Cockroft - Walton Voltage Quadrupler, for observation of atomic disintegration

electronics

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October 1942

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JAMES H. McGRAW, Founder and Honorary Chairman

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From . . . .

. . . .

To . . . .

. . . .

Signed . . . .


42-S-17

BANISH GHOSTS WITH THIS NEW TRACING CLOTH

PHOENIX is the new kind of tracing cloth, proofed against perspiration stains and water marks —*that holds erasure scars at a minimum.* PHOENIX gives you clean tracings, in pencil or ink, free from untidy "ghosts" that reproduce on blueprints!

An exclusive new process is responsible for this amazing performance, a process which defies moisture, and gives PHOENIX its unusually durable working surface. You use harder pencils . . . get sharper lines with less tendency to smudge. Even 6H pencil lines show clearly, and reproduce strongly. You don't mar the surface when you erase; erased areas take pencil smoothly —and ink without feathering. Its new white color and its increased transparency provide excellent drawing contrast . . . produce strong blueprints.

Give PHOENIX your own drawing board test. See your K&E dealer, or write for a generous working sample and an illustrated brochure.

PHOENIX DEFIES MOISTURE GHOSTS

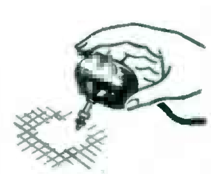
Perspiration and water splashes on ordinary tracing cloth create "ghosts" which reproduce on blueprints. PHOENIX Tracing Cloth withstands actual immersion in water for fully 10 minutes at a time! *Perspiration and water marks will not stain it!*

PHOENIX LESSENS SMUDGE GHOSTS

The new improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: Cleaner tracings and blueprints.

PHOENIX REDUCES ERASURE GHOSTS



Ordinary tracing cloths become scarred when erased . . . erased spots produce ghosts on blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.

K&E Phoenix

REG. U.S. PAT. OFF.

TRACING CLOTH

for pencil *and* ink

EST. 1867

KEUFFEL & ESSER CO.

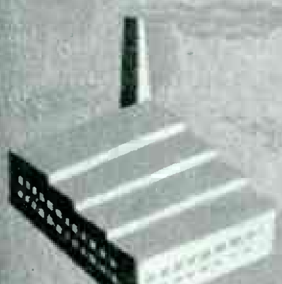
NEW YORK · HOBOKEN, N. J.

CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES · DETROIT · MONTREAL

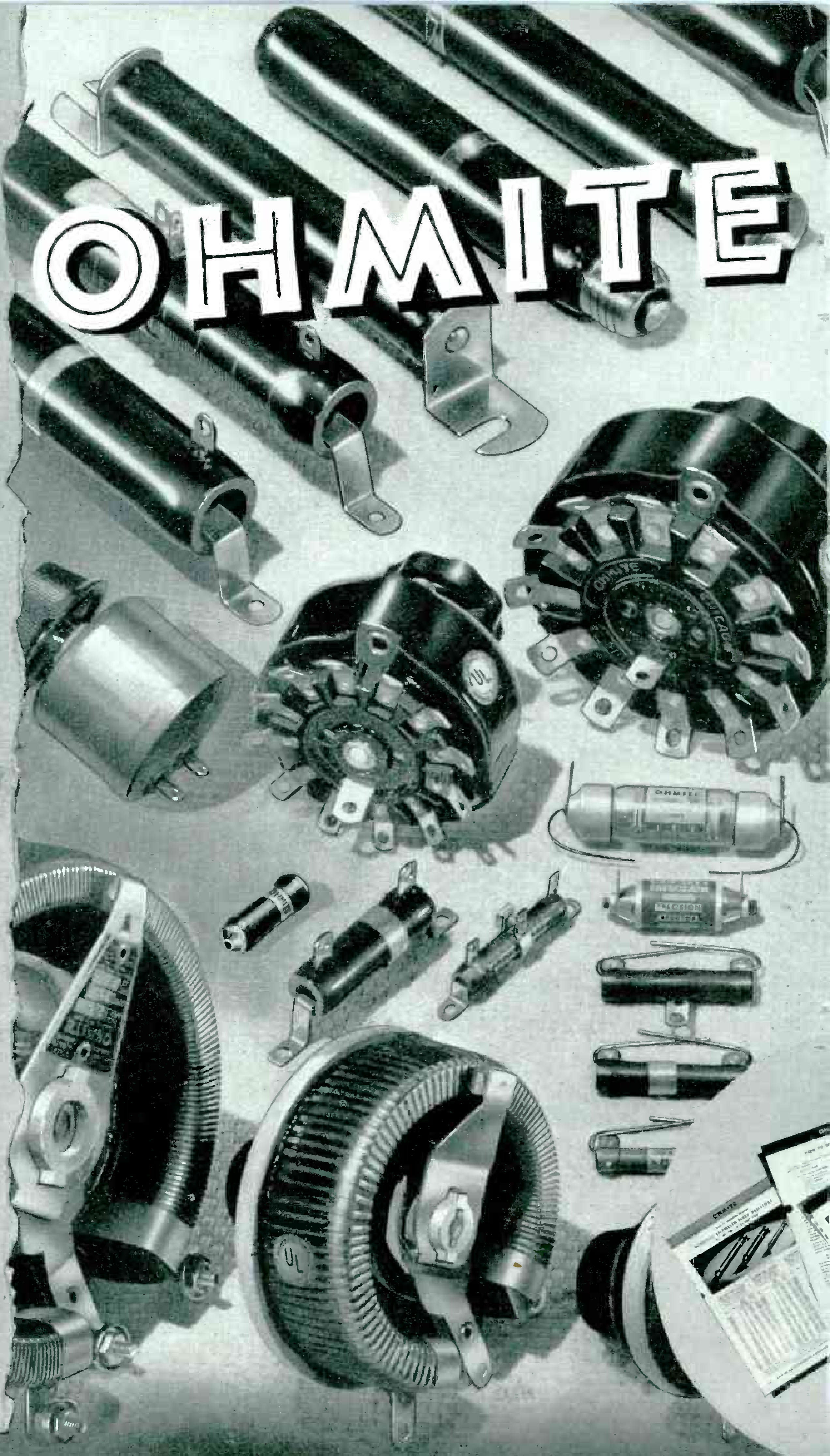
IN PLANES—Ohmite Rheostats and Resistors have pioneered the airways. Today, they fly and fight on all fronts. Approved types for Army and Navy specifications.

IN TANKS—Here, too, Ohmite Resistance Units perform essential control functions under the toughest service conditions to help fight a better fight.

IN SHIPS—Ohmite Rheostats, Resistors and Tap Switches are used in a variety of electrical control applications in battleships, submarines and torpedo boats.



IN INDUSTRY—Ohmite Units not only are used in war material which industry is producing, but in laboratory and production equipment as well, in the control of motor speed and generator fields, of heat and light, of signal and supervisory circuits.



Resistance Units

... in War and Industry

Here are facts with which many of you have long been familiar—facts which give you added assurance in dealing with today's resistance—control problems.

(1) The basic design and construction features of Ohmite Products have been tested and proved thru years of service in critical applications. (2) The extensive range of types and sizes makes them more readily applicable to almost every requirement. (3) The experience of Ohmite Engineers is especially helpful in selecting or designing the right units for each need.

Add them up together—and you can readily understand why Ohmite Rheostats, Resistors, Chokes and Tap Switches are used in endless variety and number in war and in industry—in planes, tanks and ships, in walkie-talkies and field units—in communications and electronic devices, in test apparatus and electrical control equipment—and in the development of new devices to defeat the enemy and build for tomorrow's peace.

Factory and production facilities have again been expanded to help meet the greatly increased demand for Ohmite Products.

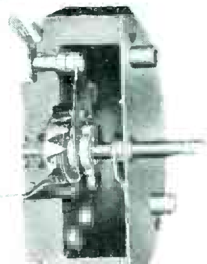
Units Produced to Government Specifications.

Close Control Rheostats

Smooth, gradual, close control is permanently built in. The wire is wound on a solid porcelain core, locked in place and insulated by Ohmite vitreous enamel. Nothing to shrink, shift or deteriorate. Self-lubricating metal graphite contact prevents wear on the wire.

Vitreous Enameled Resistors

The resistance wire is evenly wound on porcelain core, rigidly held in place, insulated and protected by Ohmite vitreous enamel. Dissipates heat rapidly—prevents hot spots and failures. Core sizes range from 2½" diameter by 20" long to 5/16" diameter by 1" long.



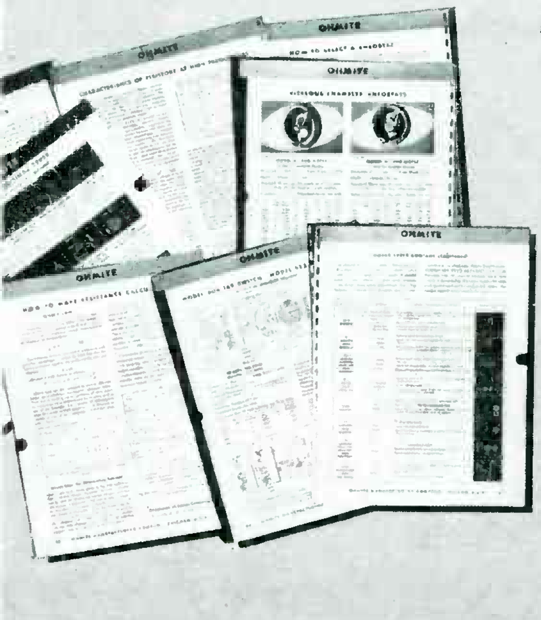
High Current Tap Switches

Load-break, single-pole, multi-point rotary selectors. Compact, all-enclosed ceramic construction. Unique slow-break action. Large self-cleaning silver-to-silver contacts. Low contact resistance. Back of panel mounting. Non-shorting type. Five sizes from 10 to 100 amperes, A.C.

OHMITE MANUFACTURING COMPANY

Foremost Manufacturers of Power Rheostats, Resistors and Tap Switches

4816 FLOURNOY STREET, CHICAGO, U. S. A.



This 96-Page Book Is Especially Helpful Today

Write on company letterhead for Complete Catalog and Engineering Manual No. 40. Helps expedite the solution to resistance problems. Gives valuable information on the selection and application of rheostats, resistors, chokes, tap switches and attenuators. Contains useful reference tables, dimensional drawings, important engineering data and a manual of resistance measurements. Tells about stock types and special units. Saves time.

Electroneering is our business!

ELECTRONEERING is the word we have coined to symbolize the part we are playing in the conquest of the stirring new world of Electronics.

Behind the closed doors of the RAULAND laboratories, new visions, new ideas, new discoveries are unfolding themselves. Here, scores of new vacuum devices are blazing new trails in the fields of Television, Broadcasting, Communications, and Sound.

But first and foremost, we at RAULAND are at war—along with 130,000,000 other fighting Americans. All of our energies, experience, engineering ingenuity, and manufacturing resources are at work on military communications, building the vital sinews of modern warfare. Electroneering for American victory is our main business.

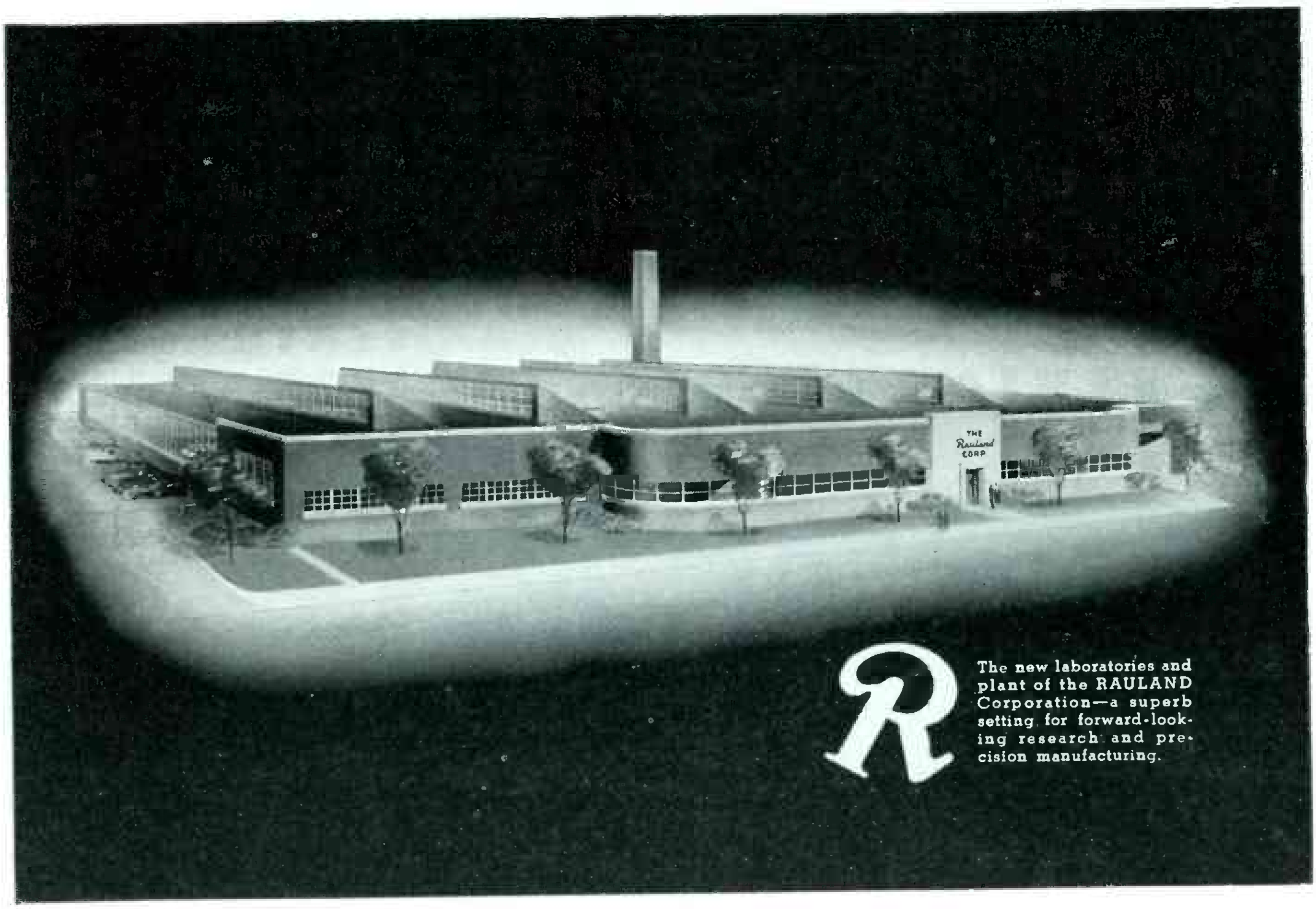
We are not unmindful, however, that since 1922 we have been at the service of the radio industry. We feel, therefore, that it is our obligation to tell you something about our present activities. It is our plan to give you, from time to time, worthwhile information (within the limits of government regulations) describing unique advances in electronic design and in techniques of manufacture that symbolize the RAULAND ideal in Electroneering.

We hope to make these messages interesting and informative—to keep you posted on the scope of RAULAND'S engineering and manufacturing activities—against the day when we can once again share these resources with you.

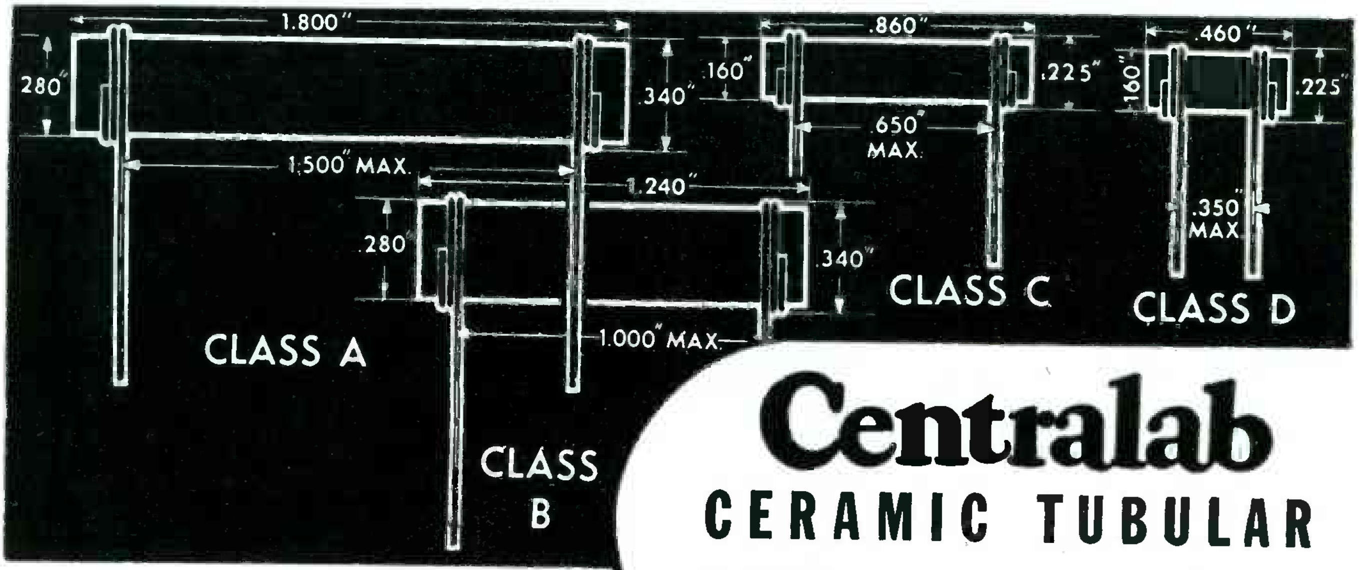
Rauland

RADIO · SOUND · COMMUNICATIONS

The Rauland Corporation · Chicago, Illinois



The new laboratories and plant of the RAULAND Corporation—a superb setting for forward-looking research and precision manufacturing.



Centralab
CERAMIC TUBULAR FIXED CAPACITORS

Write for Data

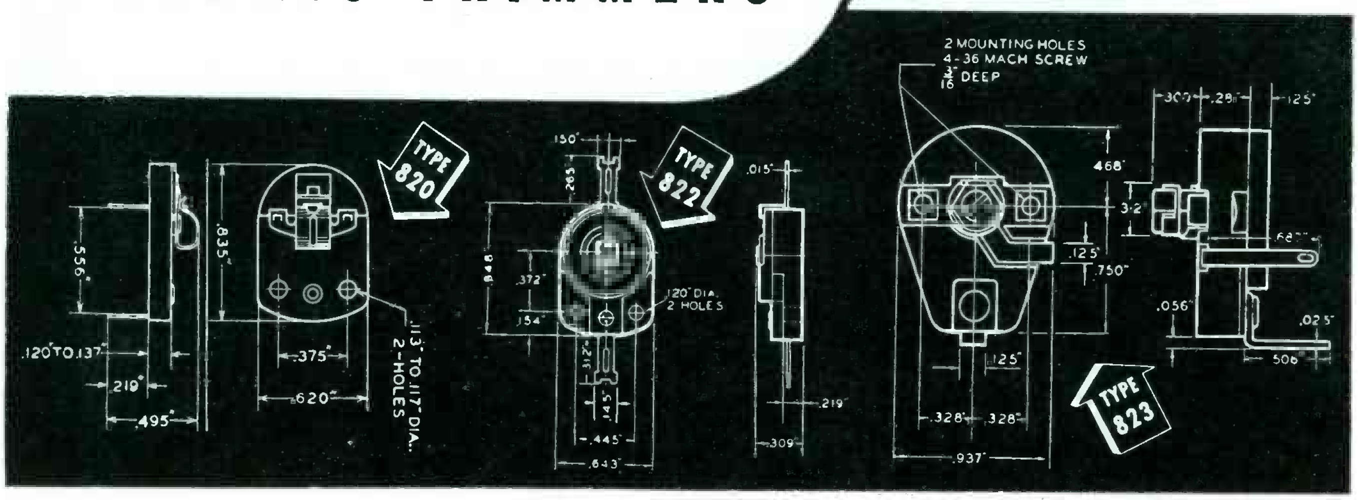
Bulletin 597 describes the CENTRALAB CERAMIC TUBULAR Fixed Capacitors with controlled temperature sensitive characteristics.

