ready with new... ever better... crystal pickups and cartridges to give even greater tone perfection to tomorrow's radio-phonographs.

When the day comes that many of the weapons of today become the everyday conveniences of tomorrow, Webster Electric's skill and experience will bring to the owners of radio-phonograph sets—to manufacturers, radio jobbers and dealers—new meaning in quality of tone reproduction.

WEBSTER ELECTRIC
"Where Quality is a Responsibility and Fair Dealing an Obligation"

WEBSTER ELECTRIC COMPANY, Racine, Wisconsin, U. S. A.
Established 1909. Export Dept: 13 E. 40th St., New York (16), N. Y.
Cable Address: "ARLAB" New York City

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WEBSTER ELECTRIC
"Where Quality is a Responsibility and Fair Dealing an Obligation"
ELCO WOULD CONTINUE
to produce and deliver promptly
PRECISION wire-wound RESISTORS!

ELCO, too, awaits the go-ahead signal to start producing those "battle-tested" resistors for America's new Electronic industries.

Whatever the application—no matter how exacting the specifications—ELCO will deliver resistors as you want them—when you want them.

FOR TODAY'S WAR REQUIREMENTS—
FOR TOMORROW'S PEACE NEEDS—
specify ELCO!

SPECIFICATIONS:

"A-1"—15/32 long x 7/16" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—±1% standard accuracy—non inductive pie wound—1/4 watt. 30° C temperature rise in free air—100° C maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

"B-1"—15/16 long x 7/16" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—±1% standard accuracy—non inductive pie wound—1 watt. 30° C temperature rise in free air—100° C maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—1/2 x .015 strap terminals—35 to 35,000 ohms—2 watts. 100° C maximum operating temperature—normal accuracy ±1%. Baked varnish finish.

"M"—13/32 long x 7/16" dia.—Mountable with 6-32 screw—1 x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C maximum operating temperature—1.5 watts—1% normal accuracy Baked varnish finish.

"G"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value ±1% standard accuracy—non inductive pie wound—8 watts. 30° temperature rise in free air. 100° C maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.

Get to know

ELCO

RESISTORS COMPANY

West 18th Street, New York, N. Y.

Telephone - Watkins 9-4774-5

ELECTRONICS - September 1944
KINNEY Compound Dry Vacuum Pumps do a hand-painted job in creating and maintaining low absolute pressures down to half a micron (0.0000097 lbs. per sq. in. absolute). This reliable performance speeds production and reduces the percentage of rejections in the manufacture of lamps, tubes and other electronic products. Where the pump is working on a new lamp or tube every few seconds, the high recovery speed and exceptional ultimate vacuum produced make KINNEY Pumps the choice of leading tube manufacturers.

Thoroughly tested in years of service, KINNEY Compound Dry Vacuum Pumps produce extremely low pressures year after year.

For the next higher range of absolute pressures, KINNEY Single Stage Vacuum Pumps are available in 8 sizes, designed to work at absolute pressures down to 10 microns.

Write for Bulletin 18
We also manufacture Vacuum Tight Valves, Liquid Pumps, Clutches and Bituminous Distributors.

KINNEY MANUFACTURING CO.
3565 Washington St., Boston 30, Mass.

KINNEY Compound Dry Vacuum Pumps
VACUUM

If you need plenty of Nothing

KINNEY PUMPS

craft, Richard E. Stowe, manager of the Dayton, Ohio, office, is given the Order of Merit by his company, Westinghouse Electric & Mfg.

From International Resistance Corp., where he was vice president and works manager, Leslie G. Thomas goes to Bayonne, N. J., to be works manager of Solar Mfg. Corp.

John J. Farrell is appointed engineer of the transmitter division in the electronic department of General Electric Co., Schenectady, N. Y. He used to be designing engineer for the division.

Vice president and chief engineer of newly-formed Madison Electrical Products Corp., Madison, N. J., is John G. Ruckelshaus, who has been doing development work for the Signal Corps. Plant supervision goes to A. L. Livera, previously assistant chief engineer at Hardwick-Hindle Co.

John B. Huarisa becomes executive vice president in charge of production and engineering for all divisions of Admiral Corp., Chicago, Ill. Vice president in charge of the radio division is former mid-west manager, Richard A. Graven.

From the WPB office of civilian requirements, Charles L. Saunders goes to Wheelco Instruments Co. to be vice president. He was previously with Minneapolis-Honeywell Regulator Co. in a corresponding post.

Elections of new chairman in the divisions of RMA include: E. A. Nicholas of Farnsworth Television & Radio Corp. to replace R. C. Cotgrove in the set division; David T. Schultz of Raytheon Mfg. Co. to replace M. F. Balcom in the tube division; and C. J. Burnside of Westinghouse to replace George W. Henyan in the transmitter division.
Carefully and difficultly acquired experience enabled Federal to produce more Ultra High Frequency Test Signal Generators than were ever thought possible—and quickly, too.

Breaking the tightness of demand by the Army and Navy, these high quality laboratory precision instruments are available to research laboratories and industrial manufacturers engaged in the production of electronic equipment.

Your inquiries are invited.

CARRIER FREQUENCY RANGE: 7.6 to 330 megacycles plus or minus 2%, direct-reading in 5 bands, 6th band available for use with blank coil form supplied.

OUTPUT VOLTAGE RANGE: Calibrated Attenuator continuously variable from 1 to 20,000 microvolts, accuracy plus or minus 10%.

MODULATION: Internal Modulation 1,000 cycles; external modulation up to 20,000 cycles; 0 to 60% direct-reading modulation meter.

STRAY FIELD LEAKAGE: Held to a minimum by Improved shielding and R.F. Filters.

VIDEO OR PULSE MODULATION: Can be pulse modulated externally with signals having very steep wave fronts.

VOLTAGE REGULATED POWER SUPPLY: 115 or 230 volts, 40 to 60 cycles, single-phase.

Manufactured by arrangement with the General Radio Company of Cambridge, Massachusetts, and in accordance with their designs.
Like many other fine products, they are subject also to first call by Uncle Sam.

We are proud of the service they are performing in so many defense jobs.

HARDWICK, Hindle, INC.
RHEOSTATS and RESISTORS
DIVISION OF
THE NATIONAL LOCK WASHER COMPANY
ESTABLISHED 1886
Newark 5, N. J., U. S. A.
For mobile two-way communication specify
KAAR RADIOTELEPHONES

KAAR PTL-10X TRANSMITTER
10 WATTS • 1600 - 2900 KC*

The PTL-10X is a highly efficient medium-frequency mobile transmitter. It provides communication from a moving vehicle over distances ranging from 50 to 75 miles when used with AUTO-LOAD self-loading antenna.

The "Push-to-Talk" button on the microphone completely controls the transmitter, lighting the instant heating tubes, starting the power supply, automatically silencing the receiver, and switching the antenna to the transmitter. The standby current is zero.

Models for special applications are available, including the PTL-22X medium frequency transmitter with 22 watts output, and the PTS-22X, a 22 watt transmitter for operation in the 30-40 MC band.

KAAR AUTO-LOAD ANTENNA

This antenna, with matching coil in the base, is designed for use with the PTL-10X (or with similar medium frequency transmitting equipment) and matches the 72 ohm transmission line from the transmitter and receiver without auxiliary tuning equipment. It provides an efficient method of obtaining maximum signal strength at medium frequencies with a short antenna. It can be quickly installed on the rear bumper or on the side of any vehicle.

KAAR 11X RECEIVER
6 TUBES • 1600 - 2900 KC*

The popular 11X receiver is a crystal controlled superheterodyne for mounting in an automobile or other vehicle. It contains a no-signal squelch circuit, and is designed for commercial, civil, and military applications.

This receiver offers remarkable accessibility. The top is removed by simply pushing aside two snap catches, or the entire receiver can be whisked out of the vehicle by releasing only four catches.

KAAR ENGINEERING CO.
PALO ALTO, CALIFORNIA

Manufacturers of high grade mobile and central station RADIOTELEPHONE EQUIPMENT • POWER PACKS • CRYSTALS • VARIABLE CONDENSERS MICROPHONES • AUTO-LOAD ANTENNAS

Export Agents: FRAZAR & HANSEN, 301 Clay St.
San Francisco 11, California, U.S.A.
The diagnosis of a healthy dynamotor furnishes the data for proving or improving the fine points of performance. Beginning with laboratory development, and through the various stages of production, performance analysis shows our engineers just how closely design and actual functioning are coordinated to meet precise specifications.

The performance curves we supply the many organizations using Eicor products play an important part in establishing dynamotor requirements. In the field of electronics, engineers find these charts extremely useful in determining such factors as efficiency and voltage regulation at the various points of power output which are characteristic of a given design. With operating details of their electronic apparatus established, this graphic presentation of performance shows how the dynamotor is affected by varying conditions of load. Illustrated are the performance characteristics of an exceptionally compact permanent magnet field 14 volt dynamotor, rectangular in shape.

Eicor manufactures many types of dynamotors, motors, and like equipment. In each design, our performance tests are considered complete only after months or years of actual service have proved the quality of the units. That's another reason why Eicor products are so frequently specified.

**CARDIOGRAPH**

Generator of Microwaves

(Continued from page 115)

on the transplantable sarcoma in the mouse.

Out of a total of 43 white mice, mixed strain, inoculated with 8. 28 mice were treated against 1 kept as control. The mice were radiated on the whole body as they moved freely inside a jar position under the radiating unit. Out of the 28, 18 mice recovered, indicating after the third application of rays a reduced activity with increasing hardness and dryness to the sarcoma, which at the end always fell from the body of the mouse as an ordinary scab. Two of 10 mice died.

Interesting is the fact that the desiccation occurred without apparent thermal effect outside the inside the mouse's body. Out of the 15 control mice, 13 died and 2 recovered although, in the latter one the tumor, growing smaller as smaller, continued to remain so and active until reabsorbed. Due to the war emergency in June, 1943 the experiments had to be discontinued.

The author wants to thank Dr. Walter Toseanini and his friend who financed the construction of the apparatus; Dr. Lenz, former Chief of the Division of Cancer New York City, who supplied the mice and the laboratory facilities. Dr. DeGregorio, also former with the Cancer Division, for his continuous interest and presence during the performance of the experiments and Prof. W. C. Ballard Jr., of Cornell University who revised the present paper.

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Righi, A., Rendiconti Regia Accad. d. Lincei, 8, p. 505, 1898.

IN 1943, the Signal Corps purchased ten times the dollar value of communications equipment sold in this country in 1940.
The high resistance to shear and fatigue found in the self-plugging Cherry Rivet is due to the Cherry principle of application—shank expansion.

The stem pulled into shank in the upsetting action, forces the sides of the rivet into the material that is fastened. This, for practical purposes, forms a tight, solid rivet that stays firm even under excessive strain and vibration.

No special locking device is required.

Cherry rivets have, for blind rivets, wide tolerance in hole size and grip length. The patented "pull head" on the Cherry Rivet stem gives a positive grip for the tool, makes it fast and easy to insert, keeps the rivet parts correctly assembled at all times.

CHERRY RIVETS, THEIR MANUFACTURE AND APPLICATION ARE COVERED BY U.S. PATENTS ISSUED AND PENDING
Petroleum Research

(Continued from page 140)

recently it has been shown that if styrene or conjugated diolefins are removed, the analysis can be made on the total octane cut (250-29 deg F).

Absorptions in this wavelength region are caused by electron transitions related to the resonance groups within the molecule. Aromatic compounds with aliphatic side chains these resonating groups are in the nucleus or ring portion of the molecule. Thus, altering the position of the side chain or ring (o-, m- and p-xylenses) adding side chains (toluene is benzene plus a methyl group) usually causes a marked difference in the ultraviolet absorption spectra. But increasing the length of the side chain has less effect upon the spectrum.

For analysis, a weighted quantity of sample is diluted with a non-absorbing solvent such as isooctane and placed in an absorption cell with quartz windows. Ultraviolet light, preferably from a continuous source such as a hydrogen lamp, passed through the sample cell, dispersed by a quartz prism, and the resulting spectrum examined to determine regions of absorption."

The spectrum may be photographed, but small ultraviolet monochromators are available which detect and measure the spectrum by means of phototubes. These are preferred for routine analysis for several reasons. First, phototubes measure the intensity of the ultraviolet light directly. Secondly, once a method is devised for a given analysis, it is usually not necessary to examine the whole spectrum but merely necessary to measure the transmission at a few specific wavelengths. The photoelectric instrument may be fast in such cases.