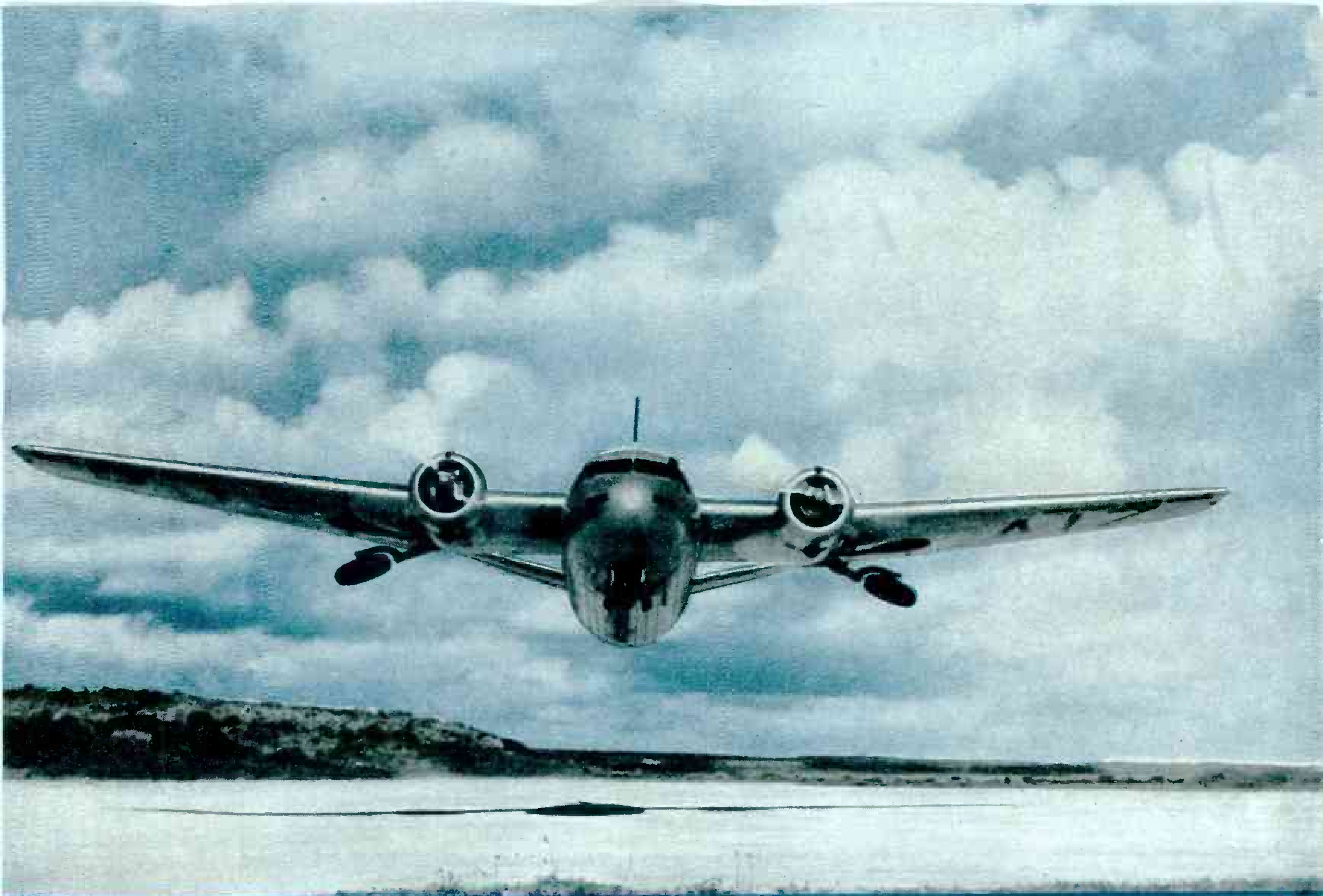
Centralab Ceramic Trimmers feature capacity ranges and stability, the equivalent of air trimmers, plus a saving in space and weight. Write for bulletins that supply full Ceramic Trimmer data.

Always specify Centralab — whether for ceramic products . . . Fixed Resistors . . . or Volume Controls . . .

CENTRALAB
DIV. OF GLOBE-UNION INC.
MILWAUKEE WISCONSIN

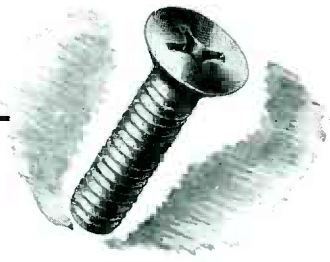
Centralab
CERAMIC TRIMMERS





Now You Have

19 Sources of Supply for Phillips Recessed Head Screws



AMERICAN SCREW COMPANY
Providence, Rhode Island

THE BRISTOL COMPANY
Waterbury, Connecticut

CENTRAL SCREW COMPANY
Chicago, Illinois

CHANDLER PRODUCTS CORP.
Cleveland, Ohio

CONTINENTAL SCREW COMPANY
New Bedford, Massachusetts

THE CORBIN SCREW CORPORATION
New Britain, Connecticut

INTERNATIONAL SCREW COMPANY
Detroit, Michigan

THE LAMSON & SESSIONS COMPANY
Cleveland, Ohio

THE NATIONAL SCREW & MFG. CO.
Cleveland, Ohio

NEW ENGLAND SCREW COMPANY
Keene, New Hampshire

THE CHARLES PARKER COMPANY
Meriden, Connecticut

PARKER-KALON CORPORATION
New York, New York

PAWTUCKET SCREW COMPANY
Pawtucket, Rhode Island

PHEOLL MANUFACTURING COMPANY
Chicago, Illinois

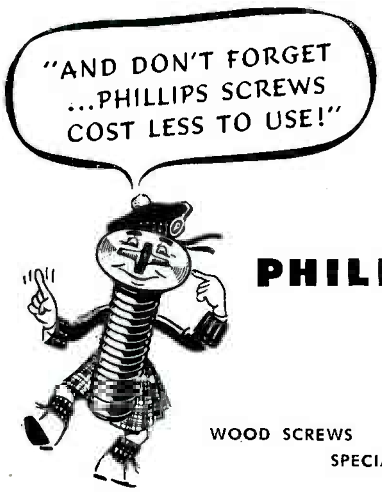
RUSSELL, BURDSALL & WARD
BOLT & NUT COMPANY
Port Chester, New York

SCOVILL MANUFACTURING CO.
Waterbury, Connecticut

SHAKEPROOF INC.
Chicago, Illinois

THE SOUTHINGTON HARDWARE MFG. CO.
Southington, Connecticut

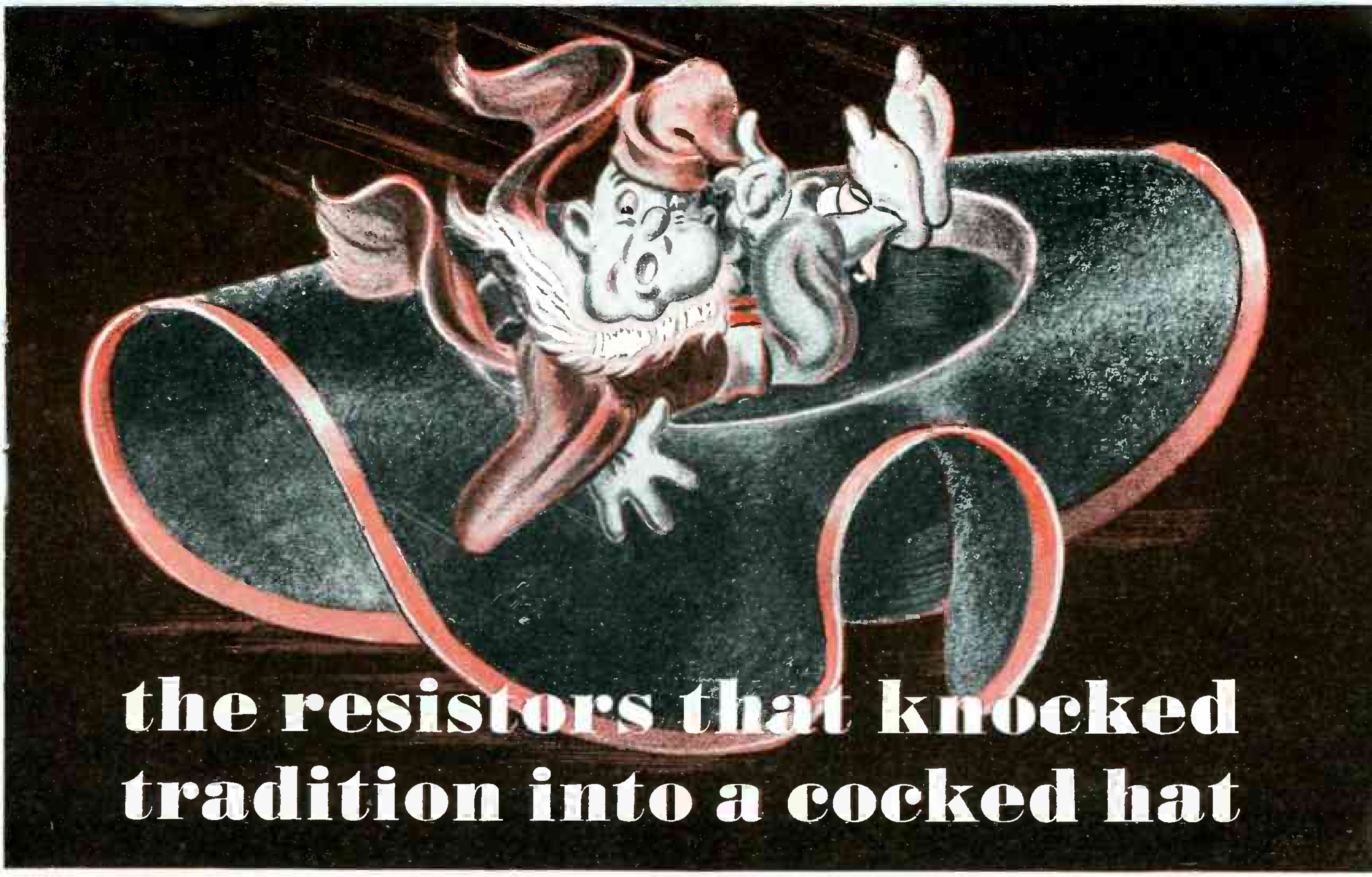
WHITNEY SCREW CORPORATION
Nashua, New Hampshire



Your screw requirements can be met without delay — with genuine fast-starting, quick-driving, tight-seating Phillips Recessed Head Screws. ***WHAT ABOUT DRIVERS?*** There are 44 sources of supply for PHILLIPS DRIVERS plus general hardware and mill supply distribution.

PHILLIPS RECESSED HEAD SCREWS
GIVE YOU *2 for 1* ***(SPEED AT LOWER COST)***

WOOD SCREWS · MACHINE SCREWS · SHEET METAL SCREWS · STOVE BOLTS
SPECIAL THREAD-CUTTING SCREWS · SCREWS WITH LOCK WASHERS



the resistors that knocked tradition into a cocked hat

BY DOING THE JOBS CONVENTIONAL WIRE-WOUND RESISTORS COULDN'T HANDLE

THE unique and exclusive construction of KOOLOHM resistors has completely revolutionized previous conceptions of wire-wound resistor design. It has freed engineers from use limitations which a few years ago they regarded as "necessary evils."

KOOLOHMS are the only resistors made with wire that is ceramic insulated *BEFORE it is wound.* This one feature alone provides you with advantages that no other wire-wound resistor can give you. It furnishes absolute protection against shorts and changed values. It makes possible extremely high resistance values in amazingly small-size units. It permits the use of larger, safer wire sizes. It permits full-rated wattage dissipation regardless of resistance value. This ceramic insulation on KOOLOHM wire is heat-proof to 1000° C. It is moisture-proof and flexible and can either be layer wound or progressively wound in high density patterns. It allows perfect Ayrton-Perry windings, thus reducing inductance to negligible values, and also permits the design of units with predetermined inductance values. It makes possible the use of an *extra* outer protection in the form of chip-proof ceramic or shock-proof sealed glass casing. Thus *doubly* protected they can be easily and cheaply mounted directly to or against metal or grounded parts with *complete* resistor circuit insulation.

Thus, KOOLOHM superiority is not a matter of hair-splitting differences—it is *conspicuously* evident in any test you care to name.

Send for free samples and catalog—today!

SPRAGUE SPECIALTIES COMPANY (*Resistor Division*), North Adams, Mass.

Turns can't "swim" or short, when wound with KOOLOHM ceramic-insulated wire. Insulation has a dielectric strength of 350 volts per mil at 400° C.!

KOOLOHM construction permits perfect Ayrton-Perry windings. As a result, resistors are available having negligible inductance, even at 50 to 100 Mc.!

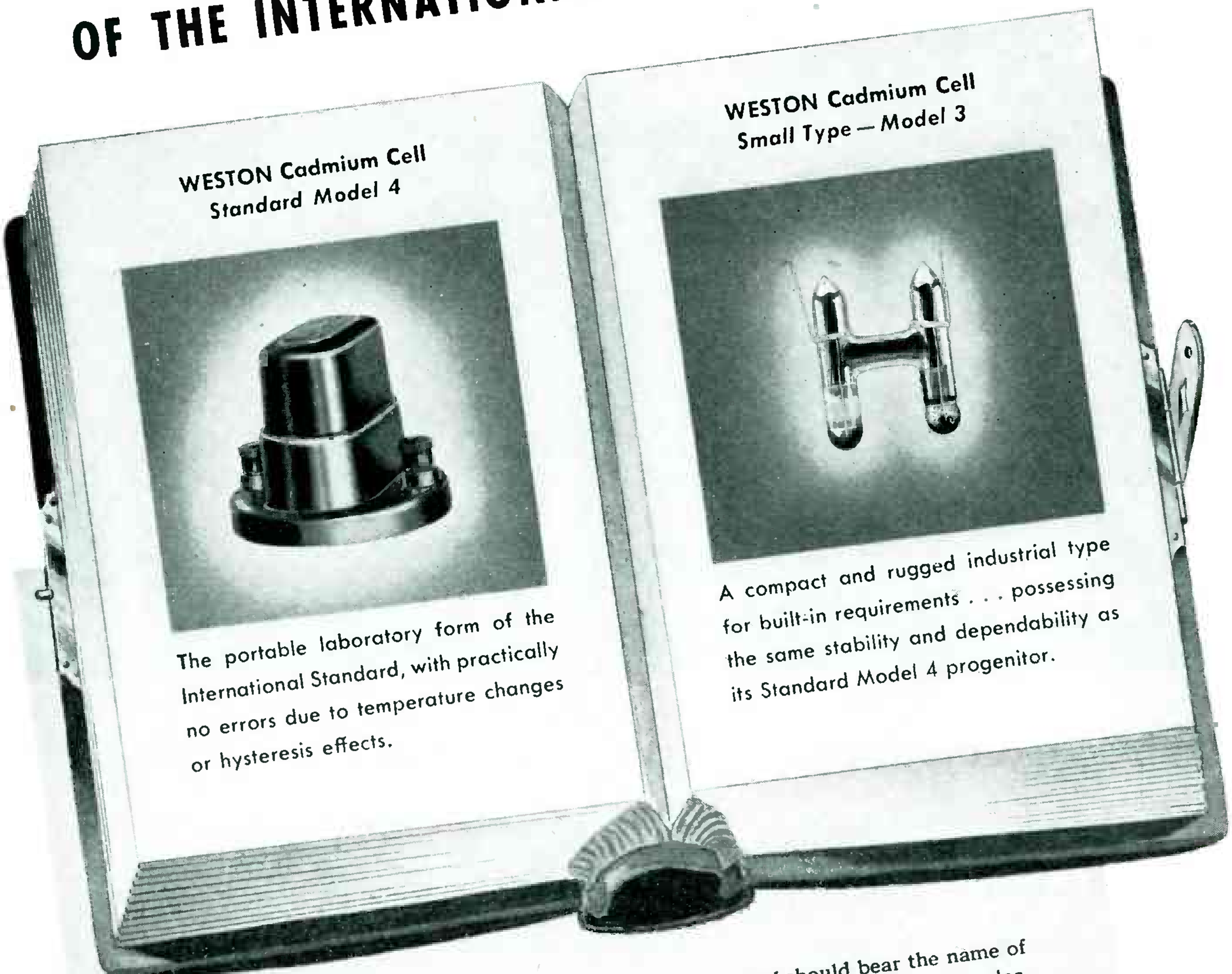
Section of KOOLOHM wire with ceramic insulation removed to show contrast between bare and insulated wire. This flexible, heat-proof insulation is actually applied to wire at a temperature of 1000° C.!

SPRAGUE

KOOLOHM

WIRE-WOUND RESISTORS

OFFSPRING
OF THE INTERNATIONAL STANDARD OF EMF



Over three decades have passed since the WESTON Cadmium Cell, developed and patented by Dr. WESTON in 1893, was adopted as the International Standard of electromotive force. The position that cell occupies as the very foundation of electrical measurement has never been challenged during this long period.

It is perhaps logical that this *fundamental standard* should bear the name of the founder of the science of precise electrical measurement. For its development required the same unique *bedrock engineering* which produced the first direct-reading instrument, and which has kept the measuring instruments bearing the WESTON name the unchallenged leaders for over half-a-century.

Laboratory Standards . . . Precision DC and AC Portables . . . Instrument Transformers . . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

WESTON

Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters . . . Aircraft Instruments . . . Electric Tachometers . . . Dial Thermometers.

WESTON ELECTRICAL INSTRUMENT CORPORATION, 618 FRELINGHUYSEN AVENUE, NEWARK, N. J.

The *exclusive* features of our Ferrule Terminal Resistors are so important that engineers everywhere acknowledge their superiority.

No other resistor offers you the advantage of *monel* terminals. In addition to their complete freedom from corrosion or oxidization, they are forced securely over the ends of the tube before enameling, and so become an integral part that can not loosen or get out of alignment. No cement is used,—so there is nothing to loosen or crumble.

The ends are open and the entire inside diameter is *completely free* from obstruction of any kind,—giving *maximum* ventilation.

The resistance winding is silver soldered to each ferrule, eliminating all possible trouble from intermediate connections.

And the winding, the connections, and the inside face of the ferrules are completely embedded-in-protecting vitreous enamel.

In addition to a complete range of sizes in this resistor, we have a large range of sizes in many other types of resistors and rheostats,—with many other exclusive advantages. Please consult us before ordering, whether you need standard or special resistance service.

HARDWICK, HINDLE, Inc.

Newark, N. J., U.S.A.