Emission Spectroscopy

The region from about 10 to 2,000 Angstroms in the electromagnetic spectrum is not of industrial importance at present largely because of experimental difficulties. In this region air, quartz, and even...
EARLY COMMUNICATIONS BY AIR

While electronics use the ether and other media, one of the most speedy methods of communications in the early days was through the air by carrier pigeon. With a finely printed note fastened to the leg, these birds faithfully reached home to bring in the latest news events and stock market reports.

Today news commentary reaches into your homes in a flash of a second via electronic voice communications making use of the various types of Universal broadcast microphones. This being a modern age, the battle front is brought into the homes of the informed peoples of the democracies via military microphones such as those now being manufactured by Universal for the Allied Armed Forces.

< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA

UNION DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA -- CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA

ECTRONICS — September 1944
Engineers at Wico Electric Company, West Springfield, Mass., conceived this ingenious part to replace a gasket and a metal dustcover on one of their automotive type magnets. Insulating properties of the material* eliminate arcing, it is lighter than the metal replaced, and it is readily formed and punched in two fabricating steps, resulting in an accurate, tough, one-piece component for quick assembly.

WICO manufacturer materials, dating for quick assembly. Accurate, tough, than the material’s one received L. We received many quantities of fibrous materials, dating back to 1832, makes Rogers a natural fabricator as well as manufacturer of such materials. WICO recognized this and had Rogers do the job.

We have many standard dies and are equipped to make rectangles, squares, rings, discs, etc. from any fibrous material you specify, in huge quantities — quickly.

But we are especially interested in fabricating your intricate, close-tolerance parts. We are equipped to handle them — with an extensive tool and die shop, complete testing laboratory facilities, and a capable engineering staff.

Ask for samples of Rogers fabrications, or send blueprints and specifications for pricing, or have a Rogers engineer call on you. Contact the Fabricating Division, Rogers Paper Manufacturing Co., 107 Mill Street, Manchester, Conn. Telephone: Manchester 5163.

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*Material in this case was Rogers 0090" RAYGREG, one of many Rogers wet-process, laminated cellulose sheet products. Made of new cotton fibers and electrically purified wood pulp (50% of each), its properties include:

<table>
<thead>
<tr>
<th>Typical Test Values</th>
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<tbody>
<tr>
<td><strong>Specific Gravity</strong></td>
</tr>
<tr>
<td><strong>Tensile, parallel grain—p.s.i.</strong></td>
</tr>
<tr>
<td><strong>Tensile, cross grain—p.s.i.</strong></td>
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<tr>
<td><strong>Elongation, parallel grain—%</strong></td>
</tr>
<tr>
<td><strong>Elongation, cross grain—%</strong></td>
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<tr>
<td><strong>Mullen, lbs.</strong></td>
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<tr>
<td><strong>Dielectric—VPM</strong></td>
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<td><strong>Tear, parallel grain—gms.</strong></td>
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<tr>
<td><strong>Tear, cross grain—gms.</strong></td>
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<tr>
<td><strong>pH</strong></td>
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</tbody>
</table>

If you should be planning a new material, Rogers can, with a total of 25 lbs. of all materials involved, produce within 24 hours a sample that will duplicate regular production runs, and can test all properties. This is possible with glass fibers, bitumen, asphalt, asbestos, lignin, rubber, phenolines, urea, casein, vinlyl or any other materials that will go through a water process and a paper machine.

The gelatin in photographic paper absorbs the radiation. However, the spectrum from 2,000 Angstroms through the visible region (rough 4,000 to 8,000 A) up to 12,000 Angstroms can be recorded on photographic plates. Many years after phenomena observed in this region formed the basis for the interpretation of modern atomic theory.

Everyone is familiar with the rainbow. This visible spectr (the separation of white light into its component colors), which in the case of the rainbow is produced water droplets in the sky, is made readily produced in the laboratory by means of prisms or finely ruled gratings. The spectrum also contains light invisible to the eye.

One commercial emission spectograph, in use in the Socony-Vacuum laboratories, uses a prism to separate the ultraviolet, visible near infrared (2,000 to 10,000 A) into component wavelengths. This prism used most frequently is quartz and gives high dispersion (wavelength separation) in the ultraviolet. A glass prism may be substituted for the quartz to increase the dispersion in the visible and near-infrared regions. Some investigators prefer instruments which use finely ruled gratings to disperse the diffracting medium. The dispersion of grating instruments do not vary with wavelength.

If an unknown sample is burned and the light given off analyzed by a spectograph, the elements present in the sample can be determined. Under proper conditions, atoms of any element will emit characteristic light. Such light is emitted when the outer electrons of an atom are disturbed or made to change energy levels. The metallic and metalloid elements can be readily excited by thermal energy supplied by flame, arc, or spark. The nonmetallic elements are more difficult to excite. Spectra or characteristic light of the non-metals is usually excited by ionization in a gaseous discharge.

In many spectrograms, then, emission spectrography is primarily useful for the exact and infallible identification of the metals and metalloid (phosphorus, arsenic, antimon and bismuth). It is especially useful in the determination of these elements where they may be present in very low concentrations. Most of
unlimited frequency selection

over two critical ranges: 20 to 100 cycles; 4,000 to 10,000 cycles with an available boost of 0 to 20 db.

Unlimited frequency selection — an unusual operational advantage offered by the equalizer unit of the Fairchild Amplifier-Equalizer — compensates for brilliance-loss at the lower 33.3 speed and for response-deficiencies of cutterhead, steel material, pickup, or speaker by electronically boosting the higher frequencies from 4,000 on up to 10,000 cycles — with negligible effect on volume and without loss in the bass.

With a Fairchild Amplifier-Equalizer and two No. 539 Fairchild Recorders, it is possible to record or play back continuously; to make duplicate records; or to "dub" from one table to the other. Wherever extreme flexibility, low noise level, low distortion content and fine frequency response are professional requirements, the one answer is the Fairchild Amplifier-Equalizer.

All Fairchild sound instruments are built to meet the exacting professional requirements of the radio and communications fields. To electronic skill Fairchild has added the plus of exceptional mechanical skill — skill long practised in .0002" tolerance production of aerial and gun cameras, and aircraft computing gunsights.

Descriptive and priority data are available.
For Positive Operation of Electrical Brushes and Contacts

USE SILVER GRAPHALLOY

Silver Graphalloy works in extremes of heat and cold. It is a molded graphite impregnated with pure silver, a highly-efficient conductor that is self-lubricating and extremely durable. Used in gun fire control, radar, slip-ring, instrument applications, and many others.

Silver Graphalloy brushes have high current capacity, low contact drop, and low electrical noise. Silver Graphalloy contacts have low contact resistance and will not weld when subjected to surge currents.

Silver Graphalloy is furnished silver-plated for soldering to springs or holders.

Investigate the superior qualities of Silver Graphalloy. Make it a silver job.

GRAPHITE METALLIZING CORPORATION

YONKERS, NEW YORK

SLIP-RING AND COMMUTATOR BRUSHES AND STATIONARY CONTACTS

the metallic elements can be positively and readily detected when present at only a few parts per million of the total sample. Elements which are difficult to identify uniquely by chemical means, as for example the alkali elements, are easily distinguished spectrographically. It has been stated that no metal has ever been made so pure that the spectrograph could not find impurities present.

Quantitative analyses for the metals and metalloids can be made by spectrographic methods. The sample is burned, the spectrum recorded, and the photograph developed under rigorously controlled conditions. The optical density of chosen lines is measured on a microphotometer and compared with those from known samples of approximately the same composition.

To summarize, if samples are of a kind that must be burned in a direct-current arc, then the quantitative accuracy will probably not exceed ±10 percent of the amount of the element present. For example, if magnesium were present in a clay catalyst at 10 percent, spectrographic methods would report it as 10 ± 1 percent at best. However, if it were present at 0.01 percent it might be reported as 0.010 ± 0.001 percent.

Quantitative spectrographic methods are especially useful to determine metallic elements in low concentration, where the accuracy of the spectrographic method usually exceeds other analytical methods. If a large number of analyses of a given kind are to be made, then spectrographic methods are rapid and time saving.

Certain metallurgical analyses are made spectrographically wherein the sample is burned in a carefully controlled spark source. The analytical results often equal, or are better than, those obtained by wet chemical methods and the time saved by the spectrographic method is almost unbelievable. Alloy steels have been analyzed to determine the concentration of some six elements and the results reported within a quarter of an hour after the sample is received.

X-Ray Diffraction

X-ray diffraction provides a means for the unique identification of crystalline materials. Just as a
This unretouched photomicrograph, approximately 50 times actual size, shows pretty clearly what we can by the value of experience, when it comes to the making of electrical instruments and testing equipment.

Pivots play an important part in determining an instrument's life and accuracy. In the Simpson-made pivot above, you have what is truly a masterpiece of its kind... perfect in contour... all surfaces brilliantly polished to prevent rusting... rounded end properly correlated with radius of jewel to minimize friction and withstand vibration and shock... heat-treated for an unusual combination of strength and hardness.

The obvious explanation for this excellence rests in the fact that Simpson employs some processes others do not, and safeguards every step of manufacture by the best and most complete control modern science can provide. But in the final analysis, it is only Simpson's long experience which makes such a pivot possible.

That experience reaches back more than 30 years. From it has come new shortcuts in manufacture, new refinements in design, which today permit Simpson to make "instruments that stay accurate" in greater volume than ever before. From this long specialization has come a sound basis for further advance; in your postwar Simpson Instruments you will see still more forcefully the value of this experience.

SIMPSON ELECTRIC CO.
5200-5218 Kinzie St., Chicago 44, Ill.

Simpson
INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory.
human fingerprint serves to identify a particular person, an x-ray diffraction pattern is a fingerprint of a crystalline material. This is possible because the distance between the atomic building blocks in crystalline materials is of the same order of magnitude as the distance between wave crests in an x-ray beam. Thus the atomic building blocks can act as diffraction centers and the crystalline material as a diffraction grating for an x-ray beam.

Specific examples of the use of x-ray diffraction in a petroleum laboratory include the identification of inorganic deposits found on valves, bearings, oil filters and other engine parts. Approximately 95 percent of the inorganic materials encountered will yield an x-ray diffraction pattern by means of which it may be possible to identify them. Other industries find the x-ray method extremely valuable in determining the structure of metals and alloys.

Electron Diffraction

The electron diffraction method as applied to industrial petroleum problems is very similar to the x-ray diffraction method. As the name implies, electron waves are diffracted rather than x-rays. Electron waves are slightly shorter in wavelength than x-rays but, unlike electromagnetic radiation of similar wavelength, electron waves do not have the intense penetrating power of x-rays or gamma rays. Electron diffraction supplements x-ray diffraction when it is desired to study surface phenomena which may be too thin to be detected by means of x-ray diffraction.

Electron Microscopy

In the past several years electron microscopes have become available which make it possible to see objects far smaller than can be resolved in ordinary microscopy. In electron micrography, electron waves travel similarly to light rays in an ordinary microscope except that in place of glass or quartz lenses the electron microscope substitutes electrostatic or magnetic fields. The maximum resolution possible at present probably does not exceed 0.01 microns (0.000001 cm or 100 A). However, another feature of the electron microscope...
The engineers of the James Knights Company pioneered in the development and manufacture of Etched quartz crystals. For some time now, we have been supplying quantities of these definitely better type crystals in hermetically sealed holders. James Knights Etched Crystals are available to improve the performance of your equipment. Catalog on request.

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The JAMES KNIGHTS Co.
SANDWICH, ILLINOIS
which is very important is the remarkable depth of focus found in electron micrographs, which thus reveal more detail than could be seen heretofore under similar magnification by other methods.

X-Ray Microradiography

A relatively little known but potentially useful technique is that of x-ray microradiography. Microradiographs of thin sections of any material may be obtained using techniques similar to that of inspecting castings, welds, etc. except that the specimen is very thin and the film is capable of extreme enlargement. The pictures obtained are truly microradiographs, for the original is usually 1/4 inch or less in diameter and sections of this are then enlarged about 300 times.

This microradiographic technique supplements the optical microscope in metallurgical and other industrial applications, with several advantages; it gives a three-dimensional view of the specimen; does not depend on differential action of etchants but only on the variations in absorbing power of constituents, including internal voids and cracks; requires no special polishing of the specimen; and can be incontrovertibly interpreted. The

BRITISH RADAR

Somewhere in England, Craftswoman Doris Birt overhauls part of a radio-location receiver for the AA Command

The ability of Luxtron* Photo-cells to operate instruments and instrument relays, without amplification, removes the hazards of complex circuits. This fact alone recommends their application to precision control problems. Using Luxtron* cells also makes for lighter and less bulky equipment.

Their exceptional resistance to vibration, shock and general mechanical violence assures long service and unusual adherence to original calibration.

PLUG-IN CONTACT
is only one of a series of mounting types available in all shapes and sizes.

Great latitude in mounting "Coprox" (copper oxide) rectifiers is afforded by the unique mounting lug and the fact that leads may be ordered at any required angle to the lug.

Lead wires are pre-soldered, to prevent overheating in assembly. Gold-coated "pellets" retard aging. Low forward resistance, high leakage resistance. Conservative ratings and high testing standards.

"Coprox" MODEL
CX-2E2D4, double half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.

Write for full technical data on all "Coprox" models.
For Example... KARP was assigned the task of converting from cast aluminum to sheet steel a junction box in which are connected all wires operating an anti-aircraft searchlight. These are the results:

**Manufacturing...**

a sheet metal product was produced with standard equipment without any special dies.

**Conservation...**

critical material and vital machine tool time were saved, with no loss in the efficiency of the unit.

**Quality...**

the KARP-produced junction box has greater strength, is lighter in weight, and is better looking.

**Savings...**

in production costs and actual man hours, in addition to speeding up deliveries.

If it's in sheet metal, KARP can make it. The scope of KARP's service can be fully appreciated only when you see KARP on your production problem.

If it's in sheet metal, we can make it!
TURRET LUGS

FIRST—they're easy to use. Just swage them to the board, and in a jiffy you have good firm Turret Terminals.

SECOND— they're convenient to solder to and provide perfect contact. Sufficient metal is used in the Lugs to give them strength, but not enough to draw heat which would increase soldering time.

THIRD—they're readily available. Turret Lugs to meet a wide range of terminal board thicknesses are in stock.

Write, phone or wire orders to

CAMBRIDGE Thermionic CORP.
439 CONCORD AVE., CAMBRIDGE 38, MASS.

Hercules
TRANSFORMERS and COILS

Standard and CUSTOM CONSTRUCTION to meet all specifications

Promp t engineering service always available
HERCULES ELECTRIC & MFG. CO. INCORPORATED
2416 ATLANTIC AVENUE * BROOKLYN 33, N. Y.

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RAF RADIOIEN

Separate cubicles simulate the radio room, a plane and help train RAF signal cadets to find troubles in radio equipment under crowded conditions

September 1944 — ELECTRONICS

You'll Like These
Heavily Silver Plated
TURRET LUGS

major difficulty lies in obtaining a specimen section 0.010 inch or less in thickness from the material to be inspected.

REFERENCES

(2) Planning Tomorrow's Electronic Highways, General Electric Review, 47. 15-21, 1944.

September 1944 — ELECTRONICS
The blistering heat and humidity of the tropics is but one of the many conditions that must be provided for in the manufacture of Electronic Tubes. The cement used to secure the bases to the glass must not loosen under the high temperatures and humidity. This is why the Army and Navy insist on a rigid "torsion-test" of all bases and top caps.

A tough test . . . sure it's tough . . .

The importance of the resistance of the cement, to heat and humidity, has always been recognized by Tung-Sol quality control engineers. Before the war, Tung-Sol Tubes were giving satisfactory service in all parts of the world.

Many new types of tubes for sending, receiving and amplifying have been developed that will be available to civilians. War has proved the dependability and efficiency of TUNG-SOL Electronic Tubes. While present facilities are now devoted entirely to war work, our engineers are interested in your plans for post-war products that will use Electronic Tubes.

THE "TORSION-TEST" FOR SECURITY OF BASES

The tube is subjected to tropic-like heat and humidity for 18 hours, then room temperature for one hour. It is then inserted in a swivel base with a weighted arm. The tube must withstand this terrific twisting strain without the base becoming loose from the glass.

TUNG-SOL ELECTRONIC TUBES
Vacuum Capacitors

(Continued from page 127)

air device, with a low-frequency capacitance of 100 μF may exhibit rise in effective capacitance of about 30 percent at 50 Mc. For a given capacitance and voltage rating, a vacuum capacitor is much smaller in size than an air unit and has far less self-inductance. Therefore, its net change of capacitance with frequency—even at very high frequencies—is very slight.

Effects of humidity and fungus growths are critical in tropical regions. Plates of variable air capacitors often require daily cleaning for removal of corrosion and fungus both of which can cause transmitter failure. Some types of fungi secrete a corrosive fluid which not only attacks metal, but also unglazed ceramics and most other types of insulating materials.

The vacuum capacitor may eventually find wide application in tropical climates because it requires a minimum of maintenance.

Vacuum Capacitor Applications

Vacuum capacitors are particularly suitable for transmitter tank applications where high voltages are involved and where space is at a premium. Resonant frequency of the tank circuit can be varied in the inductive component.

Where a short transmitting antenna is used at medium or high power input, the vacuum capacitor can be employed to good advantage for antenna coupling, because of the unusually large rf potential developed. Series-parallel combinations make up an unusually compact, stable capacitor bank where high potentials are involved.

In aircraft equipment, vibration-proof construction, small size and stable voltage ratings are a considerable asset. This type of capacitor may also be of value in uhf installations where precise, unchanging capacitance is essential. They may find further application in many kinds of precision apparatus, in which frequency stability is particularly important.

Pressurizing With Gas

Gas-filled capacitors, feature high voltage ratings by utilizing...
To meet your most exacting requirements...

ATTENUATORS by TECH LABS...

T-PAD ATTENUATORS

MIDGET ATTENUATORS

TYPE 700 Attenuators embody all improvements made during the war on our former Type 95 units. These improvements include silver contacts; improved die cast detent housing and detent gear which will stand up for a half million revolutions and more; special wiper springs of stainless silver which keep contacts clean and eliminate the necessity of periodic cleaning, and also greatly improves the noise level. In addition, the rotor hub is pinned to the shaft, preventing unauthorized tampering and keeping the wiper springs in perfect adjustment. Write for Bulletin No. 431.

TYPE 600 Midget Attenuators represent a crystallization of all the improvements and experiments made during the war. These units also have silver contacts and special silver alloy wiping springs which stay bright and clean and reduce maintenance and noise level. The hubs are also pinned to the shaft and all other parts are as rugged and mechanically perfect as is possible in this small size. Write for Bulletin No. 431.

These units can also be furnished as Ladders, Potentiometers, Dual Potentiometers and Tandem units.

CONSULTATION SERVICE...

You are invited to consult with our Engineering Department on your "special design" problems.

TECH LAB. MICROHMMEETER...

gives direct and instantaneous readings of resistance values down to 5 microhms and up to 1,000,000 megohms. Furnished in two models. Accuracy in all measurements to better than 2%. Entirely AC operated. Write for Bulletin No. 432.

MANUFACTURERS OF PRECISION ELECTRICAL RESISTANCE INSTRUMENTS

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Star Steatite

If you're looking for a finely-grained rugged ceramic that has the toughness that permits machining and threading to close tolerances, look no further. STAR STEATITE also has great resistance to thermal shock and arcing. For your after-the-war requirements, find out about STAR STEATITE NOW.

The
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PORCELAIN COMPANY
ELECTRONICS DEPT.,
TRENTON 9, NEW JERSEY

Electric
Soldering
Iron

are sturdily built for the hard usage of industrial service. Have plug type tips and are constructed on the unit system with each vital part, such as heating element, easily removable and replaceable. In 5 sizes, from 50 watts to 550 watts.

Temperature Regulating Stand

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.

Janette
D.C. to A.C.
Converters

JANETTE CONVERTERS are specially designed for use with A.C. apparatus used in marine service. Electronic devices used on ships, shore stations, as well as for domestic applications, can be operated from a D.C. power supply, by using reliable Janette converters. Better deliveries can be made on 150, 300 and 500 voltamperes, 115 volts D.C. to 1 phase, 60 cycle 110 volts A.C. rating, than for converters of other capacities or voltages.

ASK FOR BULLETIN 13-25.

Wherever there are ships, you will find Janette converters.

Janette Manufacturing Company
556-558 W. Monroe St. Chicago, Ill.
"Precision" is something more than a motto at I. C. E. "Precision" I. C. E. tubes must be right...consistently right...long-lived and dependable. I. C. E. engineers don't believe in "good enough"...they're constantly searching...experimenting...striving for even better tube performance.

Right now the war effort is claiming most of our production facilities...but we do have a limited number of precision-engineered electronic tubes, ready for delivery. Whether your problem be radio transmitting or industrial application...we invite your inquiries.

I. C. E. 250th • I. C. E. 100th

INDUSTRIAL & COMMERCIAL ELECTRONICS
BELMONT, CALIFORNIA
Switches
In Endless Variety
for Emergency Shipment to Industry

For want of a Switch, many days could be lost! And when it's vital work that is delayed, that Switch assumes tremendous importance. Now, war industries can get quantities of Switches of many different kinds, with amazing speed and efficiency. W-J has organized a National Industrial Emergency Service which delivers Switches and thousands of other Radio and Electronic Items with speed heretofore considered impossible. Oversized, over-diversified stocks, expert technicians, unique streamlined methods... every facility is employed to help keep your work on schedule. Send us a test order, or ask for all the facts NOW!

Variable Models

Some models are of the variable type, where the capacitance can be changed while in operation from about 40 percent to maximum rating. The rotor shaft is brought out through special pressure seals. A worm gear is utilized to give ratios from 15-to-1 up to 900-to-1. These units can be supplied with motor-driven remote control, including automatic stops, so that pressing a button provides a quick and accurate change of value.

Fixed units can be set at the fac-

Electronic SPECIALTIES
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- Condenser-Boxes... Gaskets...
and other Specialties, made to your Blueprint Specifications. From Fish Paper, Varnished Paper, or Special ACME Treated Stocks.

Folding PAPER BOXES
Designed to PROTECT

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Our sample department will analyze and solve your Carton problems. Consult us. Write.

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September 1944 — ELECTRONICS
"How'm I doing?"—
and Telechron tells him

Synchronous, self-starting Telechron motors provide a written record of blind "flights" made in the Link Trainer—the "plane" used to teach pilots to fly on instruments.

Two of these strong but sensitive little motors drive the recorder on the instructor's desk. Another powers the wind drift mechanism. The smooth, constant-speed Telechron motors automatically write for pilot and instructor accurate charts of flight performance.

Charting the course of the fledgling flier, controlling processes in the refinery making his high-octane gasoline—you'll find Telechron motors in all kinds of timing, controlling and recording jobs, speeding the war effort.

Adaptable and dependable, these motors are available in sizes from 12 to 250 volts for all commercial frequencies—and from 1 to 1800 rpm. Their industrial applications include:

- Timing
- Controlling
- Metering
- Recording
- Switching
- Cycling operations
- Signaling
- Fixed process controlling
- Measuring
- Gaging
- Regulation
- Communications

We have been supplying industry with self-starting, synchronous motors for all kinds of timing, recording and control jobs for 25 years. Our experience is at your service. Just write Motor Advisory Service, Dept. C.

Telechron

WARREN TELECHRON COMPANY, ASHLAND, MASSACHUSETTS

MAKERS OF TELECHRON ELECTRIC CLOCKS AND SYNCHRONOUS ELECTRIC MOTORS
To insure constant frequency and high activity, Crystals must be cut at the correct angles to the crystallographic axes. That's why C.T.C. Crystals are X-RAY ORIENTED. This process predetermines the axes of the Crystals, making it possible to cut each slice with extreme accuracy.

Next time you need Crystals send your specifications to us. You'll find C.T.C.'s "correctly cut" Crystals will meet your most exacting standards of quality and performance.

For delivery estimates, quotations, etc., get in touch with CAMBRIDGE THERMIONIC CORPORATION

CAMBRIDGE 38, MASS.