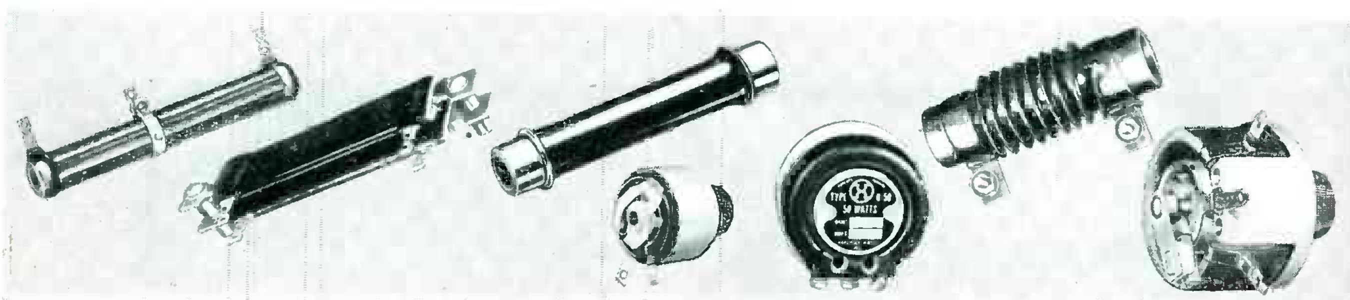
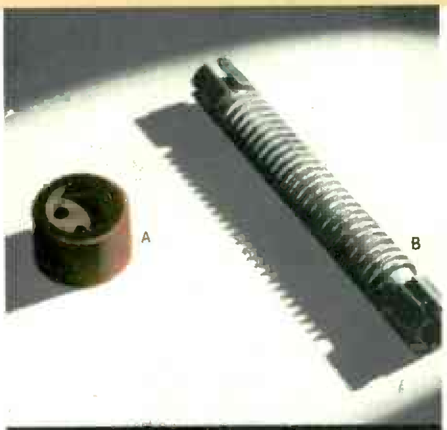


Photo by U. S. Army Signal Corps

This Year's Best Selling Car



A—Connector plug—sawed, turned, and drilled.
B—Coil form—turned, milled, and threaded.

YOU'RE looking at this year's most popular automobile—the Army's "jeep". In its vitals are certain parts made of Synthane. This is only natural for the civilian predecessors of the "jeep" used Synthane too.

Synthane is a material of value to essential industries because of an unusually wide variety of properties, including resistance to corrosion from solvents, acids, salts and water, structural strength, light weight (half that of aluminum), hardness, excellent electrical insulating characteristics and ease and speed of machining.

After the war workaday opportunities for these properties will knock again on factory doors. In the meantime, to present users of Synthane and those with future applications, Synthane offers helpful information such as appears on the back of this sheet.

SYNTHANE CORPORATION, OAKS, PENNA.

Plan your present and future with plastics

SYNTHANE TECHNICAL PLASTICS

SHEETS · RODS · TUBES · FABRICATED PARTS

SYNTHANE
Bakelite — laminated

SILENT STABILIZED GEAR MATERIAL

General Characteristics of Synthane Grades

Here are some of the standard grades of Synthane Bakelite-laminated. We also make subgrades when one or two characteristics must be emphasized.

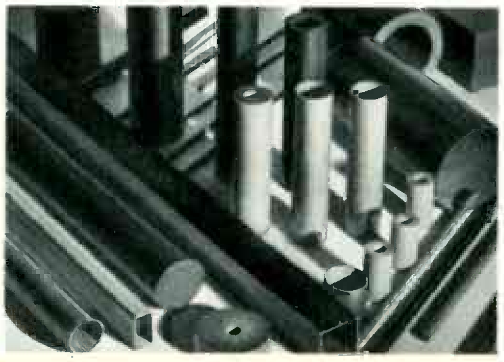
PAPER BASE GRADES

	BASE	RESIN	CHARACTERISTICS
X	Kraft Paper	Hard	A strong paper base laminated material primarily intended for mechanical applications where electrical requirements are of secondary importance. Should be used with discretion when high humidity conditions are encountered. Not equal to fabric base grades in impact strength.
XP	Kraft Paper same as Grade X	Plasticized Resin	A paper base laminated material primarily intended for punching. More flexible and not quite as strong as Grade X. Moisture resistance and electrical properties intermediate between Grades X and XX.
XX	Cotton Rag Paper	Hard Greater % of Resin than Grade X	A paper base laminated material suitable for usual electrical applications. Good machineability.
XXP	Cotton Rag Paper same as Grade XX	Plasticized Resin Greater % than Grade XP	A paper base laminated material similar to Grade XX in electrical and moisture resisting properties, but more suitable for hot punching. Intermediate between Grade XP and XX in punching and cold flow characteristics.
XXX	Cotton Rag Paper	Hard Greater % of Resin than Grade XX	A paper base laminated material, suitable for radio frequency work, for high humidity applications. Minimum cold flow characteristics.
XXXP	Cotton Rag Paper same as Grade XXX	Plasticized Resin Greater % than Grade XXP	A paper base laminated material, similar to Grade XXX, but with lower dielectric losses and more suitable for hot punching. This grade has greater cold flow than Grade XXX, and is intermediate between Grades XXP and XXX in punching characteristics.

FABRIC BASE GRADES

	BASE	RESIN	CHARACTERISTICS
C	Heavy Weave Fabric	Hard	A fabric base laminated material made throughout from cotton fabric weighing over 4 oz. per square yard and having a count as determined from inspection of the laminated plate of not more than 72 threads per inch in the filler direction, nor more than 140 threads per inch total in both warp and filler directions. A strong, tough material suitable for gears and other applications requiring high impact strength. The heavier the fabric base used the higher will be the impact strength, but the rougher the machined edge; consequently, there may be several subgrades in this class adapted for various sizes of gears and types of mechanical service. Should not be used for electrical applications except for low voltages.
CE	Heavy Weave Fabric	Hard Greater % of Resin than Grade C	A fabric base laminated material of the same fabric weight and thread count as Grade C. For electrical applications requiring greater toughness than Grade XX, or mechanical applications requiring greater resistance to moisture than Grade C. Exceptionally good in moisture resistance.
L	Fine Weave Fabric	Hard	A fine weave fabric base laminated material made throughout from cotton fabric weighing 4 oz. or less per square yard. As determined by inspection of the laminated plate, the minimum thread count per inch in any ply shall be 72 in the filler direction and 140 total in both warp and filler directions. For purposes of identification, the surface sheets shall have a minimum thread count of 80 threads per inch in each of the warp and filler directions. This grade is suitable for small gears and other fine machining applications, particularly in thickness under ½ inch. Not quite as tough as Grade C. Should not be used for electrical applications except for low voltage.
LE	Fine Weave Fabric	Hard Greater % of Resin than Grade L	A fine weave fabric base laminated material of the same fabric weight and thread count as Grade L. For electrical applications requiring greater toughness than Grade XX. Better machining properties and finer appearance than Grade CE—also available in thinner sizes. Exceptionally good in moisture resistance.

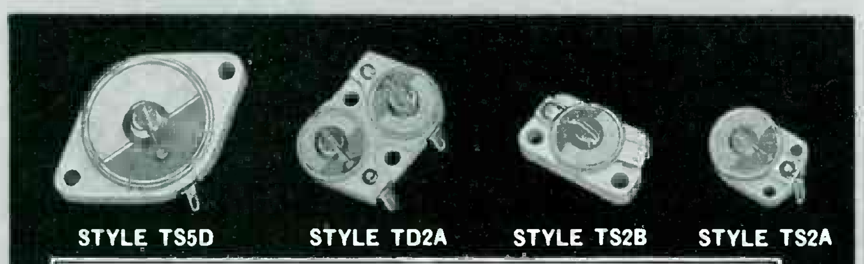
This sheet is one of a series describing the manufacture, grades, properties, and applications for Synthane. Keep it in your Synthane data file or ask us to put you on our mailing list to receive these sheets as they are issued.

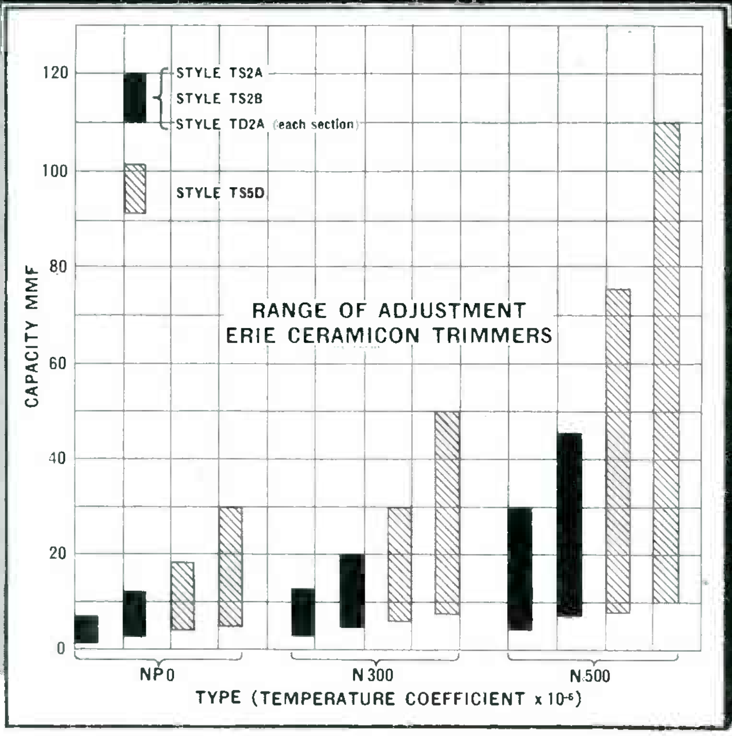


Erie CERAMICON TRIMMERS

REG. U.S. PAT. OFF.

Incorporate These 3 *Important Features*





1. **Choice of Temperature Coefficient**
2. **High Ratio of Maximum to Minimum Capacity**
3. **Low Minimum Capacity**

A few seconds spent in studying the above chart will show you that Erie Ceramicon Trimmers cover the wide range of temperature coefficients and capacities that are in popular demand. The three available temperature coefficients, zero, —300 parts per million per °C, and —500 parts per million per °C, provide a choice that covers most practical applications for temperature compensation. The high ratio of maximum to minimum capacity, combined with a low minimum capacity in each of the four standard styles of Ceramicon Trimmers, allows a wide frequency range to be covered.

The silver-ceramic construction of these units accounts for their inherent stability. A completely covered track and vibration-proof adjustment makes them particularly suitable for vigorous war time service.

These and many other features of Erie Ceramicon Trimmers are completely described in recently issued data sheets. If you are looking for a substitute for air trimmers, or require a trimmer that incorporates temperature compensation in its operation, write for a copy of these data sheets.

ERIE RESISTOR CORP., ERIE, PA. LONDON, ENGLAND · TORONTO, CANADA.

"ALL CLEAR"

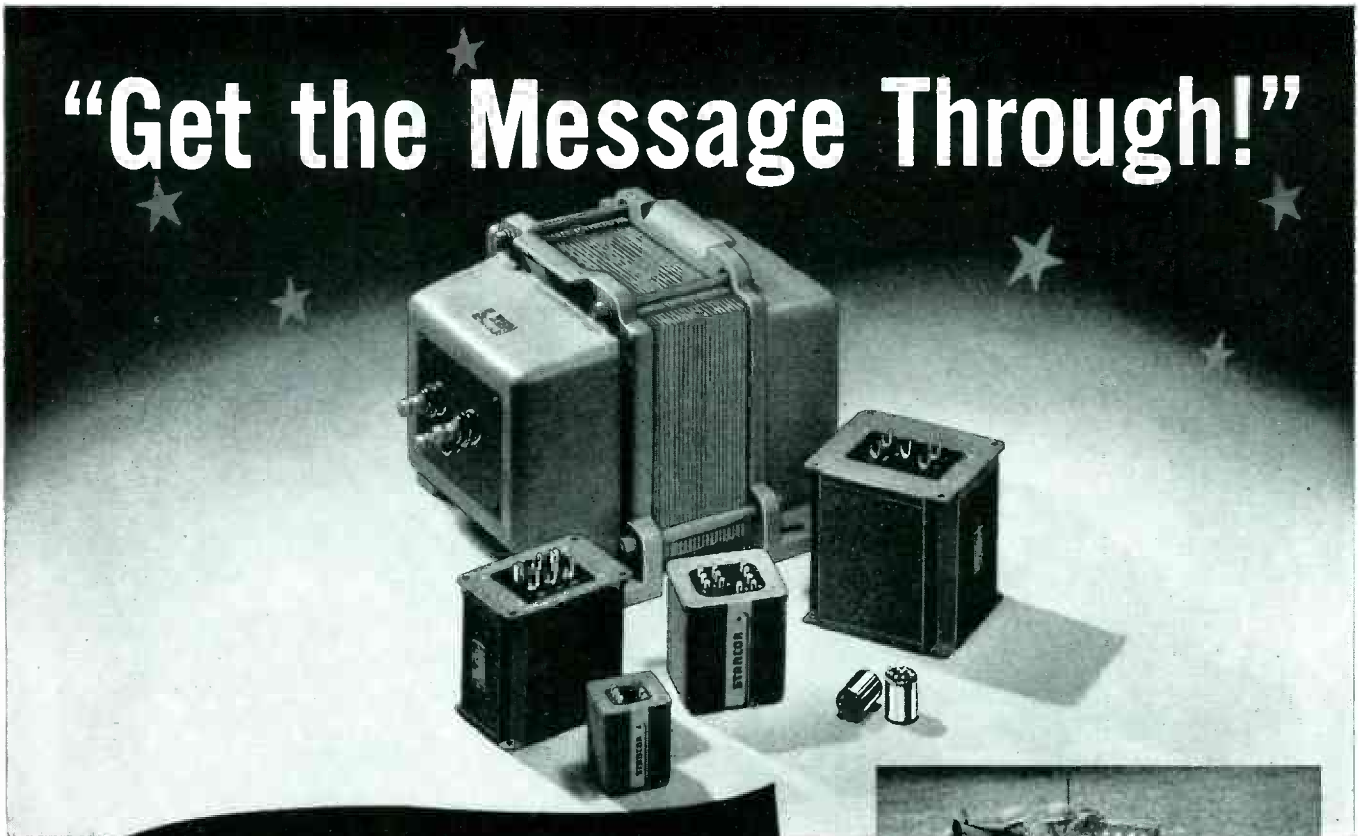
When the "All Clear" of final victory sounds, Jefferson-Travis will again make available its two-way radio communication equipment for private and commercial use throughout the world. But until then we will concentrate all of our effort and energy in the continued production of equipment for the armed forces of the United Nations.

JEFFERSON-TRAVIS RADIO MFG. CORP.

Manufacturers of Aircraft, Marine and Mobile Radio Communication Equipment

NEW YORK, N. Y. WASHINGTON, D. C.

"Get the Message Through!"



STANCOR "MADE-TO-ORDER" TRANSFORMERS

"GET THE MESSAGE THROUGH!"—the slogan of the U. S. Signal Corps—typifies the importance of communications in our armed forces.

★★★★STANCOR is geared to the vital necessities of the Signal Corps. Lives depend upon it! Successful operations depend upon it! "Unfailing accuracy" therefore is the STANCOR watchword.

Laboratory research and skillful engineering always have been highly important in the production of STANCOR Transformers. Now, more than ever before, these factors are emphasized in many new fields and in many new uses.

Illustrated above are a few of the many "MADE-TO-ORDER" STANCOR Transformers that are "precision performers." We can assist you in solving your transformer problems and meet your needs in compliance with exacting government specifications. Submit your requirements today.

PHOTO BY U. S. SIGNAL CORPS

STANCOR

STANDARD TRANSFORMER
• CORPORATION •
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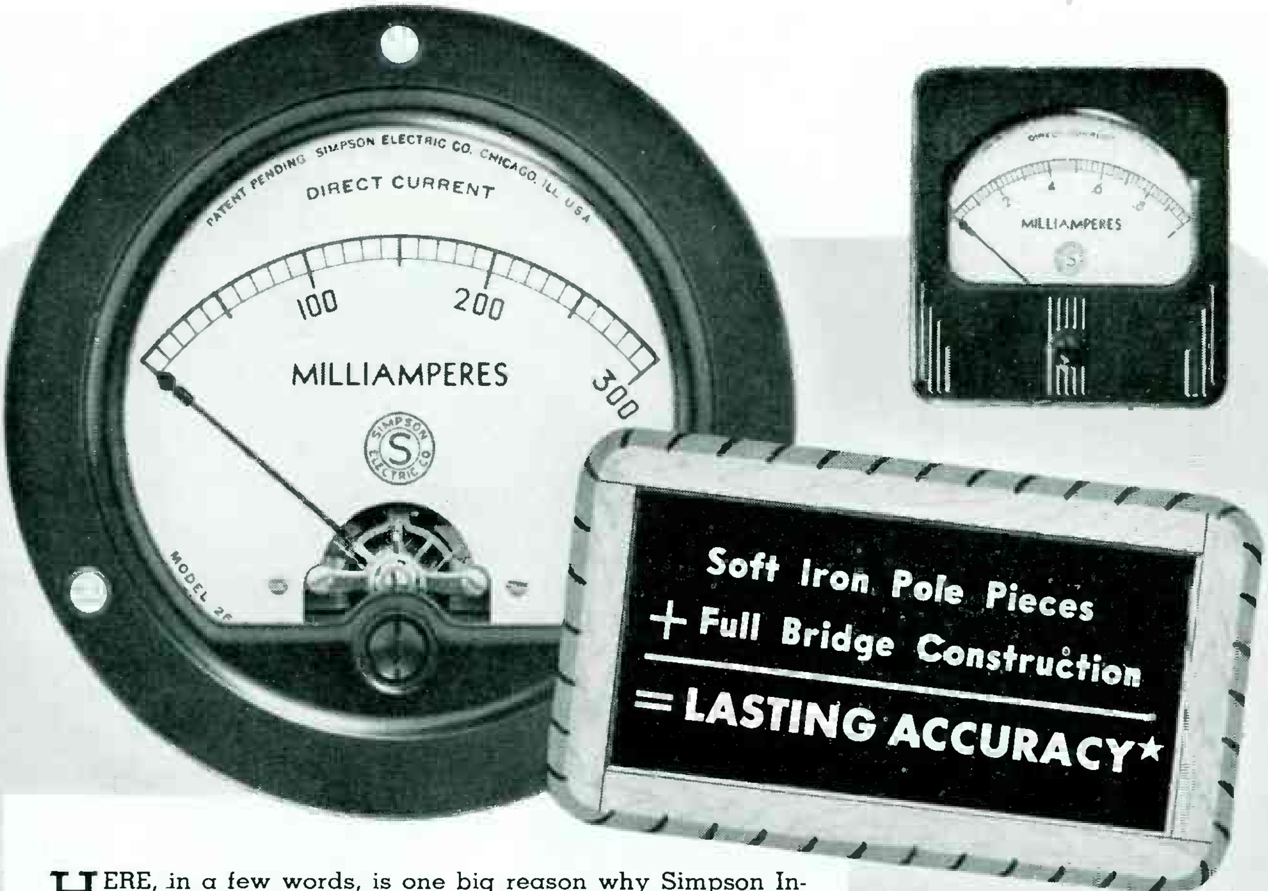
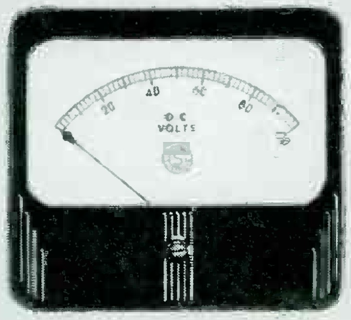


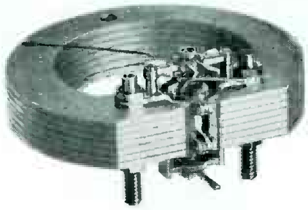
HERE, in a few words, is one big reason why Simpson Instruments have written such an outstanding service record—why, in just a few years, they have skyrocketed to the top at a pace unparalleled in the electrical industry.

Designers of electrical instruments, and users, alike, have long recognized that a full bridge type movement with soft iron pole pieces makes an instrument basically more accurate and rugged. It remained for Simpson skill and ingenuity—based on practical experience that reaches way back into the history of electrical instruments—to put this finer design into superlative practice, and to obtain for it the economies of standardization and straight-line production.

If your need for instruments is vital enough to give you the right to buy, it is vital enough to rate the best. Measured in terms of ability to *DO* the job, and stay *ON* the job, best means . . . Simpson.

SIMPSON ELECTRIC COMPANY, 5212 Kinzie St., Chicago, Ill.





★ The Movement of Lasting Accuracy

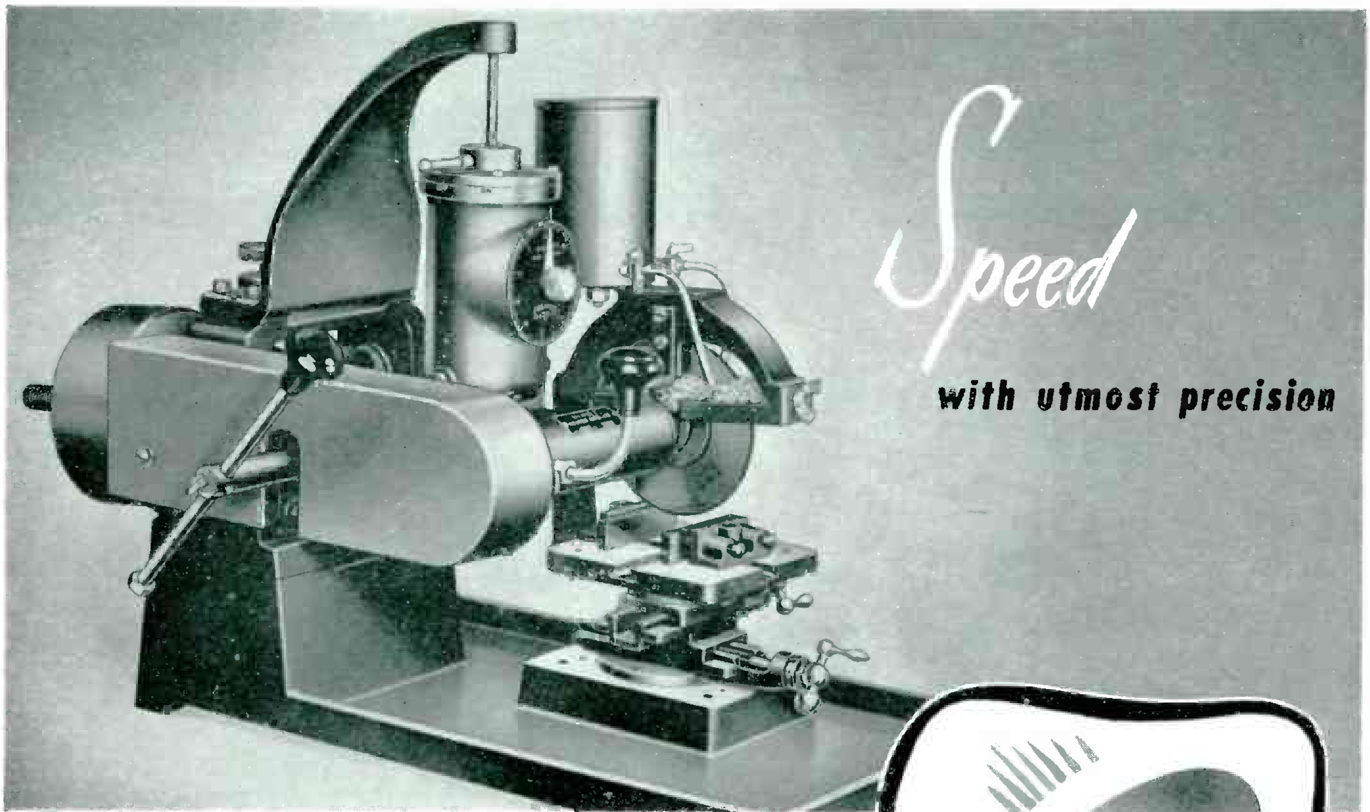
No single feature can be entirely responsible for instrument accuracy. Some of the many refinements of Simpson design—perfectly coordinated and balanced to insure lasting accuracy—are these. Soft iron pole pieces distribute magnetic flux more evenly. Full bridges at top and bottom hold the moving assembly always in perfect alignment. Magnets are heat treated, then aged for permeability. Springs are carefully tempered and tested for permanent resiliency. Pivots are completely Simpson-made—specially processed for strength and hardness. Selected jewels are the finest obtainable.

Model 260 High Sensitivity Tester

Here is a typical example of Simpson leadership. Ranges to 5,000 Volts, both AC and DC, at 20,000 ohms per volt DC and 1000 ohms per volt AC. Current readings from 1 microampere to 500 milliamperes. Resistance readings from 1/2 ohm to 10 megohms. Five decibel ranges, —10 to +52 DB.

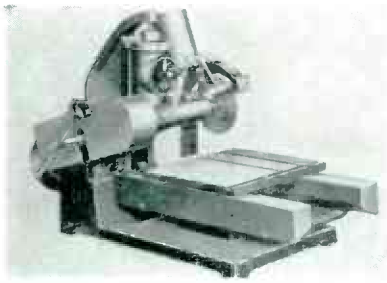
Simpson

INSTRUMENTS THAT STAY ACCURATE



Felker DI-MET

MODEL 80 QUARTZ CUTTING MACHINE

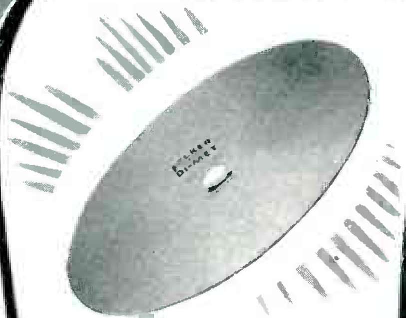


The Felker DI-MET Model 80 with the Rolling Table for fast through-cutting of slabs, bars, wafers, etc. Table dimensions are 13"x13" with a 12½" table travel.

For Manufacturing Piezo Electric Crystals

Many features of this new Felker DI-MET Model 80 insure fast, precise quartz cutting by either of two approved methods. It operates as a THROUGH-CUTTER for fast slabbing and barring of mother quartz or as a DOWN-CUTTER for extremely accurate slicing of blanks from prepared bars and wafers from mother quartz. The cutting head is equipped with the new Felker Hydraulic Retardant, which permits down-cutting with minimum blade damage . . . eliminates chipping of the blank when starting or finishing cuts . . . and insures parallelism of cuts.

The DI-MET Model 80 reduces rejects and eliminates unnecessary grinding time. Used with the Felker Resinoid Cutting Blade when cutting blanks from bars it produces a maximum smoothness of surface finish. Surface checking and cutting imperfections are so slight that an allowance of .002" per side is usually sufficient for their removal in the grinding operation. A catalog completely describing the DI-MET Model 80 Basic Unit, Model 80 with the Rolling Table and the DI-MET Rotary Table is now on the press. Reserve your copy! No obligation.



SOMETHING NEW!

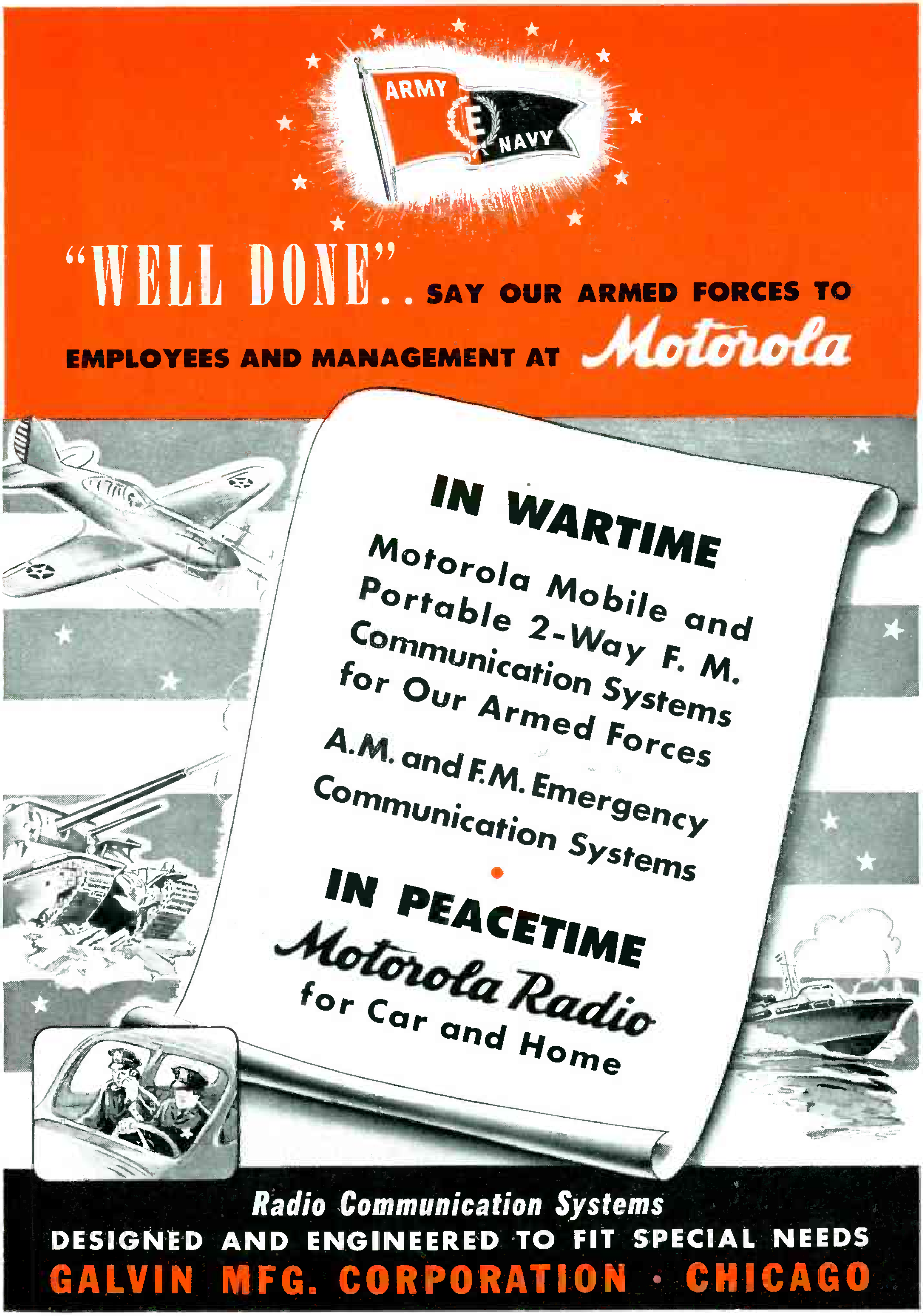
Latest Felker Development —The DI-MET RIMLOCK hard steel cut-off blade especially designed for quartz cutting. New manufacturing process (patent pending) rigidly bonds diamonds in steel wheel without crushing—produces a stiffer blade that cuts faster, freer, truer, and leaves an excellent surface finish. For speedy, economical quartz cutting try the new DI-MET RIMLOCK!

FELKER DI-MET

FELKER MANUFACTURING CO.

TORRANCE, CALIFORNIA

MANUFACTURERS OF DIAMOND ABRASIVE WHEELS

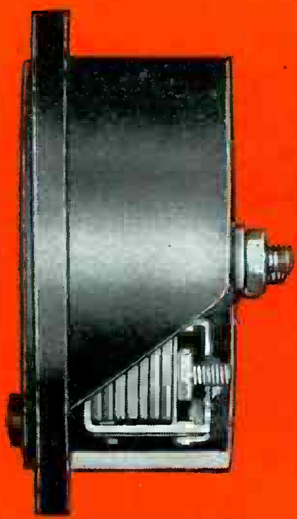

ARMY
E
NAVY
"WELL DONE".. SAY OUR ARMED FORCES TO
EMPLOYEES AND MANAGEMENT AT Motorola
IN WARTIME
Motorola Mobile and Portable 2-Way F. M. Communication Systems for Our Armed Forces
A.M. and F.M. Emergency Communication Systems
IN PEACETIME
Motorola Radio for Car and Home
Radio Communication Systems
DESIGNED AND ENGINEERED TO FIT SPECIAL NEEDS
GALVIN MFG. CORPORATION · CHICAGO


E
NAVY

When Space is at a Premium

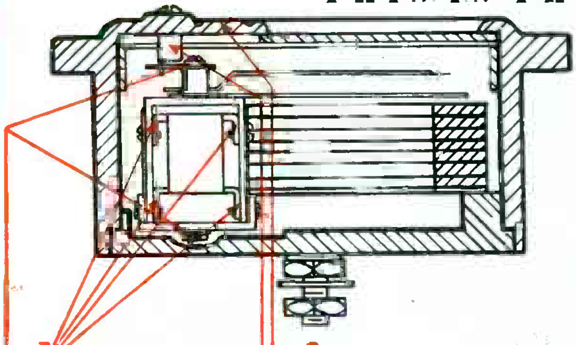
TRIPLETT *Thin Line* INSTRUMENTS

Full size of Instrument. Note deep shroud for glass protection—and "Quick-Look" Scale.



This molded case contains *full size* Triplett Mechanism. Rugged Construction—Compact Convenience.

THIS IS THE INSIDE STORY

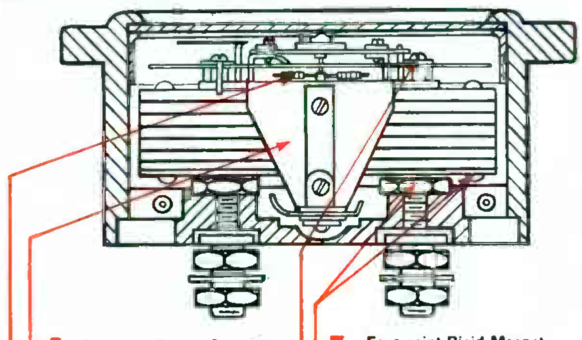


1 Four-point Core Support

2 Full Metal Bridges on Top and Bottom

3 Bezel Shroud Eliminates Unwanted Glare

4 One-piece Formed Spring Zero Adjustment



5 Balanced Frame Construction

6 Solid Balance Cross with Screw-type Balance Weights

7 Four-point Rigid Magnet Clamping

8 Separate Dial Mounting Independent of Top Bridge

Thin-Line Instruments also have Standard Large Coil Triplett Movements. Furnished with Osmium pivots for special requirements. All these features make for greater rigidity under vibration; greater permanence of calibration; greater user satisfaction.

TRIPLETT *Thin-Line*

memo

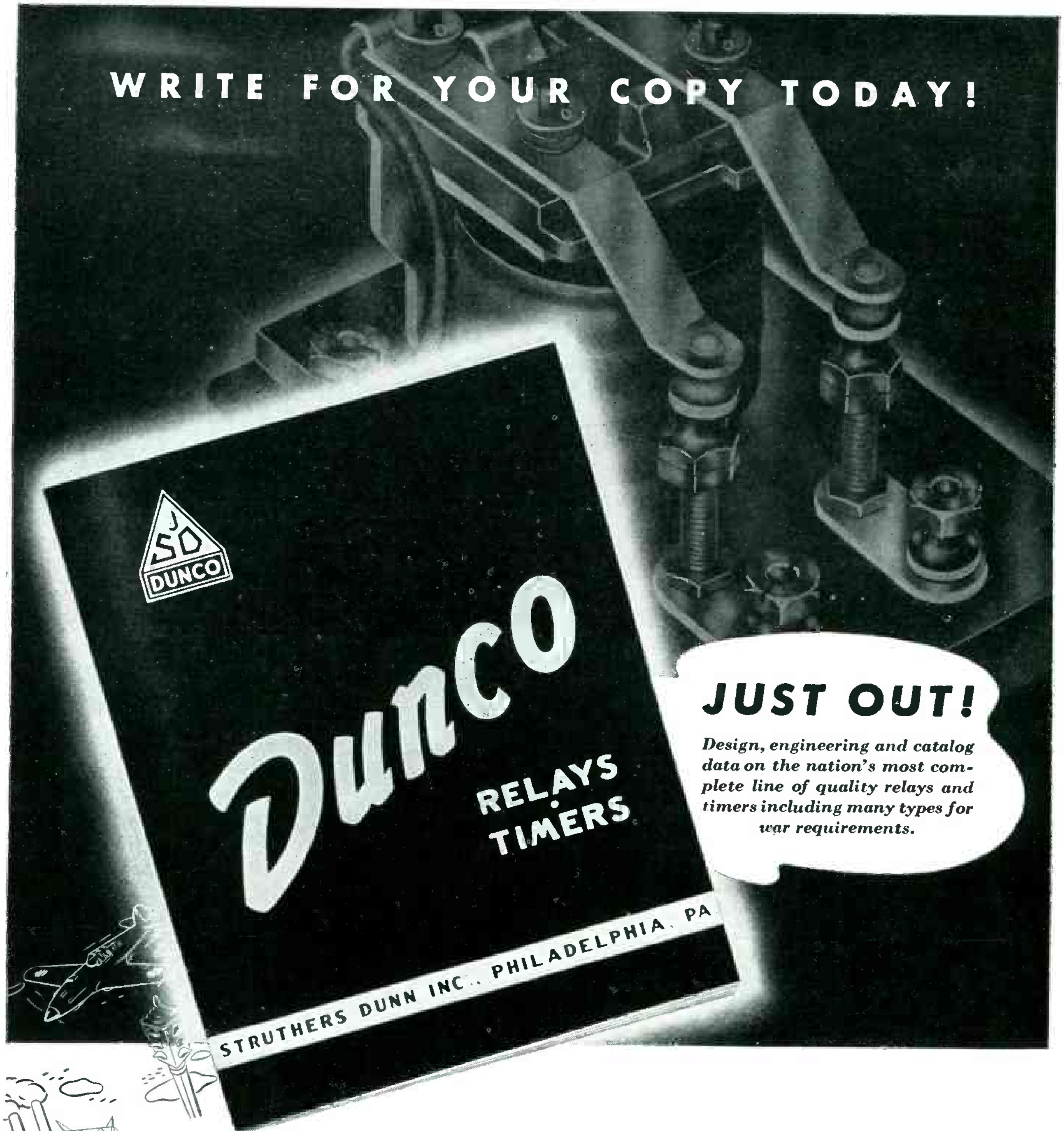
FOR CIRCULATION TO...

PLEASE INSERT INITIALS OF YOUR EXECUTIVES

Triplett Thin-Line Instruments meet rigid requirements for dependable performance. Though occupying minimum space they are *not* miniatures. Mechanisms are standard size with emphasis on excellent performance over long periods. Standardized installation. Made in three styles of cases — Molded, Metal Wide Rim and Metal Narrow Rim.

Triplett Thin-Line Instruments, available for many industrial applications, can be depended upon for precision performance in limited space. For full details write for "Triplett Thin-Line Bulletin".