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AND LOTS OF IT

Transformers for Combat

In Active Service
Over the Entire Globe

DINION COIL COMPANY
CALEDONIA, N. Y.

A complete inspection department on wheels, to check parts right on the machine or bench. Errors caught where they start and hundreds of dollars in wasted man-hours and material are saved.

The Unit consists of an 83-piece set of DoAll Gage Blocks, 20 auxiliary instruments, surface plate, Metron Comparator Gage, a file for records, desk space and collapsible seat. Occupies only 24 x 4 floor space.

These 83 little jewels of industry can turn an ordinary machine shop into a manufacturer of precision parts accurate to within ±.000002" (2 millionths of an inch).

Decide right now to make your facilities more valuable to our war effort and for later peace time needs.

Send for 64-page Handbook on the modern use and care of Gage Blocks. It's free.

CONTINENTAL MACHINES, INC
Manufacturers of DoAll Contour Machines and Surface Grinders. Offices in principal Cities.
1366 S. Washington Ave., Minneapolis 4, Minn.

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THE amount of power that transmitting and rectifying tubes will safely handle depends, in a large degree, upon the ability of their anodes to dissipate the heat of operation. SPEER Graphite Anodes have high radiating emissivity coupled with extremely high thermal conductivity... operate at lower temperatures.

Quicker diffusion and more uniform distribution of heat in these anodes prevent hot spots that cause warping and shrinkage of the anode material... minimize possibilities of strains, cracks and electrolysis... keep associated tube parts cooler... reduces primary and secondary emissivity from grids and supports... greatly lessen possibility of tube damage from severe overloads... permit successful operation at higher frequencies...

Because of their greater heat dissipating value, Speer Graphite Anodes make possible greater uniformity in tube manufacture and performance.

DO YOU KNOW?
SPEER GRAPHITE ANODES

- Increase allowable plate power dissipation.
- Lower temperatures of associated tube parts.
- Withstand severe overloads.
- Defy warping.
- Prevent hot spots or fused holes.
- Minimize bulb darkening and insulator leakage.
- Improve degassing qualities.
- Decrease gas troubles.
- Enhance tube appearance.
- Provide precise anode dimensions.
- Produce uniform tube characteristics.
- Retain original dimensions in service.
- Maintain normal tube characteristics.
- Allow wide latitude of anode design.
DO YOUR POST-WAR PLANS CALL FOR PRECISION PARTS?

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Get this new illustrated booklet and see how the ADECO organization and facilities can meet your exact specifications for close-tolerance production of parts and assemblies on a contract basis. This helpful information is yours for the asking.

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Offers Greater Mechanical Strength Plus Higher Conductivity — at Lower Cost

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Their simplified one-piece design is a distinct improvement from every standpoint, making them stronger mechanically, more efficient electrically, easier to install and more economical.

They are made from fine grain, specially rolled, pure electrolytic copper, of the highest conductivity obtainable. The entire inside of the barrel is serrated, so as to increase the contact area, grip the circumference of the wire, and form the strongest, most permanent connection.

Let us show you how you can switch over to this improved terminal without any changes in your present setup — without interrupting production. Write today for Bulletin UC-1.

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Battle Creek, Michigan

The Sherman UNI-CRIMP Solderless Terminal

Tongue, Barrel, and Insulation Gripping Ears Formed in ONE PIECE

Aircraft for Post-War Basis.

Voltage and capacitance ratings of gas-filled units cover a wide range. The variable type is made in values of 100 to 3,500 μf, while units have been constructed with fixed values up to 20,000 μf. A typical capacitor of the variable type is rated at 42,000 v peak and 100 amp at 1000 kc, having a maximum capacitance of 500 μf, a diameter of 101 in., and a total height of 24½ in. Special units have been put into service with peak ratings of 60,000 v or higher, and certain types are available for special high-frequency or high-current applications. Among companies making gas-filled capacitors are: Barker & Williamson, Good-All Electric, E. F. Johnson, and Lapp Insulator.

Power loss in a gas-filled capacitor is quite low, because of the low losses of gas dielectrics. Voltage and capacitance are rated at ±1 percent accuracy. The dielectric is a dry, inert gas, (usually nitrogen) maintained at a pressure up to 350 lb, and a pressure gage is supplied with each unit. The insulating bowl which supports the rotor is the only loss-producing dielectric. Its physical contact with the terminals is comparatively small, and its ratio of area to thickness is large, resulting in very little effect on over-all efficiency. This insulator is usually porcelain, Pyrex, steatite, or other ceramic materials.

About Availabilities

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1938... Sensitivity 10 microamperes
1940... Sensitivity 5 microamperes
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** Sensitivity many times greater than in 1940; with amplification factor 2,000,000,000 to 1, or better!

...today's emphasis on electronics, WESTON developments in the field of sensitive Relays assume utmost interest to design engineers. Even before the war, these relays provided positive control at input values low as microamperes or 1 millivolt. Employing WESTON's exclusive magnetic actuator principle, they handled 5 watts at 110 volts, with complete freedom from contact troubles.

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Have the full story on "what's ahead" in sensitive relays and instruments at your fingertips. Check WESTON, too, on all war instrument needs!

Laboratory Standards... Precision DC and AC Portables... Instrument Transformers... Sensitive Relays... DC, AC, and herme Switchboard and Panel Instruments.

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The G-C Radio Chemical Laboratory contains a complete professional assortment of often needed cements, solvents, coil dopes, insulating varnishes, lubricants, contact cleaners, etc. The bottle you want is always instantly available from its place in the permanent indexed rack. Rack can be placed on bench or wall.

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TELEGRAPH Tapes by the Paper Manufacturers Company have played an increasingly important part in the service of communications.

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- Pressure Impregnating
- Centrifuging
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ELECTRONICS — September 1944

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Very Low Hum Level

At any output from 0 to 300 volts:

1. Output voltage changes less than 0.5 volts
   with ±10% line change.
2. Internal resistance less than 2 ohms at low
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3. Hum is less than 12 millivolts, R.M.S.

Single knob control with
range-changing switch.

Some special models to meet in-
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The basic circuit is adaptable to meet a
wide variety of voltage and current re-
quirements.

Inquiries are invited, both on these
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tronic consulting service.

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Globar Brand Resistors are unusually rugged as your tests will prove. Those illustrated are standardized sizes and resistance values. In case you require resistors having special characteristics we can furnish them. Larger units or special sizes can be provided.

Write us outlining your resistor problem, it will receive prompt and careful consideration.

---

**Globar BRAND SEMI-INSULATED CERAMIC RESISTORS**

---

**Physical and Electrical Specifications**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Watt Rating</th>
<th>Resistance Range</th>
<th>Overall Length</th>
<th>Overall Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>992-A</td>
<td>1/4</td>
<td>150 Ohms to 4.7 Megohms</td>
<td>1/16&quot;</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>763-A</td>
<td>1/4</td>
<td>47 Ohms to 15 Megohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>759-A</td>
<td>1/4</td>
<td>33 Ohms to 15 Megohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>766-A</td>
<td>1/4</td>
<td>47 Ohms to 15 Megohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>792-A</td>
<td>1/4</td>
<td>22 Ohms to 150,000 Ohms</td>
<td>1/16&quot;</td>
<td>5/32&quot;</td>
</tr>
<tr>
<td>774-A</td>
<td>1/4</td>
<td>22 Ohms to 220,000 Ohms</td>
<td>1/16&quot;</td>
<td>5/32&quot;</td>
</tr>
</tbody>
</table>

**Type "CX" Resistors**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Resistance Range</th>
<th>Overall Length</th>
<th>Overall Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>991-CX</td>
<td>1 to 150 Ohms</td>
<td>1/16&quot;</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>763-CX</td>
<td>1 to 47 Ohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>761-CX</td>
<td>1 to 22 Ohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>766-CX</td>
<td>1 to 47 Ohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>792-CX</td>
<td>1 to 22 Ohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>774-CX</td>
<td>1 to 47 Ohms</td>
<td>1/8&quot;</td>
<td>1/8&quot;</td>
</tr>
</tbody>
</table>

---

**References**


---

**LETTERS FROM** former Sylvania workers, now in the armed forces, often mention seeing and using products they formerly made. To one letter from a Seabee in the South Pacific, the censor added a postscript: “This letter was censored under one of your fluorescent lamps.”

---

**ESSEX ELECTRONICS**

1060 Broad St., Newark, N. J.

September 1944 — ELECTRONICS
Shielding the
ELECTRON MICROSCOPE
From Vibration

With the Electron Microscope, scientists are enabled to peer into new worlds, at magnifications up to 100,000 times. Vibration, however, magnifies at the same rate. Even though infinitesimal it can't be felt, it must be eliminated if a perfect image is to be secured.

This baffling difficulty was overcome by U.S. Rubber technicians. They developed a set of rubber mountings engineered to a remarkable point of precision and efficiency. Observations revealed that these mountings completely eliminated all traces of vibration.

Makers of delicate instruments, electronic apparatus, light and heavy machinery, even railway and street cars draw upon the experience of the "U.S." staff for new and important applications of U.S. Rubber Mountings. In "U.S." laboratories, each such problem is treated individually, each mounting compounded and tooled to precise specifications.

Photo Courtesy RCA

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SCIENCE OF SMOOTHNESS — U.S. Rubber technology is removing guesswork from the elimination of noise, vibration and shock. Results are pre-determined and qualities of performance known in advance of installation.

AN INVALUABLE BOOK FOR ENGINEERS — an exhaustive book, "Absorbing Vibration, Noise, Impact", replete with blueprints, charts, photographs and explanatory text, contains much new and important information especially pertinent to postwar conversion and expansion. A limited number is now available. Engineers and architects can obtain copies by writing on company stationery to "Mechanical Goods Division," Room 1406. There is no obligation.

Listen to the Philharmonic-Symphony program over the CBS network Sunday afternoon, 3:00 to 4:30 E.W.T. Carl Van Doren and a guest star present an interlude of historical significance.

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Just what the Electronic Industry has asked for:—The New Metal Tube Extractor

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BOONTON, N. J.
Phone — Boonton 8-2565

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--

We've engineered and built thousands of small, fractional H.P. blower motors for operating cooling fans for hot spots such as radio tubes and transformers in many types of aircraft and radio installations. Competent engineering and precision manufacturing facilities assure volume production of small motors designed to your exact performance specifications—for any job that requires compact, lusty, dependable power. Tell us your requirements.

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--
Right now Wadsworth is making small precision parts for forty-five major companies which normally manufacture such products as radio equipment, refrigerators, automotive parts, precision instruments.

Typical example is a minute steel piece that receives thirty forming operations, sixteen of which are precision milling, although it weighs only 1/10th of an ounce.

After the war, manufacturers who will need small parts of this character will seek Wadsworth's small parts facilities in order to hold sales in competitive markets.

Let us discuss with you the postwar production of those small parts and sub-assemblies you may have found difficult to get in the past or may require tomorrow.
Impedance Measurements

(Continued from page 140)

transformer can be placed ahead of the oscilloscope, presenting to the test circuit merely the grid loading of a vacuum tube (Fig. 1).

With the input and output impedance effects minimized, the only remaining limitation on the range of utility of this method is that of frequency. The percent deviation of the wave produced by the generator from an ideal square wave is the minimum percent error to which impedance measurements can be made. The amplitude and phase shift response of the oscilloscope must be linear from at least ten times the highest square-wave frequency at which tests are to be made, to one-tenth the lowest.

To determine the frequency range within which the equipment is reliable, the generator output should be observed on the oscilloscope to be used. This procedure does not indicate which of the instruments is at fault but, because distortion in either one is equally detrimental to accuracy, it does indicate the usable range for the combined equipment.

Stray shunt capacitances to ground must be kept small. Such strays are most likely to appear from the unknown impedance to surrounding metal such as the cases of the generator and oscilloscope. Even at moderately high frequencies, lead inductance distorts square waves and therefore it is necessary to hold all lead lengths to a minimum. Because of the wide

A PASHA in North Africa has an intercommunicator system that permits him to contact each room in his harem when necessary. Interested in improvement, he asked Maj. Andre Baruch, former announcer now in Africa, "How is television progressing in your country, Major?"