THE TRIPLETT ELECTRICAL INSTRUMENT CO., BLUFFTON, OHIO, U. S. A.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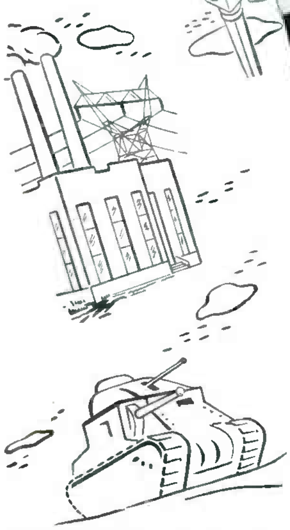
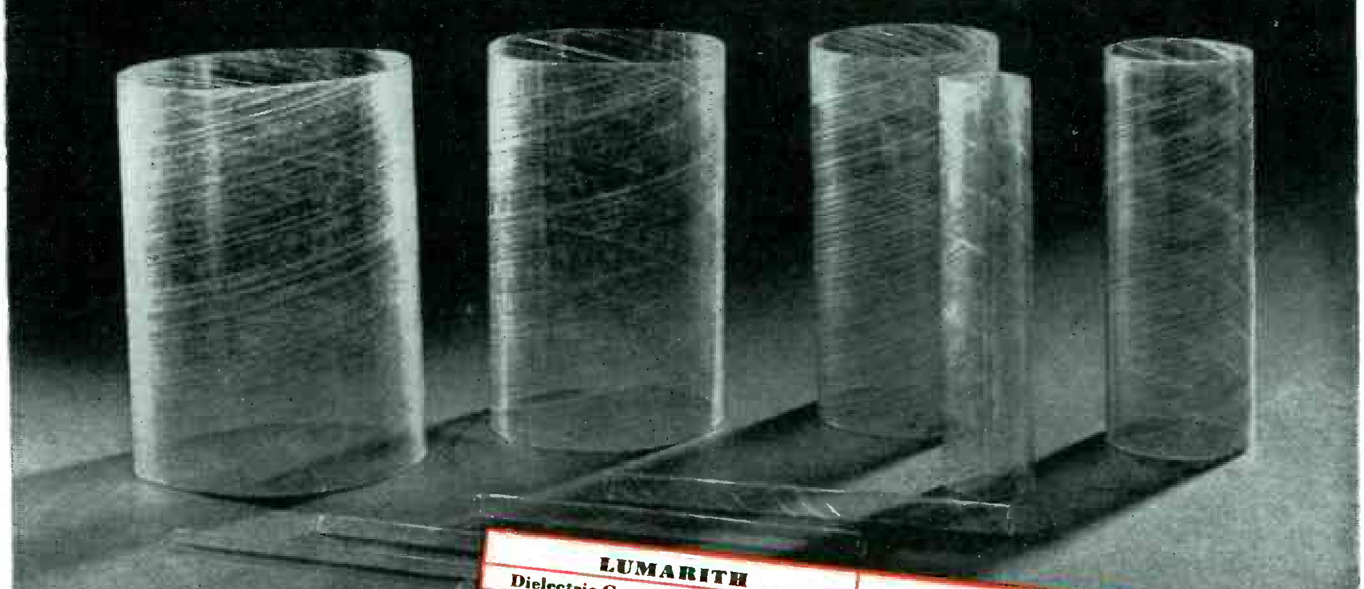
JUST OUT!
Design, engineering and catalog data on the nation's most complete line of quality relays and timers including many types for war requirements.



SPIRALLY WOUND TUBES

of LUMARITH

REG. U. S. PAT. OFF.



LUMARITH	60 cps	10^6 cps
Dielectric Constant	3.5—6	3—6
Power Factor	0.015—0.06	0.025—0.05
Dielectric Strength, Volts/mil		
0.010″ Thickness	1500	
0.020″ Thickness	1000	
0.040″ Thickness	500	
0.060″ Thickness	350	
0.090″ Thickness	300	
Volume Resistivity—megohm-cm	of the order of 10^6	of the order of 10^6
Arc Resistance	good	good

FIVE GOOD "REASONS WHY" YOU SHOULD INSULATE WITH LUMARITH

POSSESSING excellent electrical properties as the above chart shows, Lumarith has high resistance to mechanical abrasion. Lumarith tubes can either be made flexible or built up and made rigid.

Lumarith is absolutely non-corrosive . . . is unaffected by mineral oils and ordinary varnish solvents such as naphtha and toluol; is resistant to weak acids . . . is impervious to water (provides an effective water barrier) and resistant to salt water . . . is stable at temperatures up to 125°C. when protected from air, as in coil windings.

Typical Lumarith applications are . . . turn insulation on wire . . . major coil insulation . . . layer insulation . . . coil lead insulation . . . boot and pad insulation . . . core insulation . . . layer wound cores for coils . . . slot insulation . . . laminated to paper, cloth, mica, etc. . . . backing for pressure-sensitive tape.

CELANESE CELLULOID CORPORATION

a division of Celanese Corporation of America

The First Name in Plastics

Celanese Celluloid Corporation, 180 Madison Ave., New York City, a division of Celanese Corporation of America
Sole Producer of Celluloid* (cellulose nitrate plastics, film base and dopes) . . Lumarith* (cellulose acetate plastics, film base, insulating, laminating and transparent packaging material and dopes) . . . . . . Lumarith* E. C. (ethyl cellulose molding materials)
*Trademarks Reg. U. S. Pat. Off.

A BETTERMENT . . .

Not a Substitute

Push a button and you have world events before you . . . Flick a switch and you hear the best music of the ages—automatically played from a dozen recordings. Would you call the modern Radio-Phonograph Console a substitute for the gramophone of only a generation ago? Would you want to go back to the gramophone of Grandma's day?

Most manufacturers who have properly designed CONTINENTAL-DIAMOND NON-metallics into their products . . . to replace corrosive, costly, weighty and now hard-to-get materials likewise will rarely go back to the materials replaced.

C-D NON-metallics inherently possess unique characteristic combinations. VULCOID, for example, combines the strength, resiliency and machinability of Vulcanized Fibre . . . with the moisture resistance ability of laminated plastics . . . and the electrical insulating properties of both. The other four C-D NON-metallics possess equally advantageous characteristic combinations. Booklet GF-13 describes all of them. Send for it today.

When you are ready to discuss your specific "What Material?" problem, write, phone or wire for a C-D Laboratory Research Representative. He'll help you find the answer to product, process or performance BETTERMENT.

Continental-Diamond FIBRE COMPANY

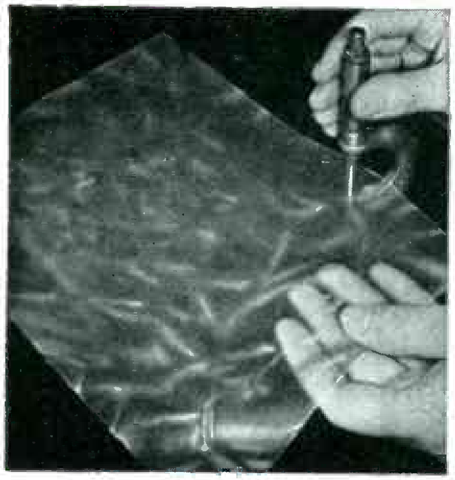
Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK • DELAWARE

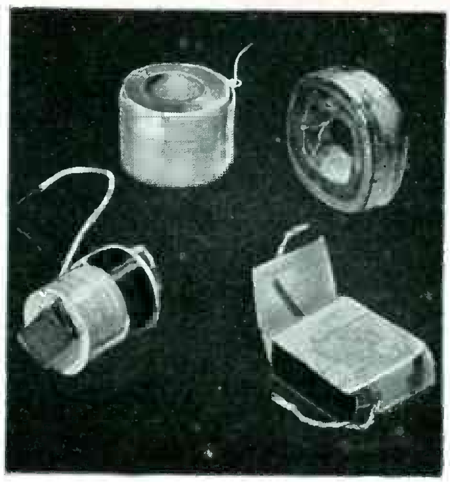
THREE INSULATING ALTERNATES FOR VARNISHED SILK!

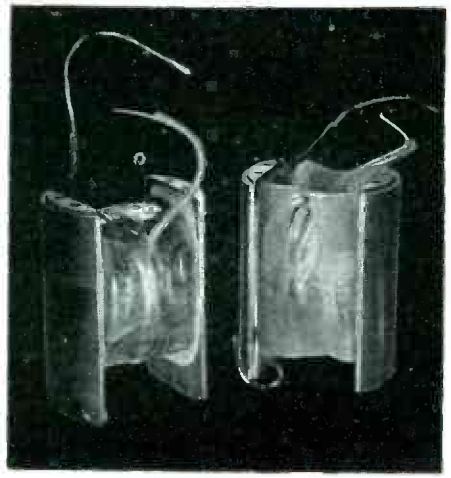
Every electrical insulation need, formerly provided by varnished silk, can now be met with one of Irvington's three new alternates.

- **VARNISHED RAYON**
- **VARNISHED COTTON CLOTH**
- **VARNISHED NYLON**

All these materials possess good dielectric strength with tensile and tear strengths equal to or better than varnished silk. They are available in thicknesses from .003" to .008". Each base material is coated with IRVINGTON special insulating varnish.

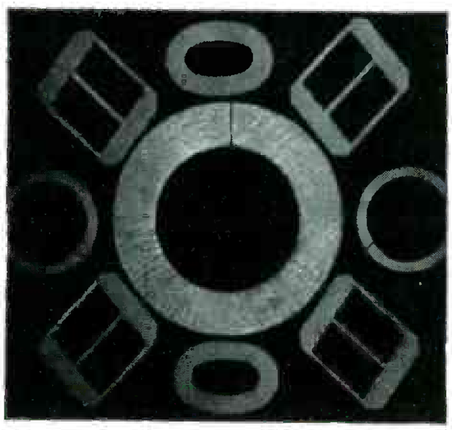






VARNISHED RAYON is the most suitable alternate for varnished silk that has yet been found. High-tenacity varnished rayon is as strong as silk and just as flexible. It is comparable to varnished silk in cost. This insulation has a dielectric strength of 1200 VPM and has been used for wrapping leads, small magnetos and coils.

VARNISHED COTTON CLOTH has much greater tensile strength than varnished silk. Its pliability allows application on odd shapes. Dielectric strength of this insulation is 1200 VPM.



VARNISHED NYLON possesses the qualities of both flexibility and high tensile strength with dielectric strength of 1200 VPM. All the alternates for silk, like Varnished Nylon above, can be punched into special shapes.

Irvington's three alternates for silk are available in black or yellow; straight-cut rolls or bias-cut strips in 51" lengths.

Let us know your requirements

We will recommend the best material for your needs. Write Department 106

IRVINGTON

VARNISH & INSULATOR CO.

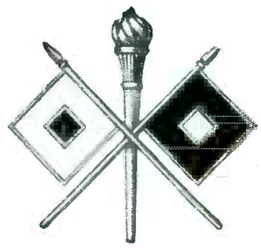
IRVINGTON, NEW JERSEY, U.S.A.

STANDARD OF THE WORLD — IRVINGTON INSULATION — TRADE MARK REG. U.S. PAT. OFF.

PLANTS AT IRVINGTON, N. J. and HAMILTON, ONT., CAN.

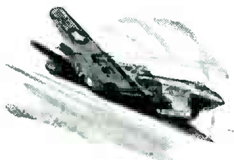
Representatives in 20 Principal Cities

COMMUNICATIONS
. . . directing arm of combat

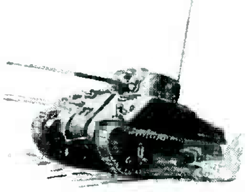


"Get the message through!" That's the tradition of the men who wear this insignia. Of the 18,000 Bell System people now in the armed forces, nearly 4,500 are with the Signal Corps. Young men can serve their country and obtain specialized training in communications in this great branch of the Army.

...and Western Electric equipment goes to every battle front



Army planes fly and fight with Western Electric radio command sets, which keep the planes of a squadron in contact with each other and with the ground forces.



Wherever American soldiers fight in tanks, they get their orders over Western Electric radio sets—vital in coordinating today's mechanized warfare.

Observers report front-line action to Army commanders over Western Electric field telephones, field wire, field switchboards.

A major source for this specialized equipment is Western Electric—for 60 years manufacturer for the Bell System—one industry with over 70,000 skilled men and women dedicated to *"keep 'em in contact."*

Western Electric

ARSENAL OF COMMUNICATIONS

ARMY E NAVY

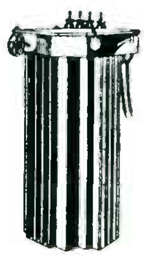

The BIG JOB
FOR Formica, as for many other companies, the essential task right now is to supply the front with war materials. Everything we have is going into that and it will continue to be our big job for the duration.
But so far we have been able to care for many users of building and furniture sheet, electrical insulation, chemically resistant parts and many other plastic laminated products—and we will continue to do so as long as we are able—to help war-essential civilian activities to continue here at home.
THE FORMICA INSULATION COMPANY
4661 SPRING GROVE AVENUE, CINCINNATI, OHIO
FORMICA

Improved Transformers

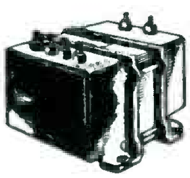
new ELECTRICAL DESIGN
new MECHANICAL FEATURES
new PLANT CAPACITY
new MANUFACTURING FACILITIES

You who are engaged in War work and are fortunate in obtaining AmerTran transformers — you know that some important improvements have been made to these products which have so long held the leadership in the electronic and radio industries. You know that they are new in electrical design—new in many mechanical features. The service these new AmerTran products are performing for war-time industry will never be forgotten—and will give them even greater acceptance in peace time. AmerTran products are engineered and manufactured to meet the specific requirements of their users. Our 41 years of experience—and service to the electrical industry—is standing us in good stead — today. We look forward to resuming all of our former commercial relationships —in peace-time.

AmerTran modulation transformers and reactors, oil-immersed type, for large broadcast transmitters.



AmerTran RS plate transformers and reactors, oil-immersed type, for all large installations.



AmerTran W plate transformers and reactors for all small and medium installations.

AmerTran transformers are manufactured to meet your exact electrical and mechanical requirements.

AMERICAN TRANSFORMER COMPANY, 178 Emmet St., Newark, N. J.

Manufactured Since 1901 at Newark, N. J.

AMERTRAN

THERE IS NO SHORTAGE OF STEATITE

. . . . IN SUCH PIECES AS THESE

Steatite, the raw material, is available in greater quantity than can be used. The only limiting factor in availability of finished Steatite insulating pieces is the facilities for producton. Lapp has mastered the technique of Steatite production and offers almost unlimited capacity for Steatite — in pieces for which Lapp processes are suitable. These include nearly all types of large pieces in which close tolerances are not primary factors—pieces that can be made by extrusion, throwing, plunging, turning, casting —such pieces as standoff insulators, rod antenna insulators, bowl entrance insulators, bulkhead insulators, streamline entrance insulators. Facilities are adequate also for a large volume of sanding and cementing of Steatite into hardware.

There is no reason to substitute for Steatite in pieces which can be made by Lapp.

Lapp INSULATOR CO., INC.

LEROY, N. Y.

The Chemical Engineer cuts years to months...

Born in the turmoil of the last war, he is shaping a new world with mighty swords and magic plowshares

German Consul-General Hossenfelder, writing from New York on March 3rd, 1916, to von Bethmann-Hollweg, chancellor of the Imperial German Government, confidently predicted defeat for the United States because we were totally dependent upon the great chemical industry of Germany. "Americans," he wrote, "can never establish such an industry. They have the resources but they lack the necessary science and technology. And, besides, the conflicting selfishness of American business renders it impossible."

Even before the ink was dry on Hossenfelder's letter a new figure appeared on the industrial scene—the American chemical engineer. With the help of patient, but progressive and venturesome capital, he laid the foundations for the largest and most resourceful chemical industry in the world.

Today he is an all-important figure. For we are fighting a chemical war, even though the emphasis that is placed on planes, tanks, ships, guns and other armament tends to obscure that fact. And this chemical engineer is waging war for us on a prodigious scale. Bombers carry more tons of more deadly explosives because he has developed stronger and lighter alloys and more efficient fuels. Tanks are better armored and wield heavier blows because of products and processes born in chemical laboratories. Ships are welded together by new metallurgical techniques that save precious months over older processes. Gun barrels that are made in minutes instead of hours shoot farther and faster because of better ammunition.

And quantity keeps pace with quality. By mid-year of 1942, explosives were being produced in newly constructed plants twelve times faster than a year ago. Smokeless powder output has been doubled since December. Five times as much TNT was being made in July as in the months preceding Pearl Harbor. One single new plant produces more of this high explosive than did the entire pre-war industry—and several of these plants already are in production.

By what Major General William N. Porter, Chief of the Chemical Warfare Service, calls a "miracle of production," the sort of incendiary bombs that General Doolittle's lads showered on Tokyo were rolling out of our plants within a few weeks after we got into the war. As General Porter puts it, "they were rolling not by hundreds or even thousands, but by the millions." That record he has cited as a tribute to the "ingenuity, industriousness and patriotism" of the American chemical industries.

Yet the General agrees that we have only started to produce in the tremendous volumes that will shortly make Germany, Italy and Japan "revolve on their boasted Axis." Our newest plants are just coming into production. They face no limiting shortages of materials for, in the main, our chemical industry draws its strength from coal, salt, sulphur, limestone, oil, natural gas, coal-tar, air and water—all available in abundance.

We have heard little about the use of poison gas by our enemies. It may be that good reasons for this are stored away in our well-stocked chemical arsenals. American chemical manufacturers have worked hard and long with our armed forces so that if the time ever comes to make good on the President's warning of retaliation, America will be more than ready.

And defense against gas has not been overlooked. Every soldier is equipped with a most efficient type of gas mask, developed through twenty-five years of intensive research. The Chemical Warfare Service already is manufacturing millions of masks for distribution to civilians. Let us hope we may never have to use them. But if we must, we need have little fear of any gas or secret chemical.

This gas mask program has been made possible by a literal metamorphosis of production facilities, as peacetime industries have been converted to war purposes. A lumber company, for example, is making activated carbon from sawdust. Novelty manufacturers of rubber goods are turning out valves and assembling other parts. Former manufacturers of shirts, swim-suits, shoes and beds have converted their facilities and are contributing their share. More than eleven hundred contractors and two hundred and fifty sub-contractors are supplying their full quotas of chemical warfare materials. And production is right up to schedule.

But the bulk of the war job of our chemical industries has to do with items other than weapons and ammunition. The German Consul-General, in that 1916 report to Berlin, said that many American industries were in a critical condition because of the scarcity of German chemicals. He related in particular that "the cries for help from the world of physicians are becoming louder and louder and more and more insistent." Thanks to our chemical industries this cry no longer is heard. Even though we are again cut off from quinine, camphor and some other strategic medicinals, our homes and hospitals are adequately supplied with synthetic products. Most of these are better and cheaper than the natural materials. The same sulfa drugs that have saved so many civilian lives in recent years have gone to war, with the result that deaths from infection at Pearl Harbor and Bataan are reported as surprisingly low. In this war we suffer no shortages of iodine and potash. Pioneering research in the field of vitamins has led to new industries that are contributing to health and better nutrition.

Those new uniforms the soldiers are wearing are of better quality and will last longer than the shoddy, ill-fitting outfits of 1918—thanks to sunfast dyes and new man-made products. And in the field of fabrics, nylon and the new rayons have gone to war in parachutes and super-strong cords for tank treads and tires.

* * * * *

And that brings up the question that 30,000,000 American motorists are asking with ever increasing concern. "When, Mr. Chemical Engineer, are you going to give us a set of new tires for the old family bus?"

That, I am told, is just what the chemical engineers have set about to do on a scale that is difficult to comprehend. In the words of Raymond Clapper, the columnist, "the synthetic rubber program for this year and the next is the biggest job of chemical engineering ever undertaken in the world." A billion dollar industry is being built at record speed to make almost a million tons a year of chemical rubber to serve our war needs and those of our allies. This cannot be accomplished overnight. Many months are required to design and fabricate complex equipment, much of which must be made from corrosion-resisting metals and alloys. We shall be lucky if a tenth of the desired capacity is in continuous production this year and even more lucky if, by the end of next year, the new industry should be turning out synthetic rubber at a rate of 875,000 tons—using both petroleum and grain as raw materials.

All this, of course, must go for essential military uses but there is reason to believe that in the laboratory and pilot-plant stages we have some promising substitutes and stop-gap materials that may tide us over until the big program starts rolling.

The present prospect of real success is possible only because of the cooperation of the chemical, rubber and petroleum industries. Individual firms and entire industries have set aside their normal desires and selfish interests to pool their patents, share their research and engineering developments for the common good. Synthetic rubber is here to stay as the basis for a great post-war industry: no doubt as to that lingers in the minds of the men who have seen many other natural products—indigo, alizarine, camphor, vanillin—all eventually fall before the ingenuity of the chemical industry.

* * * * *

In the coming peace to which we look forward hopefully, we shall find a new world full of new materials, new conveniences, new jobs, new opportunities, all stemming out of the present-day work of the chemical engineer. The same tough, transparent plastics that now make noses for bombers will give us new frameless windows for our homes and automobiles. With capacity to produce at least 2½ billion pounds of aluminum, which is five or six times pre-war production, and a magnesium capacity 50 or 60 times the pre-war figure, many new uses will develop for these structural materials of great strength and amazing lightness. Almost anything that flies, runs, moves, or otherwise is motive, will have a place for them. New fibers such as nylon and vinyon had scarcely got started before they were put to war use. Once the war is over they will be with us in greater abundance and at lower cost for a variety of uses so vast and so diverse that we can scarcely imagine them.

And the chemical engineer continues to create and to invent. He meets the challenge of scarcities and shortages with ever new "substitutes" that excel their originals. Even before the war is over he will have placed at our command a hundred new materials which we did not have before. His workshop is all industry. His contributions are as limitless as are our needs.

But right now his all-important job is to help win the war; to fight to a finish the ruthless and resourceful enemies that are devoting all their science and technology to bring about our defeat. So, as we take stock of our assets in this desperate struggle, we count among the first the proved resourcefulness of the research-minded chemical engineers we now have mobilized to help us fight this chemical war.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

This is the fourth of a series of editorials appearing monthly in all McGraw-Hill publications reaching more than one and one-half million readers.

CROSS TALK

► **JINX** . . . Sometime ago in this column the office jinx was introduced. He is the fellow that causes errors to be made. Well, he has been around again.

In August ELECTRONICS page 37 was a diagram of an electronic welding control circuit in which were copper oxide rectifiers. We are sorry to state that the thing simply won't work unless you turn one set of rectifiers around like those on page 39. Furthermore we gave readers a bum steer in stating that copies of patents issued could be obtained from the Government Printing Office. This might be so, but the correct place to apply is the Commissioner of Patents, Washington, D. C. Give the patent number desired, the date it was issued, the nature of the patent, your name and address and send 10 cents. Stamps are unwelcome.

► **PATENTS** . . . All readers should keep an eye on the current investigation of the patent situation taking place in Washington. The field of electronics is new, and patents will play a very great part in its history.

One gathers, from reading newspaper accounts of the investigation, that it should be made illegal or unethical or something for two companies, perhaps in different countries, to share their information for their mutual benefit. A patent is a mighty complex thing. It is, on one hand a disclosure of an invention, a new method, a contribution to man's knowledge. Patents are granted to encourage people to disclose the features of inventors' work. If there were no patent system inventors would have to rely upon secrecy for protection; and thus there would be no disclosure of the work of inventors the cumulative effect of which is very great. A very important process, important to the common good, might die with the inventor because he was afraid to disclose its details during his lifetime.

We do not see why it should not react to the advantage of man everywhere for inventors to share their knowledge. So far as we have read and heard, it is not the sharing of information that Mr. Thurman Arnold, Assistant Attorney General, does not like but the using of patents to maintain artificially high prices and to keep down competition, thus limiting the use of the patent material by the greatest number of people.

ELECTRONICS will have more to say about patents later; and will endeavor to keep its readers up to date on the situation. But, as ever, readers should read carefully the newspaper stories and remember that they personally have not heard what Mr. Arnold, or Senator So-and-So or President So-and-So of such-and-such a company have said —they have only read what a newspaper reporter says he heard these gentlemen say. Single statements removed from their context often give a completely wrong impression.

► **CODE** . . . Until the war drove radio station W1AW off the air, people wanting to learn the code by actually listening to radio transmissions were served by this headquarters station of the American Radio Relay League. Nightly, however, at the present time code learners will find GSA on 6050 kc at 8:30 EWT sending "news from London" first in English, then in French and finally in German. This station is modulated at about 500 cycles, sends each word twice and fairly slow. The news summary is excellent giving what seems to be straight facts. The day's important events are put tersely and make good listening safe from jamming. The program comes from the British Broadcasting Corp. It's worth listening for.

► **STATIC** . . . On August 23 Roy A. Weagant, former chief engineer of the Marconi Wireless Telegraph Company, died in Vermont. Mr. Weagant was another of the old timers whose memory is strong in the minds of those whose days in radio go back to the beginning. The work for which he is most remembered was in problems connected with conquering static as a troublemaker in the early code days. His work in this field brought him the Morris Liebmann prize, contributed to lowering the power necessary to communicate over long distances, and to a reduction in the effective height of antennas. Mr. Weagant is credited with the discovery that static radiations and desired signalling radiations travel in different directions, the undesired noises coming from overhead, desired signals moving along the surface of the earth in a horizontal direction. Mr. Weagant worked with the Westinghouse Company, with the National Electrical Signalling Company, Marconi Company, DeForest Radio Company, and the Radio Corporation of America—to mention only the communications companies.

Another loss to the ranks of radio was that of Malcolm P. Hanson, Commander U. S. Navy. Commander Hanson was chief wireless operator on Admiral Bird's Antarctic Expedition in 1928-30.

RADIATION INSTRUMENTS Using GEIGER

By PAUL WEISZ, *Bartol Research Foundation of the Franklin Institute, Swarthmore, Pa.*

IN a previous issue of ELECTRONICS the Geiger Müller tube was discussed as a very versatile instrument for the detection and measurement of radiation[1]. Its development necessarily went hand in hand with the development of suitable electronic circuits for the utilization of such tubes for many different purposes. Circuits had to be created capable of transforming the electrical response of these tubes to audible or readable data, qualitative or quantitative records, or to act as relay devices for the control of other instruments. In this way, by combining Geiger Müller tubes with appropriate electronic circuits a variety of tasks can be performed in radiation technique.

A simple circuit connected to three Geiger Müller tubes operated a relay which turned on the illumination of the New York World's Fair in 1939 instantaneously when a cosmic ray particle traversed all three tubes. In the same manner a great many research problems have been carried out by having the tubes and proper circuits automatically operate other apparatus. For example, many thousands of photographs have been taken of tracks of particles in the so-called "cloud-chamber", by having the particles "photograph themselves" by tripping the GM tubes, operating the circuits, and thus causing the various relay mechanisms to work the chamber, the light arc, the camera exposure, and other essential operations. The circuit usually employed for such automatic control action is shown in principle in Fig. 1. A ray passing through one GM tube will result in a negative electric pulse reaching the grid of the vacuum tube associated with it, and will, because of its great amplitude, cut off the plate current of this tube for the duration of the pulse, say, 10^{-5} sec. The effective grid bias on tube *RL* during this time will be about 40 v negative. If the ray went through two of the GM tubes, and two of the vacuum tubes were cut off, reducing the grid bias to 20 v on tube *RL*, the latter would still be sufficiently negatively biased to stay out of action. However, a ray passing through all three GM tubes will reduce the grid bias to zero, tube *RL* becomes conducting and initiates whatever function may be desired.*

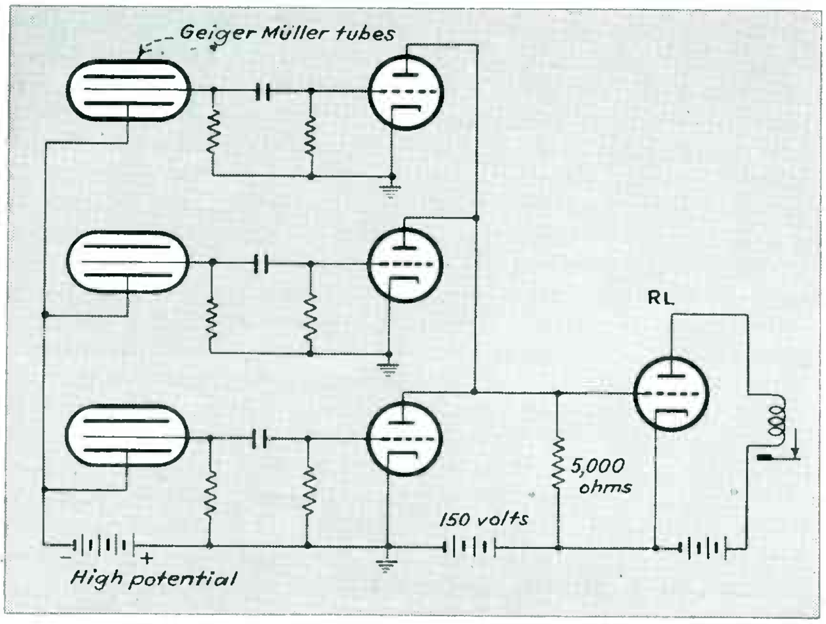


Fig. 1.—The common "coincidence circuit" for the control of any mechanism by rays which pass through all three GM-tubes. Such a circuit turned on the illumination of the New York World's Fair by the passage of a cosmic ray

The Fundamental Circuit Problem

Most applications of the Geiger Müller tube are concerned, directly or indirectly, with the measurement of radiation intensity, e.g., the measurement of quantities of radium or other radiating substances, determining natural radioactivity in field work, finding x-ray intensities, fixing therapeutic dosages, hunting lost radium, finding x-ray leakages and undesirable radiation, measuring thickness of materials by absorption, and so forth. Regardless of which of these applications we may want to utilize we are always confronted with the following fundamental problem:

The Geiger Müller tube supplies electrical pulses of an amplitude of some 50 to 200 v, having a sharp rise of some microseconds duration, and an exponential recovery determined by the *RC* constant of the input circuit. Every such pulse represents an ionization event in the tube, and the number of these pulses produced per unit of time is therefore a measure of the intensity of the radiation responsible for the production of the observed pulses. These pulses are naturally not periodic but follow each other at random distribution in time, because of the very nature of

* Editor's note. If each tube draws 4 ma plate current, a voltage drop of 20 v per tube exists across the 5000-ohm input resistance to *RL*. For each tube cut off, this voltage, representing negative bias to *RL*, will be reduced by 20 v.

MÜLLER TUBES

their production. Thus the fundamental problem to be handled by the electrical circuit is the determination of the frequency of randomly distributed electrical pulses. The order of magnitude of the average pulse frequency, often called the "counting rate", involved in this type of work may vary within great limits from one type of application to the other. However, the ever present background rate of pulses due to cosmic rays and natural radioactivity sets a lower limit of the order of about one pulse per minute[2] due to radiation to be detected, and the intrinsic recovery time of the Geiger Müller tube provides an upper limit of counting rate which may be set at approximately 100,000 per sec.

It must always be kept in mind that these pulses handled by the circuits are randomly distributed which means that although the *average* time elapsing between two successive pulses may be, say 1 sec., there will sometimes occur two pulses within, say, 1/1000 sec. The probability of this happening may be small, but constitutes a certain percentage of the total pulse rate. By mathematical means, we can determine just exactly what this probability is. Figure 2 shows quite generally the percentage of pulses which will follow within a time interval less than t for different average counting rates. This is an important aspect in the design of any circuit or circuit element, since they all possess a certain maximum resolving power represented by the smallest time interval between two successive pulses for which the circuit or circuit element will still differentiate them as actually two pulses instead of skipping the second pulse because it followed too closely to be resolved. This characteristic time t is called the "resolving time". For a certain given range of pulse rate which a circuit element or circuit is to handle, its resolving time should be small enough so that the number of "lost" pulses is negligible for the purpose of the measurement. Figure 2 can be used to determine the resulting error, and in many cases to correct for it if necessary. Mainly as a consequence of these considerations regarding the speed requirements of the circuits, the various measuring and recording methods are each most suitable for certain ranges of pulse rate, and therefore for particular types of applications.

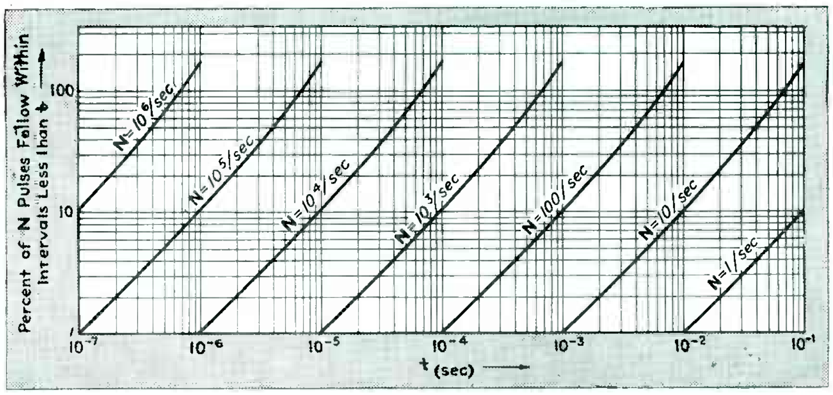


Fig. 2.—For a completely random distribution of pulses as are dealt with in all work with Geiger Müller tubes, this chart shows the percentage of pulses which follow one another within a time interval smaller than t, at different average pulse-rates N. This percentage of pulses would be "skipped" by a circuit or circuit unit the resolving time of which is t, and thus constitutes the error of measurement

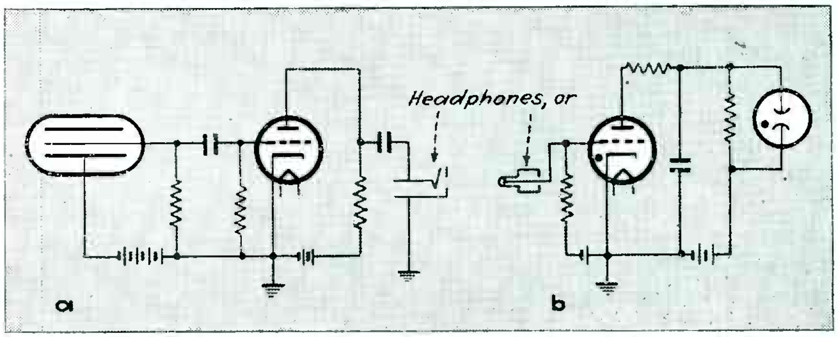


Fig. 3.—Fundamental circuits for the use of a Geiger Müller tube for audible or visual observation of pulses

Audible and Visual Methods

Whenever there is no need for an accurate quantitative determination of radiation intensity, but merely relative variations in intensity are to be observed, or the intensity estimated, comparatively simple circuits can be applied to serve this purpose satisfactorily, by having the individual pulses supplied by the Geiger Müller tube produce audible clicks in a loudspeaker or a pair of headphones, or by causing them to produce flashes of a neon lamp. Particularly the audible method has proven very valuable in many applications.

It is found that an electrical pulse will become audible in an ordinary set of headphones when it corresponds to a quantity of electricity of at least 10^{-8} coulomb passed through the phones, irrespective of whether this be accomplished by a fast pulse of great amplitude or a long lasting

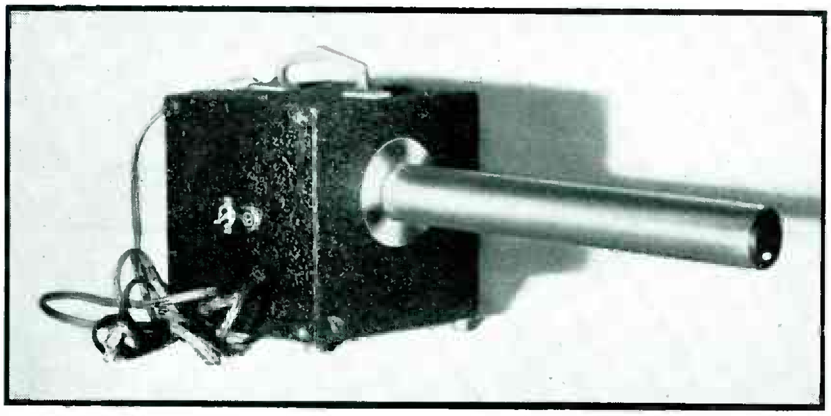


Fig. 4—A small universal hand set for radiation measurements

pulse of smaller amplitude, within wide limits. The GM tube itself releases a spurt of charge of the order of 10^{-9} coulomb per pulse, so that an amplification of a factor of somewhere between 20 and 100 usually will be sufficient to transform all pulses into well audible clicks. This can be accomplished by a single vacuum tube, preferably with high transconductance, as shown in principle in Fig. 3.

Based on this general principle, a portable radiation instrument for universal use has been developed. The set shown in Fig. 4 contains the complete combination of a GM tube amplifier, power-supply and high potential source for the GM tube, housed in a small case. Properly designed, such an instrument will follow pulse rates from an occasional pulse per minute to more than 10,000 per sec. or so. While the human ear perceives an impression of individual pulses or clicks only for pulse-rates up to about 20 per sec., the psychological impression at higher rates is that of an unsteady rattle which slowly goes over into a more or less constant hiss at still higher pulse rates. It is thus readily possible to estimate the radiation intensity by means of the sound impression of the pulse rate, especially if it is possible to make comparisons with sources of known intensity. In the apparatus shown in Fig. 4, this is made possible by providing the GM tube with a 0.0005-in. thick glass window which is made accessable by sliding away a protecting disk at the end of the neck extension, where the GM tube is located. The GM tube is then sensitive for ultraviolet radiation which penetrates the thin window. A burning match will supply a sufficient amount of ultraviolet radiation so that the response of the set to any intensity of another radiation can be simulated by holding the match at the proper distance from the window, and an estimate of the unknown intensity can be made by comparison with the response to the u-v radiation from the match at different distances. In this way, the manufacturer is able, for instance, to supply information with each set as to the distance of a burning match from the window at which the pulse-rate will correspond to that produced by a γ-ray intensity of 0.1 r-units per day, which is generally recommended as the maximum radiation intensity representing safe working conditions. By the same comparison method, quantities of radium and radioactive material can be estimated. The fact that weak β radiation and α rays will also penetrate the thin window makes such a set a simple tool for wide application.

For demonstration purposes the visual method of observation is often desirable, in which case a neon bulb is flashed by the instantaneous plate-current pulse in a self-extinguishing thyratron circuit, such as shown in Fig. 3b. The first vacuum tube serves to amplify as well as to invert the polarity of the negative pulse which originates on the GM tube wire producing the positive electrical pulse necessary for the control of the gas triode. The visual method is far inferior, however, to the audible one, since it serves satisfactorily only at very low counting rates, since the eye can not discriminate any higher pulse-rates than some 15 per sec.

Quantitative Methods

Mechanical Recording. A logical way of recording the pulse rate from GM tubes is to operate an electromechanical recorder or counting device. This can be done conveniently by inserting the recorder in the discharge circuit of a thyratron which is operated as in Fig. 3b. In this way, the number of pulses can be directly recorded and read from the dial over any desired period of time. It is probably the simplest and most accurate method for the measurement of weak intensities. However, the limitation lies in the mechanical inertia of the recorder, i.e., its resolving power. Such a recorder is seldom capable of resolving pulses following one another within an interval of less than 1/50 sec., so that its resolving time can be set at usually $t = 2x10^{-2}$ sec. From Fig. 2 it follows then, that to keep the error below, say, 5 percent, counting rates not exceeding 2 per sec. can be counted accurately.