MORE THAN 150 new electronic tubes and 300 types of apparatus not made by anyone before the war have been developed by RCA for the armed forces.
DEAR SIR, During a few quiet spare moments out here on the latest battle front, I thought that perhaps you would care to know the story of one of your model B-X Recording Machines. Just what it has been through, just what it has done for thousands, perhaps millions of people all over the world, and just what it is doing at the present moment.

It was available in Cairo for work on the front, recording everything anything that would be interesting to the public of the world.

I am the engineer that has had the pleasure of operating this machine all this time, and believe the radio trades for fourteen years, should know when a job is well made or not.

It has travelled over 120,000 miles. Approximately 20,000 by road, and 5,000 by air.

It has recorded bomb and shell explosions in slit trenches, covered with dust.

It has recorded bomb and shell explosions in slit trenches, covered with dust. It has also recorded the air, and on many rescue craft, with better results than expected.

For travelled to: Amman Transjordan, to Tripoli, back to Cairo, back to Tripoli, on to Tunisia, Marseilles, on to Algiers, back to Tunisia, on to Sicily, all through Sicily, on to Italy. All this way by truck, recording, recording.

Neatly, through all this bumpy, buffeting, and bonging about has it let our little party down. Never in my opinion, has any radio apparatus stood up so well, for so long in such conditions.

Recordings from this machine have been broadcast from the following countries: England; America; Canada; New Zealand; Australia; Sin Africa; Egypt; Palestine; Algeria. Perhaps presently, from Italy itself.

Efficient and trouble free recorder, and may you continue to put such products on the market. If you care to acknowledge this letter please address to my home in England. 110 Cardinal Avenue, Jordan Park, Borden, Surrey, G.B.

Yours truly,

To: The Managing Director,

Presto Recording Corp;

242 W. 55th St., New York; U.S.A.

What we've been through!

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RAP.
24/19/43.

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frequency response of the oscilloscope, the circuit must be shielded from stray fields. Typical measurements are illustrated in the following table which gives an indication of the accuracy to be expected from square-wa... impedance measurements of this type.

**ACCURACY OF CAPACITANCE MEASUREMENTS**

<table>
<thead>
<tr>
<th>Actual</th>
<th>Measured</th>
<th>Percent Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000</td>
<td>0.9990</td>
<td>0.1%</td>
</tr>
<tr>
<td>0.1000</td>
<td>0.0992</td>
<td>0.8%</td>
</tr>
<tr>
<td>0.0100</td>
<td>0.0092</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

Calibrated resistor used in this measurement: 10,000 ohms.

*Generator output noticeably not a square wave at this frequency.

**EFFECT OF IMPEDANCE ON INDUCED MEASUREMENTS**

<table>
<thead>
<tr>
<th>Resistance</th>
<th>Frequency</th>
<th>Induced</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohms</td>
<td>cps</td>
<td>mhos</td>
<td></td>
</tr>
<tr>
<td>314</td>
<td>740</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>3140</td>
<td>3300</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>31400</td>
<td>2800</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td>314000</td>
<td>27000</td>
<td>0.016</td>
<td></td>
</tr>
</tbody>
</table>

*Internal impedance of the generator was 100 ohms for this one measurement.

Test equipment used in these measurements was connected directly to the impedances under test (not as shown in Fig. 1) to illustrate the accuracies which can be expected if commercial equipment is used directly, and to show the desirability of using impedance changing networks where higher accuracies are required. The internal impedance of the square wave generator was 500 ohms; the input impedance of the oscilloscope was 2 meg.

The value of R used in measuring capacitance was chosen as the mean between the generator and oscilloscope impedances (500 × 10 ohms = 33,000 ohms. The constants of the inductor for which the measured values are given are: L, 0.189 mH; j, 48,000; Q, 11.8 at 1000 cps.

Measurements of this inductor could not be carried out using larger resistances because of the free oscillations appearing on the trace; the low resistances used damped these oscillations. The particular values of R used in measuring inductance were chosen to cancel the n term. Data is only reliable to three places in the above measurements.

**REFERENCES**


September 1944 — *Electronics*
Designed originally for space saving and fine reception in portable radio sets, Ken-Rad miniature tubes easily adapted themselves to walkie-talkie and other military uses. Expansion and future progress with this rugged Little Giant is limitless.
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

UHF Calibrator

THIS MANUFACTURER specializes in the development of uhf equipment and has available a new secondary-standard calibrator, designated as Model No. C-200, which is designed to establish frequencies at uhf with quartz-crystal accuracy. The instrument provides fast, easy calibration up to 2000 Mc. It may be used for calibrating wavemeters, signal generators, oscillators and receivers. The unit is equipped with transmission line output and a built-in detector unit.

Lavoie Laboratories, Morganville, N. J.

Electronic Heating Generators

A COMPLETE LINE of electronic heating generators with ratings of 1, 2, 5, 10 and 20 kw, in line with NEMA standards, are available for both induction and dielectric heating loads. These units are completely self-contained and have no external cooling or other auxiliary units. They operate on 60 cps lines. Units of 50 to 200 kw capacity can be supplied in addition to the standard 1 to 20 kw ratings. The primary voltage is 220 or 440, single phase for ratings of 5 kw or lower, and 3 phase for 10 kw and higher. The oscillator, power supply, blower, and other switchgear are housed in one unit. The high-frequency section is shielded to minimize the possibility of interference with nearby communications circuits. An automatic timing-control permits load cycle adjustment to a predetermined time, which can be automatically repeated. Terminals are provided for remote control. Air-cooled tubes are used in these generators.


UHF Signal-Generators

THESE UHF SIGNAL generators (Type 804-CS1 and Type 804-CS2) are laboratory-type units which operate from 7.6 to 330 Mc and their frequency calibration is accurate to ±2 percent. Voltage output is controlled by an accurately calibrated attenuator network which allows control from 1 µv to 20,000 µv. The output of the instruments is arranged so that an internal source of modulation at a frequency of 1,000 cycles may be used, or, by use of an incorporated switching arrangement, external sources of modulation between 30 cycles and 20,000 cycles may be used, adjustable from zero to 60 percent, indicated by a direct-reading modulation meter.

A special input circuit is used to pulse-modulate the generators from an external source, having very steep wave-fronts and extending in rapidity to pulses of approximately 20 microseconds. Shielding and r-f filters hold stray field leakage to a minimum. Frequency changes due to power-line fluctuations, are held to a minimum by the use of a stabilized power-supply, which is incorporated in the unit for operation on either 115 v or 230 v a.c., 40 to 60 cycles, single phase.

Each generator weighs less than 35 lb and comes supplied with a 3-ft coaxial output-cable of 75 ohms impedance, a fixed 10:1 attenuation reduction unit, a special terminal unit, an adapter plug, line cord, extra blank plug-in coil form, spare pilot lamps, fuses, and one set of 4 tubes.

Federal Mfg. & Engineering Corp., 211 Steuben St., Brooklyn 6, N. Y.
America today is analogous to the laboratory where work is scientifically planned on foundations of the past, present, and future. The mistakes that the world made after 1918, the current conflict, and our hopes for the years ahead serve as the foundation components for a postwar program of peace and security and abundance. Like the laboratory technician, our country's thinkers should plan our participation on a scientific basis.

The objective of the nation is already established. You know that technical advancements, especially those in communications and transportation, have made isolationism and nationalism impossible. America, therefore, must participate in world affairs. Friendly relations in the international community mean not only an interchange of ideas, but an interchange of goods. Out of the former comes a better understanding of each nation's problems... out of the latter will come wider markets for our greatly expanded production. In gaining such markets, we can still maintain our industrial set-up as it stands today, yet avoid any of the ills that might arise from overproduction.

The effects of such a policy are closely allied to the welfare of the American people. An economy of abundance can be translated into an abundance of jobs... for present workers as well as men and women returning from the battlefields. Equally important, it gives our country the opportunity to make even greater strides in securing the well-being of the individuals... be they capital or labor. Through such an economy of abundance, the businessman can protect his production peaks without fear of drastic reductions in sales, and resulting tragedies—and the worker can be assured of a steady job, and all that it implies.

We have the qualities for winning the war... that is certain. Whether or not we have the qualities for winning the peace remains to be determined. Should we recognize our nation as a huge laboratory, and ourselves as scientists, engineers and technicians working in the simplest, most direct method, we can achieve our goal of a just and lasting peace with opportunity and security for all.

READY SOON! A sound, workable and realistic plan for a postwar world of abundance and lasting peace, prepared by the Electronic Corporation of America. Write for your copy today.

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The Electronic Corporation of America is "on the air," eight times a week, featuring two nationally-known commentators: Johannes Bleet, over Station WMCA, New York, and William S. Gaimor, over Station WHN, New York.

ELECTRONICS - SEPTEMBER 1944
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For over-all treatment of assembled ground equipment such as the walkie-talkie, handy-talkie, radar, power plants, etc., there is available a No. 25A moisture and fungus-resistant coating, Signal Corps approved. It is fast drying and non-toxic to humans.

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IMPROVED TYPE 58 wire-wound potentiometer-rheostats include a metal strap on the shaft face to provide for a two-position locating pin which cannot break or tear off. The metal strap grounds the metal cover which is clinched to it. The cover will not loosen or turn because it is keyed in place on the casing. The bushing is also prevented from slipping or turning, when the locking nut is drawn tightly, because it is keyed into the Bakelite case. The case is dust-proof. The can is made of molded Bakelite and tends to eliminate cor-

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PERSPECTIVE: Selecting Insulated Cable Requires a Multi-Dimensional Approach

This 3-dimensional graph illustrates practical fields of usefulness of 4 widely-used types of cable insulation. Each type has particular characteristics that make it suitable for definite applications — but at the same time each possesses certain limitations.

The pictured values show the present maximum voltage, frequency and temperature limits for which these four insulations are commonly used. The insulations with the higher values can, in many cases, be used as alternatives for those having lower values.

Design engineers may find this rather unusual graph helpful in selecting a cable for some specific application. The problem, however, is not always as simple as indicated because it is often necessary to obtain cables having additional characteristics not covered by this graph — such as resistance to moisture, oil, chemicals, flame, etc.

Actually there are available many other insulations developed through Okonite Research — such as glass, paper, cambric, rubber and many synthetics — that cover the full range of electrical applications. Through intensive laboratory and long field experience, our engineers have acquired the over-all perspective that can help you select the one cable best suited for your purposes from every angle. Just outline your problem and let us make recommendations. The Okonite Company, Passaic, New Jersey.

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Especially designed for communications equipment of all kinds, radio equipment, aircraft equipment and other applications, SP Relays are a general purpose relay with the ability to withstand shock and vibration. One-piece phenolic base and stationary contact support is resistant to the corrosive action of salt water and weathering. AC and DC types.

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Master-Cam Lever-Switch
A NEW MASTER-CAM lever-switch (Model MCL-CS) is designed for use in electronic and communications equipment, and wherever multiple circuits must be controlled. The switch is static-shielded and non-corrosive. The positive positioning-cam has roller detents which eliminates friction and contact bounce. Coil springs are used on both sides of the cam, so that equalized pressure is assured regardless of the number or arrange-

A cut of JELLIFF .0008 "C" WIRE was laid upon the above square ... it is so fine, the camera almost missed it.
Below is a microphoto of the same wire, enlarged 420 diameters ... a sturdy uniform wire.

Wanted ENGINEERS

- Radio
- Chemical
- Electrical
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Work in connection with the manufacture of a wide variety of new and advanced types of communications equipment and special electronic products.

Apply for writel, giving full qualifications, to:

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Applicants must comply with WMC regulations
MATURE EXPERIENCE and JUDGMENT in Industrial Electronic Applications

Many years before “Electronics” blossomed as the wonder child of a post-war world, United Cinephone Corporation Engineers were putting Electronic devices to work for industry; devices which were practical, rugged, and down-to-earth.

Experience has shown that the solution of problems in Industrial Electronics usually requires the merging of Mechanical engineering with Electronic engineering to the fullest extent possible.

United Cinephone engineering and production facilities have proved valuable in many important industrial plants in connection with product control, automatic machine operation, operator safety and simplification of manufacturing methods. When our responsibilities as a Prime Contractor in the manufacture of military electronic equipment have been fulfilled, our facilities will again be at the disposal of industry.

MODEL BRT AIRCRAFT TRANSCEIVER
A typical military product of United Cinephone Corporation

UNITED CINEPHONE CORPORATION
TORRINGTON, CONNECTICUT
FIBRE FABRICATION DATA BOOKLET
FREE! ON REQUEST.
DATA AND INFORMATION FOR THE CORRECT SPECIFICATION OF PHENOL FIBRE & VULCANIZED FIBRE

Just off the press—the new BAER descriptive bulletin! Contains factual, concise, vitaly-pertinent data for the fibre-fabrication specifier or purchaser. What to use and what not to use for your particular application, from the standpoint of functional efficiency, service dependability and production economy.

Illustrated with tables and charts for quick reference. Write for your copy now—a note will bring it promptly.

N. S. BAER COMPANY
Craftsmen in Fibre Fabrication
9-11 N. Montgomery St., Hillside, N. J.

This New Jig Speeds Your Radio Assembly

1) Can be loaded and unloaded in two seconds.
2) Indexed 360° fixture to hold chassis in any position to step up soldering and all other assembly operations.
3) Adjustable to any size to base limits of the Jig. Comes in various sizes or we will make Jigs to your chassis or specifications.
4) Sturdy, rigid construction.
5) Holding adapters to fit your chassis.

Send us your chassis or specifications for quotations. We are ready to meet your delivery schedules.

This New Jig Speeds Your Radio Assembly

Mandrels
THIS MANUFACTURER has extended his line of mandrels so that approximately 750 different types are available for the forming of round, square, and rectangular paper tubes, used as coil bases. These mandrels are available for immediate use in many sizes, shapes and lengths, and any ID or OD, and handle kraft, fish paper, cellulose acetate, or combinations of these materials.

Precision Paper Tube Co., 2023 W. Charleston St., Chicago 47, Ill.

Dummy Tubes and Tube-Pin Straighteners
TO AID RADIO manufacturers in obtaining accurate alignment of panel openings and contact points, minia-
THE VARIAC . . . the original continuously adjustable, manually operated a-c voltage control . . . has these features:

- **SMOOTH CONTROL** — The VARIAC may be set to supply any predetermined output voltage with absolutely stepless variation.
- **HIGH EFFICIENCY** — Exceptionally low losses both at no load and at full load.
- **HIGH OUTPUT VOLTAGES** — VARIACS supply output voltages 17% higher than line voltage.
- **LINEAR OUTPUT VOLTAGE** — Output voltages are continuously adjustable from ZERO by means of a 320 degree rotation of the knob.
- **SMALL SIZE** — VARIACS are smaller than any other voltage control of equal power rating.
- **CALIBRATED DIALS** — VARIACS are supplied with reversible dials which read directly in output voltage both from zero to line voltage and from zero to 17% above line voltage.
- **ADVANCED MECHANICAL DESIGN** — Rugged construction; no delicate parts or wires; two or more units may be ganged on the same shaft for multi-phase operation.

VARIACS are stocked in nine models with power ratings from 170 va to 7000 va; prices range between $10.00 and $100.00.

Because all of our facilities are devoted to war projects, VARIACS are available at present only for War work; all orders must have a priority rating.

**VARIACS** are made only by General Radio

**GENERAL RADIO CO.**

Cambridge 39, Mass.
New York
Chicago
Los Angeles

● WRITE FOR BULLETIN 883
THE RIGHT BULB TO USE
NO LONGER A MYSTERY

THE NEW GOTHARD CATALOG— is actually an Engineering Handbook that gives you this and complete engineering data on each of a wide range of models for varied applications. Here is an example of the information given:

Mazda No. and Voltage of lamp received by each specific Pilot Light is given opposite each photograph.

Listings of:
#1206 Faceted Jewel
#1207 Plain Jewel
#1208 Frosted Jewel, Colored Disc.

Pilot Light Dimensions are presented in blue print diagram.

Specifications include essential data on panel thickness, mounting dimensions, metal substance, jewel colors, etc.

Voltagels:
Mazda No. 64 6-8 Volt
Mazda No. 68 12-16 Volt
Mazda No. 72 18-24 Volt
Mazda No. 1252 24-28 Volt

Disconnect Terminals

QUICK ACCESS to contacts of small switches is facilitated by the use of solderless knife-disconnect terminals. Switches which have tabs extended from the contact, to which the external connections are soldered, may be converted readily to quick-disconnection switches without affecting the housing or any

ture dummy tubes and tube-pin straighteners are available.

Stainless steel pins are used in the dummy tubes, which are used to hold socket clips in correct alignment during wiring. The tube-pin straighteners are available with either hardened tool steel inserts (for factory use) or with stainless steel inserts (where greater resistance to corrosion is desirable). Body and posts are plated with cadmium. Inserts are replaceable. Both the tubes and tube-pin straighteners meet requirements of the WPB Sub-Committee on miniature tube standards.

Robert L. Stedman Machine Works, Oyster Bay, Long Island, N. Y.

ENGINEERS

• with experience in the
DESIGN
DEVELOPMENT
PRODUCTION
OF AM AND FM RECEIVERS

• Also Mechanical Engineers and Engineers familiar with Electro-Physical Apparatus and Design

We are a well-established concern located in New York City. To men who are qualified, we offer a most interesting proposition. You will, of course, be paid a good salary. You will have wide range of expression due to our progressive thinking and planning. You will work with engineers who have contributed much to radio and electronics. You will have the opportunity to carve out for yourself a real and secure future. And you will not be hamstrung by "inside" politics. Tell us all about yourself in your first letter. It will be held in confidence.

P-700 Electronics
35 West 42nd St., New York 18, N. Y.

Insuline

Maintaining SUSTAINED HIGH-SPEED PRODUCTION OF RADIO-ELECTRONIC PRODUCTS!

With production redoubled, ICA is striding ahead of schedule—delivering Radio, Sound, and Electronic Products to the Armed Forces. At the same time, we are planning ahead, and therefore suggest that you get the complete ICA picture now. Write for 48-page Catalogue and 8-page Brochure describing our products and manufacturing facilities.

Illustrated: ICA Antenna Installations are in wide use in the Armed Forces.

Insuline Building · Long Island City, N.Y.
*Units illustrated are designed for maximum intelligibility through high noise levels plus economy of installation. Recommended for areas where wide angle distribution of high frequencies are necessary. Complete technical bulletins describing the above upon request.

Type 26-B is designed for voice reproduction when used by itself. Also an excellent high frequency component to a wide range system. Provides uniform distribution over horizontal angle of 120° and vertical of 40°. Handles power input of 40 watts when equipped with two Jensen U-20 drive units. 22" wide, 14½" deep, 20" high.

Type 24-A is primarily an outdoor speaker. At 50 watts input produces a sound level of +94 db. (Zero reference level $10^{-14}$ watts per cm$^2$) at 100 ft. distance on the axis of horn. Two or four Jensen U-20 drive units allow a maximum of 50/100 watts input. 38" long, 26" wide, bell diameter 25".

Type L-360 is designed for 360° horizontal coverage and 40° vertical with uniform frequency and power distribution. Handles power input of 20 watts when equipped with a single Jensen U-20 drive unit. 23" in diameter overall; weight 25 lbs.
IF IT'S "ELECTRONICS" GIVE BUD YOUR SPECS

If it's Electronic Equipment you are manufacturing, specify BUD precision parts and be sure of utter dependability and accuracy. Get our complete catalog of BUD precision radio and electronic equipment. It's yours for the asking.

BUD RADIO, INC.
CLEVELAND 4, OHIO

Unusual Contact Designs ARE NOT UNUSUAL TO GIBSON

2½ Times Actual Size

★ While war necessity does not permit release of information covering operational details we can present this illustration as an example of unusual design of electrical contacts being produced in our plant. It is a coin silver contact ring for use on an assembly of special ceramic parts and made expressly for Stupakoff Ceramic & Manufacturing Company, Latrobe, Penna. This contact is being manufactured in large quantities by punching, forming and butt-brazing, with tolerances held to ± .001" on I. D. and ± .002" on width.

Gibson

STATISTICIAN Wanted preferably a B. S. or B. A. in ECONOMICS

Must have some background in market research and writing reports.

An excellent post war future for a capable man in the radio division of this internationally known company.

Essential workers need release

FEDERAL TELEPHONE & RADIO CORP.
The mfg. unit of the I. T. & T. 39 Central Ave., East Newark, N. J.
IMPORTANT CURVES

During our many years of service to industry in designing and manufacturing permanent magnets, we have conducted hundreds of tests. From the result of these tests we have been able to plot charts and nomographs for taking much of the guess out of magnet design.

The one shown above—“Typical Demagnetization and Energy Product Curves”—is used constantly by our own engineers in designing magnets from various proved alloys. If you are designing your own magnets, these curves should be useful, particularly as they are accompanied by an instructive pamphlet—“Permanent Magnet Design”.

Send for the chart and pamphlet. Try designing your magnets. We’ll be glad to check your results.

CINAUDAGRAPHER CORPORATION
2 Selleck St. Stamford, Conn.

Send for the chart shown above; also for a copy of “Permanent Magnet Design”
Talk About PRODUCTION Without DIES!

4,000 Parts Per Day with DI-ACRO Bender

Here is an example of "DIE-LESS DUPLICATING" typical of a great variety of formed parts readily made with DI-ACRO Precision Machines—Benders, Brakes, Shears. Picture below shows an acute right angle bend and photograph above shows the finished part formed to die precision. Operating DI-ACRO units maintain a high out-put on production work.

Send for CATALOG showing DI-ACRO Precision Machines and many examples of parts made with "DIE-LESS DUPLICATING." Pronounced "DIE-ACK-RO".

"Enclosed pictures in our plant prove the DI-ACRO Bender will do a real production job. We are making 4,000 completed parts per day which is competitive to most Power Presses."

(Name on request)

O'NEIL-IRWIN MFG. CO.
321 EIGHTH AVENUE SOUTH - MINNEAPOLIS 15, MINNESOTA

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SELF-LOCKING SET SCREWS
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For assured dependability, use "UNBRAKO" Self-Locking, Hollow Set Screws with the KNURLED POINTS.

Past performances over long periods in a vast variety of applications have marked "UNBRAKO" Knurled Point Hollow Set Screws as uniquely SATISFACTORY, because they won't shake loose—come Hell and high water. They're strong and hard... their hex socket won't round... and they positively stay put.

The Knurling of Socket Screws Originated With "UNBRAKO" Years Ago.

OVER 40 YEARS IN BUSINESS

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JENKINTOWN, PENNA. BOX 596
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20-WATT UNIVERSAL AMPLIFIER

Plug in for A.C. or 6-volt auto battery; no power pack necessary. Uses mike and built-in phone at same time. 78 RPM motor, 9-inch turntable, crystal pick-up, separate on-off switch. Long-playing needle included. Continuously variable tone control on inclined eye-level control panel. Use one or two 8-ohm speakers without need of extra transformer. Has one 6SJ7GT, one 6SC7, two 6L6Gs in push-pull, two 6X5GTs. Model 6720, with tubes, F.O.B. New York $56.28
Model 6721, same as 6720, less phone player $42.87

TERMINAL RADIO-CORP.
85 CORTLANDT ST. NEW YORK 7, N.Y.
PHONE WORTH 7-4415

September 1944 — ELECTRONICS
General Control Company, the original cam lever switch specialists, are pleased to announce two new cam lever switches. The new Model MCL-CS is similar in design to the well-known Model MCL-FS, except that coil springs are used instead of flat springs to assure longer life and equalized pressure on both sides of the cam, regardless of the number or arrangement of contacts on each side of the switch. Also it can be supplied with either light or stiff action on the control knob to suit your requirements. This model is rated at 10 amperes, 125 volts A.C. and is outstanding for long life and dependability.

The new Model MR Rotary Cam Lever Switch is designed for one to six index positions. It fills a definite gap, and a definite need, in the multiple contact switch field. With the new Rotary, any combination of contact arrangements can be used in each of the six positions. It is adaptable to actuate practically any number of circuits in sequence (or repeat) with the convenience of a single control knob. Its unique construction provides such features as circular cams for locating from one to five low-friction, roller spring actuators on each cam. A single hole only is required for mounting, and contacts in any section can be removed from frame by removing a single bolt. This switch can be easily rearranged. The Rotary is rated at 10 amperes, 125 volts A.C.
BIRTCHER STAINLESS STEEL LOCKING TYPE TUBE CLAMPS

Comparison Bridge

For speedy testing of resistors, capacitors or inductors in terms of ohms, microfarads or henries, respectively, the Type LB direct-indicating comparison bridge may be used. Components under test are connected one by one to terminals and are then rejected or passed. Components outside the limits set up (limits may be set with any combination of high or low value, such as -6, +14 percent) will result in a meter deflection.