Scaling by Trigger Circuits. At pulse rates higher than those which the mechanical recorder can safely handle, one may still successfully apply the mechanical recorder by subsequently using an electrical circuit

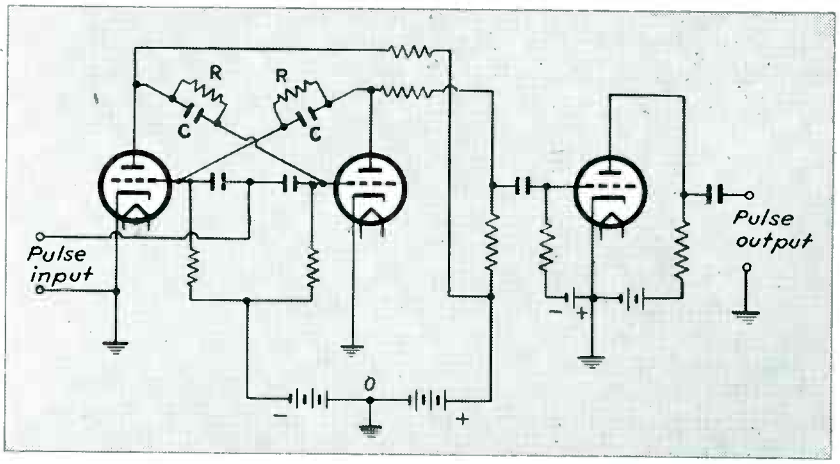


Fig. 5.—The "scaling couple" for counting higher pulse rates, working on the trigger principle

capable of scaling the pulse rate down by a given factor, i.e., a circuit which will act so that only every 2nd, or every 8th, or every nth pulse will trip the mechanical recorder, n being the desired scaling ratio of the circuit.

Such scaling can be attained by using a vacuum tube trigger circuit as is shown in Fig. 5.

There are other circuits based on the same working principle. An interaction between the plate current of one tube and the grid bias of the other of a "scaling couple" and vice-versa, provides that one tube of the couple is conducting when the other is cut off. The pulses to be scaled are coupled to both grids, so that a pulse will fire the tube which is "dead", thus causing the other tube to be cut off; this occurring alternatively between the two tubes when pulses arrive on the grids. By coupling to the plate circuit of only one of the two tubes, one can obtain a reaction for every second pulse on the grid of that tube. Thus the couple represents a scale-of-two circuit. By feeding the scaled pulses after proper amplification into another such scaling couple, a scale-of-four is obtained, and so forth. X stages of scaling couples therefore will result in a scaling ratio of 2^X to 1.

The resolving time of such a circuit (in seconds) is determined by the circuit RC constant, using the values for R (in ohms) and C (in farads) as indicated in Fig. 5. If this time is sufficiently small, and it is possible to make it as small as between 10^{-3} and 10^{-6} sec., the scaled pulses reaching the recorder are again randomly distributed but with an average pulse rate of $1/n$ the original counting rate, n being the scaling ratio. Thus, while with a mechanical recorder of 2×10^{-2} sec. resolving time, a counting rate of 2 per sec. was the maximum permissible speed at which we could operate at an error less than 5 percent, after scaling by a ratio of, say 16 to 1, we may count as fast as 32 per sec. original pulse rate at the same small amount of error.

Scaling by the Accumulation Principle. With a scaling circuit of the kind described above a scaling ratio of 16 to 1 can be obtained only with four scaling couples comprising 8 vacuum tubes, plus three intermediate tubes for the proper transmission of the pulses from one couple to the following one, and in addition at least one converter stage as input amplifier, and an end stage to operate the mechanical counting device. It is obvious that for even higher scaling ratios such an apparatus would become much too elaborate to be conveniently constructed or used. Fortunately, other methods of scaling enter the scope of possibility for high counting rates.

By electronic means, every pulse causes the transportation of a spurt of charge into a condenser, increasing the potential thereon as the pulses charge it. When a certain predetermined value of potential is reached on this condenser, another electronic device is made to respond, thereby supplying the "scaled" pulse, and also to reestablish the initial conditions of potential on the condenser so that the cycle of operation can be repeated. In this manner scaling is accomplished by the accumulation of electric charges up to a certain value and by the repetition of this operation. Figure 7 gives two examples of circuits employing this method of scaling. In Fig. 7a, every positive pulse operating the grid of tube V will cause the point a to go more positive with respect to b, and hence will cause current to flow through D for the duration of the pulse, and supply the capacity C with a spurt of charge. With each pulse the potential across cathode-plate of the thyratron T_h will increase until at a certain critical value the tube will discharge condenser C and operate the relay or

Fig. 6.—Complete vacuum tube scaling apparatus working on the trigger principle, containing pre-amplifier, recording end stage for the mechanical recorder, and a neon tube circuit for visual observation of the scaled pulses. It can be operated at scaling ratios of 2, 4, or 8 to 1, or without scaling, and with its regulated power supply and high-voltage source for the GM tube, represents a reliable apparatus for radiation measurements

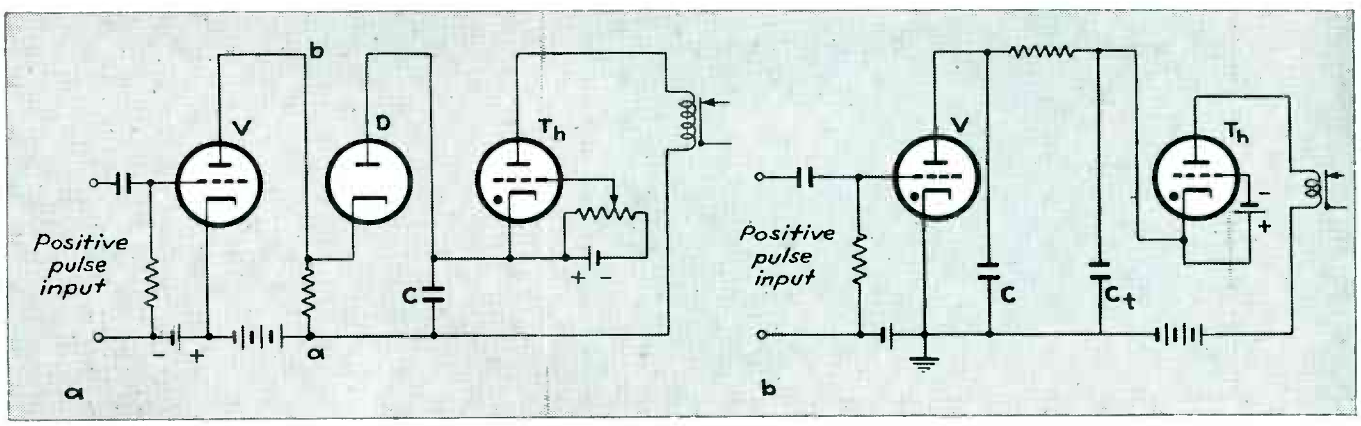


Fig. 7.—Fundamental circuits for the scaling of pulse-rate by accumulation

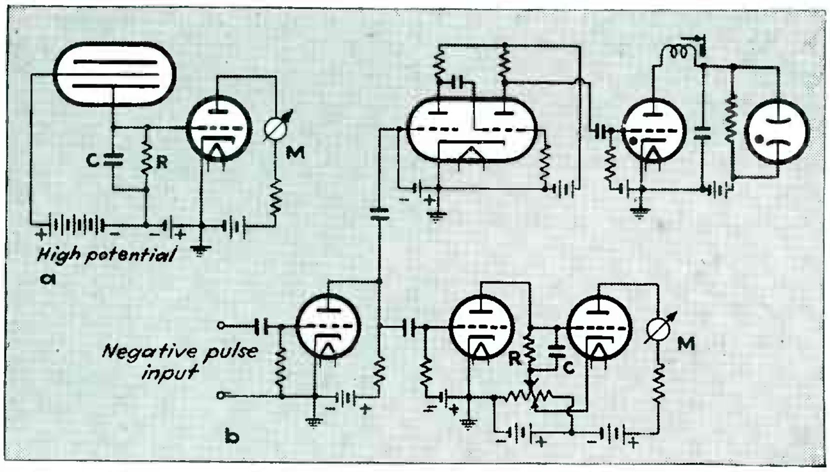


Fig. 8.—(a) Simplest integrating current meter used on a self-quenching GM tube. (b) Direct reading intensity meter of the type shown in Fig. 9. The pulses are "integrated" by the RC circuit in the final VT voltmeter stage. The thyratron circuit is provided in case mechanical recording of very small radiation intensities is desired, and is coupled to the main circuit over a double-triode stage to prevent the feedback of the thyratron discharge pulse into the integrating circuit

recorder mechanism. Then a new cycle can follow. The scaling ratio of such a circuit can be controlled within very wide limits by controlling the amount of charge supplied to C by each pulse, i.e., its duration as well as amplitude, by giving C appropriate dimensions, or by varying the grid bias of T_h to control the critical plate potential at which discharge will be initiated.

Figure 7b shows a circuit in which V, normally non-conducting, is fired by a positive pulse and thereby discharges a condenser C which is subsequently recharged from a larger condenser C_t until the latter has lost a predetermined amount of charge resulting in a certain maximum value of cathode-plate potential on thyratron T_h which will fire it. The grid of thyratron T_h is biased to such a value that the tube will discharge with the full plate voltage applied, and stay conducting until the plate voltage is reduced to approximately 20 v. In other words, when the set is turned on the thyratron T_h fires immediately and conducts until the condenser C_t is charged sufficiently to reduce the voltage between the cathode and heater to about 20 v. Now C_t carries the anode voltage for tube V. Each pulse operating tube V will discharge C_t by a small amount and thus the effective anode voltage on tube T_h will increase step by step until it fires. A relay in the anode circuit records the number of times T_h fires and therefore the number of impulses reaching the grid of tube V. The cycle then repeats itself.

There is practically no limit to the scaling ratio for which such an accumulation circuit can be designed, and it is possible, therefore, by providing a sufficiently great scaling ratio, to operate under conditions limited only by the properties of the input circuit. If the latter consists of vacuum tubes, this limitation in resolving time may lie around 10^{-6} sec. of even lower. However, there is a lower limit of pulse rate for an accumulative circuit of given scaling ratio due to the loss of charge (or sometimes addition of charge, as in Fig. 7b) due to leakages in the condenser itself and in associated circuit elements. If there is sufficient time between successive pulses such leakage may amount to a noticeable error in the scaled counting rate obtained. This will become serious if the time constant of the leakage circuit (i.e., as determined by the value of leakage resistance and the capacity of the accumulating condenser), approaches the same order of magnitude as the reciprocal of the average scaled counting rate.

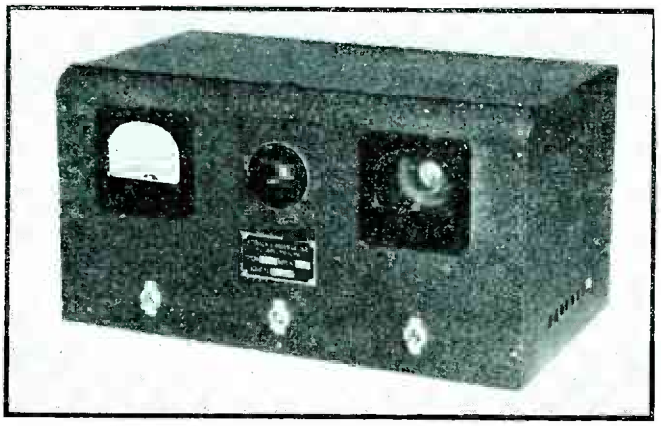


Fig. 9.—A sensitive direct-reading intensity meter, especially useful for work with radioactive materials

Pulse Integrating Current Method. Instead of looking upon the response of Geiger Müller tubes as consisting of individual electrical pulses which we may count individually for a period of time, and thus determine the counting rate, we may picture their response to represent simply an electrical current like the response of an ionization chamber, but many times amplified. Then we can measure the average current through the GM tube and take this as a measure for the radiation intensity. Since the current consists of relatively great spurts of charge the electrical averaging process is very important to minimize the fluctuations to such an extent that a fairly steady meter reading of the current can be made, as we will see later on.

Figure 8 demonstrates what is probably the simplest method of average current measurement with a GM tube, and will serve to demonstrate the principle of this method. Suppose that the GM tube to be used is known to deliver 5×10^{-10} coulomb per pulse. Then, if we desire our instrument M to give a full scale deflection for a counting rate of, say 1000 per sec., this will correspond to a current of 1000×10^{-10} coulomb per sec. $= 5 \times 10^{-7}$ ampere average. Along a resistance R of 2 megohms, an average potential drop of 1 v is consequently obtained, and is easily measured as a full scale deflection by a vacuum tube voltmeter circuit of moderate sensitivity. For the purpose of averaging the current of

(*Continued on page* 118)

Applications of CATHODE RAY TUBES

The great number of applications of cathode ray tubes are surveyed, as an introduction to the uses of this versatile tube in ultrahigh frequency technique

By **BEVERLY DUDLEY**

Acting Managing Editor, Electronics

ESSENTIALLY the cathode-ray tube is a device for producing a visual image, produced by means of an electron beam impinging on a fluorescent screen, the beam having negligible inertia and being capable of deflection at very great rates of speed by the action of electric and/or magnetic fields. Since the beam may be deflected in two dimensions as a function of time, and since the intensity of the beam and size of the spot may be varied by voltages applied to the tube, a wide range of possible applications exist. In fact, the tube may be used to produce transient or recurrent traces (depending upon the phenomena encountered) of any chemical, mechanical, or physical variation which can be converted into electrical or magnetic variations by the proper types of energy converters; it can, of course, produce visual traces in accordance with electrical or magnetic variations acting upon the beam.

Because of its ease of operation, application over an unusually wide band of frequencies, production of an image of either transient or recurrent phenomena which may be observed visually or by photographic means, and its diverse applications to measurement, the cathode-ray tube has found wide use in communication and industrial purposes. Although it is not generally used directly at frequencies usually classified as being in the u-h-f spectrum because of certain inherent limitations in the tube and its associated circuits, it does form an important adjunct and auxiliary piece of equipment for use in television and other ultra-high frequency communication systems.

It is impossible to list all of the actual or potential applications of the cathode-ray tube and its associated circuits, but among its most frequent uses may be listed the application of the tube for:

1. Measurement of voltage*[1, 15, 16]
2. Measurement of current[4, 16]
3. Measurement and determination of frequency[1, 2, 3, 4, 5, 6, 16, 35]
4. Determination of waveform and distortion[4, 18]
5. Measurement and determination of phase relationships[5, 6, 16, 17, 18]
6. Measurement of ratio of charge to mass of electron[11]
7. Measure of power[1, 5, 6, 16]
8. Determination of power factor[2, 16, 17]
9. Determination of dielectric loss[2, 16, 17, 18]
10. Determination of magnetic hysteresis, and B and H[2, 5, 16, 17, 18]
11. Determination of characteristics of oscillatory circuits[18]
12. Determination of ionosphere characteristics[2, 18]
13. Determination of polarization of electromagnetic waves[2, 4, 18]
14. Study of atmospheric disturbances[2, 17]
15. Study of corona[16]
16. Study of sparks and atmospherics[16]
17. Determination of field strength[18]
18. Determination of electromagnetic echoes[18]
19. Studies of spectroscopy[19, 20, 21]
20. Determination of bridge balance[3, 17, 18]
21. Determination of amplitude, frequency and phase modulation[2, 3, 4, 5, 16, 17, 18]
22. Modulation generator[9]
23. Frequency and phase multiplier[10]
24. Measurement of acoustic properties of gases[17, 18]
25. Measurement of velocities of sound[17]
26. Recording speech and other sounds[16, 17, 18]
27. Determination of characteristics of microphones, speakers and other acoustic devices[18]
28. Determination of noise in internal combustion engines[18]
29. Determination of frequency response in audio amplifiers[16]
30. Determination of frequency response in i-f and r-f amplifiers and radio receivers[4, 6, 8, 16, 17]
31. Determination of power output and efficiency of amplifiers[4]
32. Determination of electron tube characteristics[1, 2, 4, 16, 17, 18]
33. Study of rectifier characteristics[16]
34. Determination of characteristics of arc and discharge tubes[16]
35. Determination of characteristics of gaseous discharge tubes and phototubes[18]
36. Production of pictorial images in television[5, 8]
37. Determination of mechanical characteristics such as pres-

* Numbers refer to bibliography at end of article.

sure, impact, acceleration, linear and torsional oscillation, stretching, etc. [18, 17]

38. Study of piezoelectric oscillations [2, 16, 17]
39. Illumination measurements [16]
40. Operation of amplifiers [18]
41. Gas reactions [18]
42. Direction finding [16, 17, 18]
43. Electrocardiography and similar medical applications [16, 17]

In such applications as listed above, the tube is used to form a visual representation of the various voltages applied to the deflection and timing circuit. A wide variety of patterns may be produced through the various adjustments of the tube and its associated circuits. A proper analysis of the visual image produced on the screen enables the operator to determine the unknown voltage, current, or wave with which the cathode-ray tube is associated in terms of some corresponding electrical quantity whose characteristics are known. The information which may be derived from the analysis of the trace on the screen of the cathode-ray tube depends upon the type of pattern and therefore upon the method in which the tube is used. Therefore, the operator of cathode-ray tube equipment should be familiar with the particular application of the cathode-ray tube, or if this is not possible, he must be prepared to analyze the traces on the screen in accordance with directions provided to him for this purpose. Facility in analyzing screen patterns comes with practice and experience as well as with an intimate knowledge of the details of certain operations of the associated equipment. The analysis of screen images is made easier if the operator has at least an elementary knowledge of the function of the cathode-ray tube and its associated scanning, deflection, and sweep or timing circuits.

Construction of Cathode-ray Tube

A cathode-ray tube with electrostatic deflection plates consists of an evacuated glass tube containing the cathode, or source for producing a beam of electrons, a grid for varying the intensity of this electron beam and thereby varying the intensity of the spot on the fluorescent screen, a first anode having a positive potential with respect to the cathode and whose purpose is to focus the spot on the screen, a second anode also positive with respect to the cathode for accelerating the electrons from the cathode, a secondary electron collector (in some types of tubes), and two sets of deflection plates at right angles to one another. In traveling down the axis of the tube from the cathode to the screen, the emitted electrons come under the electrostatic influence of the control grid, first anode, second anode, deflection plates and impinge upon the fluorescent screen where secondary electrons are produced which are collected by the secondary collector anode. In some types of tubes, called electromagnetically deflected cathode-ray tubes, the electron beam is deflected by means of horizontal and vertical deflection coils rather than by electrostatic deflection plates. These coils are not an integral part of the tube itself, but must be incorporated with the associated or auxiliary equipment. In this case the degree of deflection of the electron beam depends upon the current through the deflecting coil, whereas in the case of electrostatically deflected tubes, the deflection of the beam depends upon the voltage applied to the deflection plate.