This production-test instrument is an a-c slidewire bridge with a vacuum tube null-indicator arranged so that resistors, capacitors or inductors can be compared with a similar standard. Ranges are:

1. To Serve You Better
2. AN ALTERNATE SOURCE OF GENUINE BIRTCHER TUBE CLAMPS
3. Prompt Delivery

- We are fully licensed to manufacture the complete BIRTCHER line of locking type, stainless steel tube clamps. Orders placed with us for prompt delivery using BIRTCHER part and identification numbers will be filled at prices as favorable as those to which you are accustomed. All clamps will be identical with those manufactured by the Birtcher Corporation.

THE BIRTCHER CORPORATION
Manufacterers of AIRCRAFT and RADIO PARTS

Littelfuse equipment on Pan American Clipper. Courtesy of Pan American Airways System.

LITTELFUSE INC.
200 Ong Street, El Monte, Calif.
4757 Ravenswood Ave., Chicago 40, III.

COMPLETE CIRCUIT PROTECTION

requires Fuse Clips especially engineered to the multitude of today's services.

Littelfuse FUSE CLIPS

PHOSPHOR BRONZE • BERYLLIUM COPPER, SILVER PLATED

In aircraft, communications, industry, electronics, electrical products—from most delicate meters to high voltage services, Littelfuse solves the problem with new improvements.

Exclusive Littelfuse design and forming effect contact over largest possible area. Results: Extra tight grip—maximum electrical conduction—less heat produced—panel board and switch temperatures reduced—loss of clip-temperature prevented—spring qualities retained much longer.

Whatever your fuse clip requirements, Littelfuse will be glad to counsel with you.
Acceptance, between 0.0001 to 1.0pf; resistance, between 2000 ohms to 20 meegohms; inductance, between 5 and 50,000 henries. The dlewire is uncalibrated. External standards are used.

Industrial Instrument, Inc., 17 Ellock Ave., Jersey City, N. J.

Multi-Output Dynamotor

This piece of equipment is designed to save space and battery current in mobile applications, particularly where a transmitter and receiver are used. The dynamotor is capable of delivering simultaneously as many as three separate outputs. For instance, it is possible to obtain 6.3 volts a.c., "B" power for the receiver, and also high voltage for the transmitter.

Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

Constant-Voltage Transformer

Illustrated below is a small, compact unit in a hermetically sealed case, designed for chassis mounting. Rated at 6.3 v, 17 va output, his constant-voltage transformer will maintain that value within ± 1 percent regardless of line-voltage variations as great as ± 12 to 15 percent. This unit is especially

A powerful handful, capable of calling tanks and planes for support or attack, the "Handie-Talkie" is the electronic answer to modern warfare's demand for a light, compact communication unit. Lightweight Burgess Batteries give the "Handie-Talkie" necessary energy to operate under all conditions and in any climate.

SPECIAL-PURPOSE BATTERIES. The battery needed to operate the "Handie-Talkie" was developed by Burgess engineering research to give dependable service wherever the Army goes. Burgess engineers are constantly creating new special-purpose batteries, and new uses for standard batteries. Let them solve your portable power problems. Write about your specific needs, or send coupon below for free Engineering Manual.

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You'll find Cellusuede Flock an ideal material for coating wire grills, cabinet interiors, cabinet bases and phonograph turntables—it's practical, economical, and has a high acoustical value. The soft suede, velvet or velour effect will also enrich the appearance of your product at low cost. Rayon or Cotton Flock is furnished in a wide assortment of colors. No rationing... no priorities... no delay.

Write for Color Card, Samples and Prices

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Timing is vital today—indispensable tomorrow! Compact, rugged and with extreme flexibility, Haydon timing motors lead the field. Manufactured to your specific voltage, frequency, speed and torque requirements, they are available with brake for instant stop— reversible, and with shift device for automatic reset. Whatever Your Timing Problems May Be... our timing engineers are ready and willing to help you solve them—Just drop a line to our Timing Engineering Service Department.

"Depend on Diamond"

IN WAR
We are manufacturing to the toughest specifications of the armed forces and are producing cordage to their satisfaction.

A Complete Plant from Copper Drawing to Assembled Cords!

Diamond Wire & Cable Co.
Chicago Heights, Illinois

Manufacturers of electrical flexible cord, cables, and instrument wires for radio and appliances.

Haydon Manufacturing Company
Foralville, Connecticut

As makers of the most complete line of Synchronous Timing Motors, Haydon Manufacturing Company offers a complete TIMING ENGINEERING SERVICE.
suitable for use in stabilizing electron-coupled oscillator circuits. Electronic equipment in which this transformer is included does not require filament voltmeters or manual filament-voltage controls. Bulletin DCV-102 describes the new designs of transformers available from the manufacturer, Sola Electric Co., 2525 W. Superior Ave., Chicago 14, Ill.

Pulse-Initiated Timer

The PSEH-1 timers can be supplied for a-c operation on 110 or 220 v, 60 cycles or 25 cycles; for d-c operation at any specified voltage from 6 to 120 v. Typical units measure $\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4}$ in. Contact operation occurs at the end of a delay interval after power has been applied, or after receipt of a momentary impulse from a pushbutton, push switch, or other source. The adjustable timing range is 20-to-1, and the mechanism is immediately recycling. A built-in DP, DT auxiliary relay provides a variety of circuit arrangements common to, or isolated from, the control circuit. Struthers-Dunn, Inc., 1321 Arch t., Philadelphia 7, Pa.

Ivot Type Ball-Bearings

Ivot ball-bearings are available in sizes ranging from 2 to 10 in O.D. They are made of beryllium, stainless or chrome steel. Each bearing is equipped with four balls of the same material as the cup, and fitted with a retaining cup. Miniature Precision Bearings, Keene, N. H.

Triple-Action Locknuts and Fasteners

The main feature claimed for the 6NAC Palnut locknuts and fasteners is a triple locking action. The sides have been extended and the heads of the petals are turned n, leaving a hole in the top slightly smaller in diameter than the outside diameter of the bolt. When the bolt extends through the top, it forces the top open so that a strong spring pressure is exerted on the bolt, resulting in a triple grip. Because this spring tension is constant and will hold the nuts in any desired position on the bolt regardless of vibration, this type of nut may be used as an adjustment nut for Stationary Operation.

For Aircraft Applications, etc.

Type 4 requires 50 to 50 mw
Type 5 requires about 5 mw
—is most stable as to adjustment
—will withstand severe shock
(500 R's) without damage.

Send for complete information, stating your problem.
Eliminate set generated heat and you get not only peak efficiency but longer life too from all components parts in electronic equipment. Pilot Blowers are proving this for leading manufacturers in this field. Easy-to-install—compact—quiet running—economical...these are the features which make Pilot Blowers ideal for the important job of air circulation and ventilation in Radio equipment. Available in standard models to move from 15 to 110 C.F.M. Write for Bulletin 507 today!

F.A. SMITH MFG. CO., INC.
801 DAVIS ST., ROCHESTER 5, N.Y.

FRACTIONAL H. P.
MOTORS Pilot CENTRIFUGAL BLOWERS

Pyroferric IRON CORES

Pyroferric powdered metal cores have kept pace the vital precision instrument development. They are manufactured to specification:

- PERMEABILITY: HIGH
- "Q": as desired
- FREQUENCY: HIGH
- MEDIUM
- LOW
- RESISTANCE: LOW
- CONSULT PYROFERRIC ON YOUR POWDER METALLURGY REQUIREMENTS

PYROFERRIC CO.
175 VARICK STREET NEW YORK, 14, N.Y.
electrical contacts, and mechanical travel-limits.

Type 6NAO nuts may also be used, because of their light weight, bolts holding together parts of glass, plastic and other materials, where a resilient fastening is required that can be tightened without danger of fracturing relatively brittle materials.

Another feature of these Palnuts is that they are all-metal and will therefore withstand high temperatures.

The Palnut Co., 77 Cordier St., Irvington, N. J.

Rotary Relay

I-TROL is a new type of relay which operates on a rotating balance principle. It is designed especially for applications involving severe vibration, temperature and humidity specifications. The basic unit is a compact driving-mechanism providing up to 30 deg of lockwise or counter clockwise rotation. When used to operate switch wafers, the basic unit makes a relay providing a great variety of contact arrangements adaptable for spaced wafer switches, or switches in separate compartments. Where switch wafers are not used, a special self-contained coil break-switch is provided. The unit measures 2 1/2 x 1 1/2 x 1 in.

Price Brothers Company, Frederick, Md.

Coaxial Plugs and Jacks

To make soldering of coaxial plugs and jacks an easy and out-in-the-open job, these plugs and jacks are built with sliding sections so that they can be quickly disassembled. The conductors to be soldered are

TRANSFORMERS HELP THEM WIN!

All important to a Task Force are the many and varied electrical units that play such a vital part in the operating and coordinating of both ships and planes.

One factor common to all these units is the need of an unfailing source of Proper Power—the Hermetically Sealed Transformer.

Chicago Transformer designs and manufactures transformers that more than meet the rigid standards set for equipment of this type.
Among Export 1189 BELL Special - Electronic Sequence equipment permanent communicating electronic not obligate and manufactured amongst perhaps assemblies. If assemblies? Perhaps we can help you! 

Fungus-Proof Resistors and Switches

Fixed wire-wound resistors (Akra-Ohm), and switches which have been treated with anti-fungus materials and which meet Signal Corps Specification No. 71-2202A are available without any manufacturing delay occasioned by this special treatment.


Aircraft Push-Pull Circuit Breaker

KLIXON D-6751 designates a new aircraft circuit-breaker which makes use of a push-pull feature to permit the opening of the circuit breaker manually. Thus maintenance and repairs to a circuit can be accomplished without de-energizing the entire power system. A elaborate pull is required, and the off position is retained safely against accidental tripping when operating adjacent switches. The push-pull button travels outwardly approximately 1/2 in. upon tripping and ex-
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Are you engineers having trouble finding an exactly correct electrical power supply for today's war products? Are you planning the power supply for your future products? Then let Wincharger Engineers help you. They can save you lots of time and worries if you need:

MOTORS
- Built in and shell type motors
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A SURE GRIP THAT CAN'T SLIP!

The BOOTS SELF-LOCKING RADIO ANCHOR NUT, SIZE NO. 6
Designed especially for Radio and Electronic products

The all-metal, built-in lock permits no axial play—holds the nut securely in place despite the severest vibration. Not affected by temperature changes. Can be used safely and effectively again and again. Additional important advantages:

- Remarkably small, compact and sturdy—helps good product design.
- Will not turn.
- More readily applied than a clinch nut.
- Threads are never distorted since no punch is required.
- Allows flush surface on opposite side without chamfering.

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35 years of service to American Industry

DIALS - PANELS - PLATES
made to your precise engineering specifications in etched metals and finishes.

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21-03 44th Ave.
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TEST INSULATION THE MODERN WAY

...WITH A MODEL B-5
MEGOHMER
NEW BATTERY-VIBRATOR TYPE


Write or phone for Bulletin 430

Herman M. Sticht
27 Park Place
NEW YORK, N. Y.

---

September 1944 — ELECTRONICS
**METAL-COATING PROCESS**

**FAST AND ECONOMICAL COATINGS**

PLATINUM AND SILVER for electronic use

**PLATINUM**
- WIRE
- FOIL
- RIBBON

**SILVER**
- SHEET
- WIRE
- BRAZING ALLOYS & FLUX

**THE AMERICAN PLATINUM WORKS**
Refiners & Manufacturers
N.J.R.R. Ave. at Oliver Street
Newark 5, N. J.

**Gas Proportioner**

**This new piece of apparatus was developed as an aid for electronic tube manufacturers, heat treaters and others who use mixtures of gases for protective atmospheres. It is designed to produce an accurately proportioned mixture of such gases at a pressure not in excess of 5 lb per sq in. The device consists of a mixing block incorpor...**
Marking Unit

DELICATE and precision parts having a ground or mirror surface may be marked without marring by means of a marking unit (Airgrit) which is operated by air pressure and employs a principle similar to sand-blasting except for the fact that it is especially designed for delicate materials. A timing unit aids in making uniform markings.


Film Recorder

FILMGRAPH is a new device for permanently recording and reproducing sound on film instantaneously and without processing. The instrument consists of an electromagnetic dual-purpose head (recording and playback), sapphire stylus, motor, and necessary controls and connections. It is available in a cabinet complete with an amplifier, speaker and microphone, (weight is 16 lb), or without these accessories. Recordings can be made on Filgraph M-5 special film, on which a number of sound tracks (up to 40) may be recorded, or a recording may be made directly on 16 mm film. Recordings cannot be made directly on 8 mm film because the speed of 8-mm projectors is too slow for good results on this recorder. Where it is desirable to use 8-mm film, it is necessary to use Filgraph M-5 film as an auxiliary.

Miles Reproducer Co., Inc., 812 Broadway, New York 3, N. Y.

Electronic Weld Controls

TWO TYPES OF welding controls are available. The first of these is Model 40, which is a general-purpose control for seam, spot, or pulsation-welding machines. It is designed for the control of welders...
For the Best In MECHANICAL, THERMAL, CHEMICAL, AND ELECTRICAL PROTECTION

Get Pedigree Electrical Insulating Varnishes


The P. D. GEORGE CO.
5200 North Second Street • St. Louis 7, Mo.

Call in the Pedigree Varnish Man Nearest You

American Capacitors are giving peak performance in front line battle areas . . . they have to be tough! They are precision engineered to meet the most exacting demands. American Electrolytic and Paper Capacitors, incorporating new plastic designs, cover all standard capacitance values and working voltages.

AMERICAN CONDENSER CO.
4410 RAVENSWOOD AVENUE • CHICAGO 40, ILLINOIS

HERE IS AN AMERICAN CAPACITOR FOR EVERY SIZE AND PURPOSE
The importance of MICA
for National Defense

Submarine engines depend on Mica parts for reliable performance. Electrically-driven TORPEDOES would be almost an impossibility if it were not for certain MICA segments contained in the motor parts!

Ford Radio & Mica Corp.
JOSEPH J. LONG, Pres.
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here more than one kind of operation is to be controlled by a single general-purpose control, and particularly where more than one type of operation is to be performed interchangeably on the same machine. Model 41 is specifically designed for production seam-welding control. Heat and cool times repeat automatically for continuous seam-welding until interrupted by the operator. This unit is simple to adjust and is easy to maintain.

Bulletin No. WT-40-41 illustrates and describes these units in greater detail. It is available from the manufacturer, Weltronic Co., 19500 7. Eight Mile Road, Detroit 19, Mich.

**Literature**

Television Pamphlets. Two companies have issued brochures on television:

The first of these is entitled "Television" and the purpose of this 24-page book is to tell the advances of television; its progress and promise. A map is included which tends to show how east and west may be linked in a television network. Department of Information, Radio Corporation of America, 30 Rockefeller Plaza, New York, N. Y.

The second booklet is entitled "The Story of Electronic Television" and it attempts to tell the aymn in simple language, and with illustrations, how television is accomplished. Two pages in the back of this 28-page book are devoted to television equipment available from the manufacturer, Farnsworth Television & Radio Corp., Fort Wayne 1, Ind.

Transformer Bulletin. A complete range of transformers for small and large electric power requirements are illustrated and described in a bulletin entitled "Standard Transformers For Every Need" available from Standard Transformer Co., Warren, Ohio.

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September 1944 — ELECTRONICS
table of mechanical and electrical properties is included in Bulletin No. 143. The bulletin also describes and illustrates insulators made of this ceramic material (which is designated A1SiMac No. A196). American Lava Corp., Chattanooga, Tenn.

Thermoswitches. The purpose of this catalog is to introduce the complete line of standard temperature and pressure control apparatus made by this manufacturer. It contains 44-pages of descriptive material, including installation drawings and photographs, plus a brief history of the company. Fenwal Inc., 200 Pleasant St., Ashland, Mass.

Flexible Shaft Machines. Catalog No. 130 illustrates and describes machines for light production work and for maintenance needs on small irregularly-shaped parts which cannot be handled by conventional machine set-ups. Available accessories are also described. Foredom Electric Co., 27 Park Place, New York 7, N. Y.

D-C Motor Control. "Electronic Control of D-C Motors" is a reprint, with changes, of a series of articles on this subject by E. E. Moyer, which appeared in 1943 Electronics. This reprint is designated as Filing No. 8930 and the articles in it are "Outline of General Principles", "Reference Voltage and Speed - Control Methods", Extending Speed Range by Electronic Means of Field Weakening", "Starting, Stabilizing, and Reversing", and "Regeneration by Inverter Action, and Stopping." Electronics Section, Industrial Control Engineering Div., General Electric Co., Schenectady, N. Y.

Springs. Catalog No. 44, entitled "Springs for All Purposes", contains a spring design chart. When he dimensions, load and travel distance is known, this chart may be used to find the number of coils and the proper wire size which one should use. Round or square wire 0.006 to 0.375 in. diameter, and strips of 0.003 to 0.187 in. thickness, and of any desired material are available. Types of springs illustrated in the catalog include compression, extension,
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Illustration shows panel with patch cord in place.

Questions and Answers on RCA. This 48-page catalog entitled “RCA, What It Is, What It Does—Questions and Answers” is exactly what the title implies. The catalog is carefully indexed according to subject matter. Subjects include research and engineering, pioneering, broadcasting, television, manufacturing, communications, marine radio and technical training. Radio Corp. of America, 30 Rockefeller Plaza, New York 20, N. Y.

Smoke and Combustion Control. Indicators, controllers and recorders for smoke and combustion controls are illustrated and described in an 8-page folder form (Bulletin No. 431). Ess Instrument Co., Fort Lee, N. J.

Temperature extremes from 295°F. to minus 80°F. are just one sample of the varied conditions which "Surco-American" flexible plastic tubing is able to meet. Over twenty-six different formulations provide positive and tested qualities such as ageless durability, non-inflammability, tremendous flexibility, and proof against moisture, all kinds of weather, dilute acids, oils and most solvents.

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Other units in the new General Electric line of laboratory measuring instruments include: Visual alignment signal generator, wave meters, wide band oscilloscopes, square wave generators. *Electronics* Dept., General Electric, Schenectady, N. Y.

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375
**Phase Inverter Circuit**

Last month, CREI presented the first part of a technical article describing the Phase Inverter Circuit. Part 2, which appears in the September issue of "THE CREI NEWS," gives a typical numerical example of the phase inverter circuit and indicates the type of performance that can be expected.

Derivations are then made of the gain and stability of gain of such a stage and its linearity. It is shown that very good results can be expected. Finally, an analysis of the input admittance is made, as well as remarks on some practical features of the circuit.

Each month the "THE CREI NEWS" features such a technical article, in addition to other interesting features concerning The Institute and the industry.

We shall be glad to add your name to the mailing list without obligation. Simply write to The Institute at the address below and request the September issue of "THE CREI NEWS" containing the article on the Phase Inverter Circuit.

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**Coast Contractors**

Industrial X-Ray Unit. "Search-ray", Model 150, is a self-contained industrial x-ray unit manufactured by North American Phillips Co., Inc., for the internal inspection of castings, parts, assemblies, etc., and for locating flaws and defects. This unit is described in folder No. S150 distributed by Walker-Jimieon, Inc., 311 South Western Ave., Chicago 12, Ill.

Adhesive Data. Viscosity, bonding range, and method of application are all contained in a booklet entitled "3-M Adhesive Data" which is designed to serve as a reference book to anyone using adhesives or coating materials, impregnators, spray-on insulators and sound-deadening compounds. Minnesota Mining & Mfg. Co., 411 Piquette Ave., Detroit 2, Mich.

Frequency Meters. Type 21-FX miniature frequency meter, which superseded Model 21-F, is described in Bulletin VF-43-lb. Meters which operate on 60, 120, and 400 cps are available. These meters are designed to match other 2½ in. panel instruments. J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.

Introductory Booklet. "Let Lewyt Do It" is the name of a booklet which illustrates and describes the facilities this company has to offer other manufacturers in the production of mechanical and electrical products. Some of the jobs they do include tool and die, machine work, sheet metal, welding techniques, mechanical and electrical assembly, product finishing, inspection and production engineering. Lewyt Corp., 60 Broadway, Brooklyn 11, N. Y.

Coaxial Transmission Line. Type 83 (⅛ in. diameter), a low loss coaxial transmission line for high or uhf radio frequencies is illustrated and described in Bulletin No. 29, which also contains descriptions of accessories for this line. Andrew Co. 363 East 75th St., Chicago 19, Ill.

Spot Welders. This is the name of a 58-page catalog, No. CE-44W, which shows all types of standard and many special resistance welding machines manufactured in ca-
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Capacity ranges from 3 kva to heavy duty models up to 500 kva. Another booklet available is called "Light Type Bench Spot Welders" and this booklet features small spot welding machines from 4 to 8 kva. Eisler Engineering Co., 740 S. 13th St., Newark 3, N. J.

Connector Chart. Type K and RK wall chart, No. 3, contains, in condensed form, material on K connectors. It is for use in schools and factories for the instruction, identification, assembly, ordering, servicing or repair of these connectors and accessories. It is free of charge and is available from Cannon Electrical Development Co., 3209 Humboldt St., Los Angeles, Cal.

Story of Tubes. "It Was a Tube They Wanted" is the name of brochure which briefly tells of the part tubes played in the summer of 1940. It contains illustrations and descriptions of the part this laboratory played in producing tubes. Amperex Electronic Products, 79 Washington St., Brooklyn, N. Y.

Pilot Light Assemblies. "Pilot Light Assemblies for Panel Board and Instrument Signaling" is a 24-page catalog and data book which illustrates and describes pilot light models for a wide range of applications and voltages, including variable intensity and fixed types. Lamps, brackets and accessories are also listed. Gothard Mfg. Co., 1800 N. Ninth St., Springfield, Ill.

Resistance Material. A brief description of this manufacturer's resistance material having negative temperature coefficient is presented in a folder which also contains a graph of typical characteristics of resistance units. Keystone Carbon Co., Inc., St. Marys, Pa.

Colored Brochure. This beautifully colored brochure contains reproductions of various advertisements of this manufacturer's war effort. A very brief description is included of Model SCR-299 mobile radio station. The Hallicrafters Co., Chicago 16, Ill.
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Publishers of Electronic Engineering are issuing a series of technical monographs to give radio engineers and students at low cost information that could only be obtained otherwise from a number of books and periodicals. The title is justified largely by the fact that the last of six chapters gives special attention to electrical and dielectric properties of plastics. Tables of comparative properties and graphic charts showing variation of power factor and dielectric constant with temperature are included in this chapter.

The first three chapters give a brief chemical picture of the different types of plastic materials and their manufacture, with the aid of numerous reproduced photographs. These are followed by a chapter devoted to physical properties of plastic products made of different materials and another describing the different methods of fabrication.

Appendices give miscellaneous information such as analyses or names of cements and solvents, how to identify the raw materials by heating tests, and a bibliography of books and articles on plastics.—M.G.V.

Calculus Refresher for Technical Men

Designed for the engineer who has allowed his calculus to get a little rusty, this work serves the purposes of review most effectively by its unusual arrangement as a series of questions with related and full answers. This format likewise helps in reference because each question is set forth in boldface type so a particular point is easy to find.

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Radio Waves and the Ionosphere

By T. W. BENNINGTON, British Broadcasting Corp. Iliffe & Sons Ltd., Dorset House, Stanmore St., London, S. E. 1. 85 pages, price 6/- net, 1944.

Many who work with radio or make a hobby of short-wave broadcasting and receiving, but who do not have use for mathematical conceptions of short-wave propagation as the subject is usually presented, will be interested in this little book. Its aim is to explain short-wave communication, and in particular the part that the ionosphere plays in bending radio waves around the earth, in as simple language as possible without any mathematics.

Although the book is not a textbook, it can be recommended as preliminary reading for anyone who is planning to delve deeper and master the mathematics involved.

The six chapters of the book deal with ground waves vs. sky waves, the ionosphere and its characteristics, how the ionosphere is sounded, its variations, long-distance transmission, and disturbances and other abnormalities of the ionosphere.—M.G.V.

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