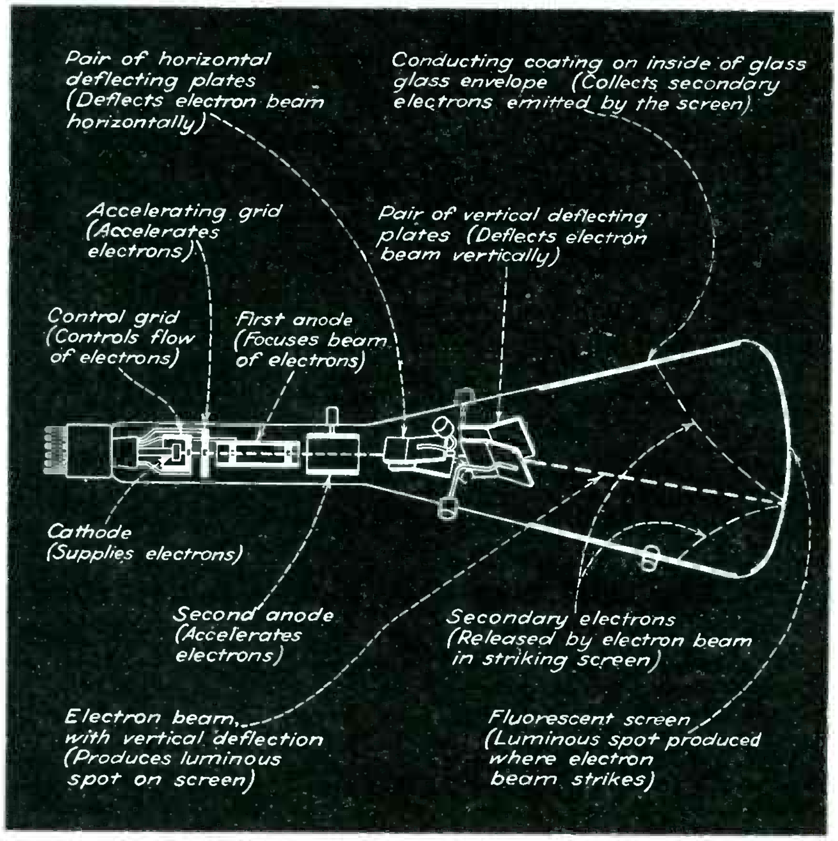
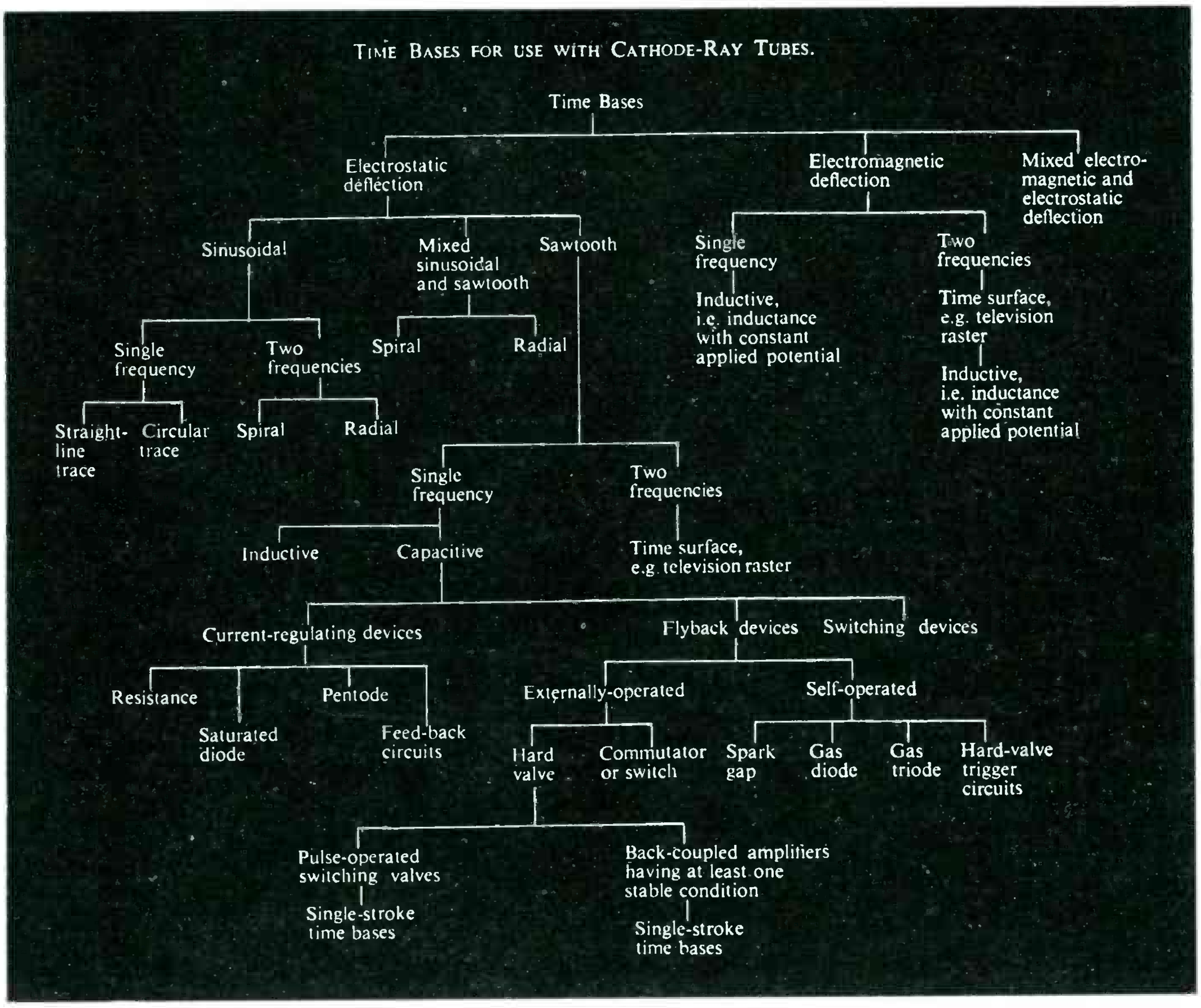


Diagram of cathode ray tube with electrostatic deflection, indicating function of each essential element. In some tubes the accelerating grid is omitted

Cathode-ray Tube Adjustments

To a reasonable degree, the voltages (or currents) applied to the various electrodes in the cathode-ray tube produce effects on the electron beam which are largely independent of one another. This is a considerable convenience in the design of associated equipment and in the manipulation of cathode-ray tube circuits, for it makes possible a single adjustment for any single desired change in the size, intensity, or deflection of the spot on the fluorescent screen. In practice, the cathode or heater is maintained at a constant temperature by operating it at a constant voltage. Accordingly a steady and continuous supply of electrons is available and the cathode voltage is not used as a control means. The intensity or brilliance of a spot on the screen may be varied (for other electrode voltages maintained constant) by changing the voltage on the control grid. The size of the spot, or the sharpness of focus, is determined by the voltage on the first anode, or, more correctly, the ratio of the first anode voltage to the second anode voltage. For a given second



Classification of time bases according to Puckle [35]

anode voltage there is, usually, one value of first anode voltage which produces the sharpest spot on the screen. The second anode voltage determines the acceleration which is given the electrons traveling from cathode to screen, the acceleration increasing as the positive second anode voltage is increased. Because the second anode voltage alters the acceleration of the electron, and therefore alters the time during which any group of electrons comes under the influence of the deflection system, the second anode voltage has some effect on the deflection sensitivity of the tube. This deflection sensitivity is the ratio of the displacement of the fluorescent spot on the screen to a unit voltage (or in the case of electromagnetic tube, to a unit current) flowing in the deflecting circuit. It now remains to consider only the effects of the deflecting system. For convenience, this article will discuss the applications of the electrostatically deflected type of tube. It should be understood, however, that the same general type of reasoning applies to electromagnetically deflected cathode-ray tubes if we replace the term "deflection voltage" for the electrostatic tube, by the term "electromagnetic deflection coil current" in the case of the magnetically deflected cathode-ray tube.

Since the motion of a moving electron may be influenced by an electrostatic or a magnetic field through which it passes, three possible modes of deflection are available: (1) We can make the electrons travel from the cathode to screen through an electrostatic field in which both vertical and horizontal portions of the electric field intensity may be varied to produce a motion of the spot in two orthogonal (90 deg.) directions, (2) we can make the electrons travel through a magnetic field whose vertical and horizontal components may be varied to produce the desired vertical and horizontal deflection of the beam, or, (3) we can make the electrons travel through a combination of electric and magnetic fields in such a manner that variations of the electric field produce deflections in one direction whereas variations of the magnetic field produce deflections in another direction, which is, most conveniently, at right angles to the first direction. In any case, and for constant voltages applied to the other electrodes of the tube, the deflection of the beam is proportional to the instantaneous voltage on the deflection plate, or to the instantaneous current in the deflection coil, within the frequency limits of tube operation.

Screen Traces and Spot Deflection

Since the deflection of the spot on the screen (or the deflection of the electron beam, which is the same thing) is proportional to the instantaneous values of the deflection voltage (or current) it is evident that a direct voltage applied to the vertical set of deflection plates will produce a sudden and constant vertical deflection of the beam (or displacement of the spot), while a direct voltage applied to the horizontal set of deflection plates will produce a sudden and constant vertical deflection of the beam or displacement of the spot. Likewise, if a direct voltage is applied simultaneously to both vertical and horizontal deflection plates, the resultant deflection of the electron beam will be both vertical and horizontal in accordance with the usual addition of vector quantities.

If an alternating voltage is applied to the vertical set of deflection plates, the instantaneous voltage of the plate will vary from zero to maximum amplitude value in one direction and then through zero to a maximum amplitude value in the opposite direction. The electron beam will likewise follow the variations in voltage and the steady constant deflection which was observed in the d-c case, will now be found to resolve itself into a thin vertical line (or vertical deflection) in which the length of the vertical trace on the screen is proportional to the peak value of the deflection voltage. Likewise, alternating voltage applied only to the horizontal deflection plate will produce a horizontal trace on the screen of the cathode-ray tube. When alternating voltages are applied simultaneously to both the horizontal and vertical deflection plates, any of a wide variety of closed loop screen traces may be obtained depending upon the amplitude, frequency, phase relationship, and the wave shape or harmonic content of the deflecting voltages on the two sets of deflection plates. For sinusoidal voltages whose frequency ratios are integral multiples or submultiples, the trace produced is any of the common Lissajous figures and the voltage applied to one set of deflection plates may be analyzed with respect to that of a known voltage on the remaining pair of deflection plates through the usual method of analyzing Lissajous figures.

The chemical composition of the fluorescent screen determines the color of the spot as well as rapidity with which the intensity of the spot decreases after the control grid voltage has been made sufficiently negative as to cut off the electron from reaching the fluorescent screen. For television purposes a screen producing a white image is most satisfactory, especially if it has a relatively short persistence of image. For visual observation of electrical phenomena, the color of the screen is usually unimportant, although if the traces are very fast or very faint, there is some advantage in using the green screen since the eye is most sensitive to the green portion of the spectrum. For photographic purposes a blue screen is usually most satisfactory since most photographic films have their peak of sensitivity in the blue or near-blue visual spectrum. For the observation of transient phenomena, a screen having a long persistence of image is desirable, since in this case the screen trace is retained for an appreciable part of a second or perhaps for several seconds. The persistence of image on the screen is less important where recurrent phenomena are observed and in such applications where recurrent traces occur with some displacement, it may be desirable to use a fluorescent screen of a phosphor having a short persistence of image so that one trace is practically obliterated before the next trace is built up.

Deflection System

It is not the purpose of this elementary review of cathode-ray tube technique to go into details of the various types of electrical circuits which may be used for producing a time deflection base or scanning pattern for the electron beam. A wide range of deflecting or scanning circuits is possible and these have recently been surveyed in an article "Wave Form Circuits for Cathode-ray Tubes," by H. M. Lewis in the July and August 1942 issues of ELECTRONICS. Nevertheless, it is believed that a brief discussion of the characteristics of the various systems may be useful in analyzing the screen patterns in any particular case, and also in determining the complexity of the deflection and scanning circuits which may be required for any particular application of cathode-ray tube oscillography. This is particularly true in u-h-f applications of cathode-ray tube analysis because of the complexity of the patterns produced and the frequency limits of the tube and associated circuits for satisfactory operation.

Scanning Sweeps Related to Phenomena to be Analyzed

By properly calibrating the deflection of the spot in terms of voltages and currents applied to its electrodes, the cathode-ray tube may be used directly as a measuring device. It is equally useful as a comparator in which case the deflection of the spot need not be calibrated in known electrical quantities. In any case the unknown quantity is applied to one or more electrodes of the cathode-ray tube, and the known quantity, in terms of which the analysis is made, is applied to the other electrodes of the tube. Since the unknown quantity is determined in terms of a known voltage or current considered as a standard, it is essential that the frequency, amplitude, waveform, or other characteristics of the standard be known with sufficient precision as to be suitable for the application at hand.

The type of screen pattern produced, and therefore the type of scanning, timing, or sweeping circuits for the known or standard voltage, will depend upon the kind of phenomena under investigation. Particularly will it depend upon the manner in which the unknown phenomena varies with time or frequency. Although it does not appear possible to build up a rigorous classification which is at the same time simple, the following classification is believed to be useful in establishing the type of sweep circuit most satisfactory for the examination of various kinds of phenomena.

Broadly speaking three classifications are useful:

(1) Phenomena which depend upon voltage, current, or power, but which are (largely if not completely) independent of time or frequency, do not require time base

(*Continued on page 154*)

DESIGN CHART FOR

Phase Shifting and Amplitude Control Networks

Design charts present a graphical solution to the problem of determining the network required to deliver proper power to each of several loads fed by the same source. Phase and amplitude relations of coupling network easily determined

By W. S. DUTTERA

Radio Engineering Department
National Broadcasting Company

ONE source of power is frequently used to feed several loads connected in parallel. Problems of this general type may arise, for example, when a transmitter feeds, simultaneously, the various elements in a directional antenna system. In such cases suitable networks must be designed for insertion between the source and the loads, to deliver the desired power to each load. The purpose of the network is to alter the effective impedance of the load so that the current and voltage fed to it are of the proper amplitude and phase relations. The accompanying graphical chart permits the rapid determination of the reactive elements, in the simplest L network, which will suffice.

As may be seen from the simple schematic diagram on the next page, the source delivers a voltage, E_o, and a current, I_o, to a resistive load, R. The voltage across this load is E_1 and the current through it is I_2. The required network is composed of X and X_1 whose function is to change the magnitude and phase of the current I_2 so that the load R may take the required amount of power.

In the absence of reactances X and X_1, the current to the load is $I_2 = E_o/R$ at an angle 0 deg. with respect to E_o and I_2. The introduction of the reactive elements will alter the magnitude of I_2 by a factor K, and the phase by the factor ϕ. The value of K may be greater or less than 1, and ϕ may be a positive or negative angle up to 180 degrees.

When K, ϕ, and R are specified, from the requirements of the problem, the chart enables us to determine the normalized reactances X and X_1. These normalized reactances are expressed in terms of X/R and X_1/R, so that we must multiply the values, as determined from the chart by the value of the load resistance, R, to ascertain the true values of the reactances actually required. The advantage of plotting the normalized reactance is that, by so doing, the chart is applicable to loads of any resistance.

When the proper values of K and ϕ are known from a statement of the problem, the chart is entered along the vertical line, K, until the concentric circle corresponding to the appropriate K value is obtained. This circle is then followed until it intersects the correct angle, ϕ. From this point, the values of X/R may be read from the scale at the right edge of the graph, while the values of X_1/R are read from a set of dotted radial lines having $K=1.0$ and $\phi=0$ as their origin.

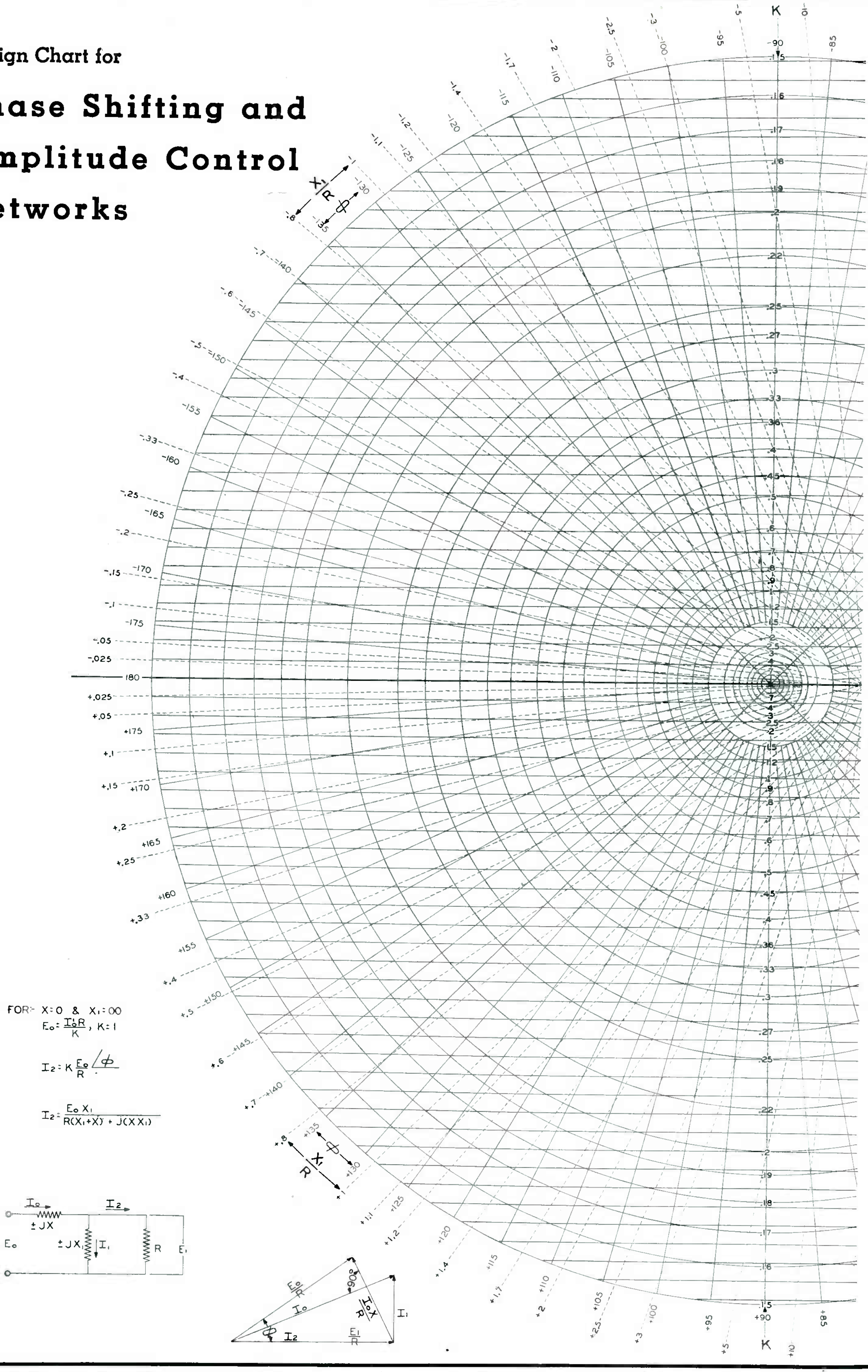
Suppose three transmission lines, A, B, and C, are to be fed in parallel from a single generator. Let the relative magnitudes and phases of these three currents be given, in polar form, as $I_A=0.60 \angle +160°$, $I_B=0.40 \angle +50°$, and $I_C=1.0 \angle 0°$. The first transmission line will require a correcting network which reduces the magnitude of the current to 60 percent of its value without the network, and which shifts the phase by +160 degrees. Thus, for the network required for transmission line A, we have, $K_A = 0.6$ and $\phi_A = +160$ deg. The network for line B reduces the current magnitude to 40 percent of its original value without the network, and shifts the phase +50 deg. Thus, for the network to be inserted in line B, we require $K_B=0.4$ and $\phi_B=+50$ deg. No network is required for transmission line C.

The problem is now to find the reactances X and X_1 for lines A and B from the chart. For the corrective network for line A, we enter the chart on the vertical line, K, until we reach the circle whose K value is 0.60. Follow this circle toward the left until we reach the solid radial line whose value is $\phi=+160$ deg. From this point of intersection, we project to the scale at the extreme right and find $X_A/R=-0.55R$. From the same point of intersection, we read the value of X_{1A}/R from the dotted radial lines intersecting the heavy vertical line. This gives $X_{1A}/R=0.22$. By multiplying these values through by the load resistance, R, we find $X_A=-0.55R$ and $X_{1A}=0.22R$. The negative sign indicates a capacitance while a positive sign indicates an inductance. From these values of X_A and X_{1A}, the network elements are easily determined.

The corrective network for the line B is found in a similar manner. From the point $K_B=0.4$ and $\phi=+50$ deg., we find $X_B=1.95R$ and $X_{1B}=-3.3R$. Thus, X_B is an inductance of $1.95R$ ohms reactance and X_{1B} is a capacitance of $3.3R$ ohms reactance.

Design Chart for

Phase Shifting and Amplitude Control Networks

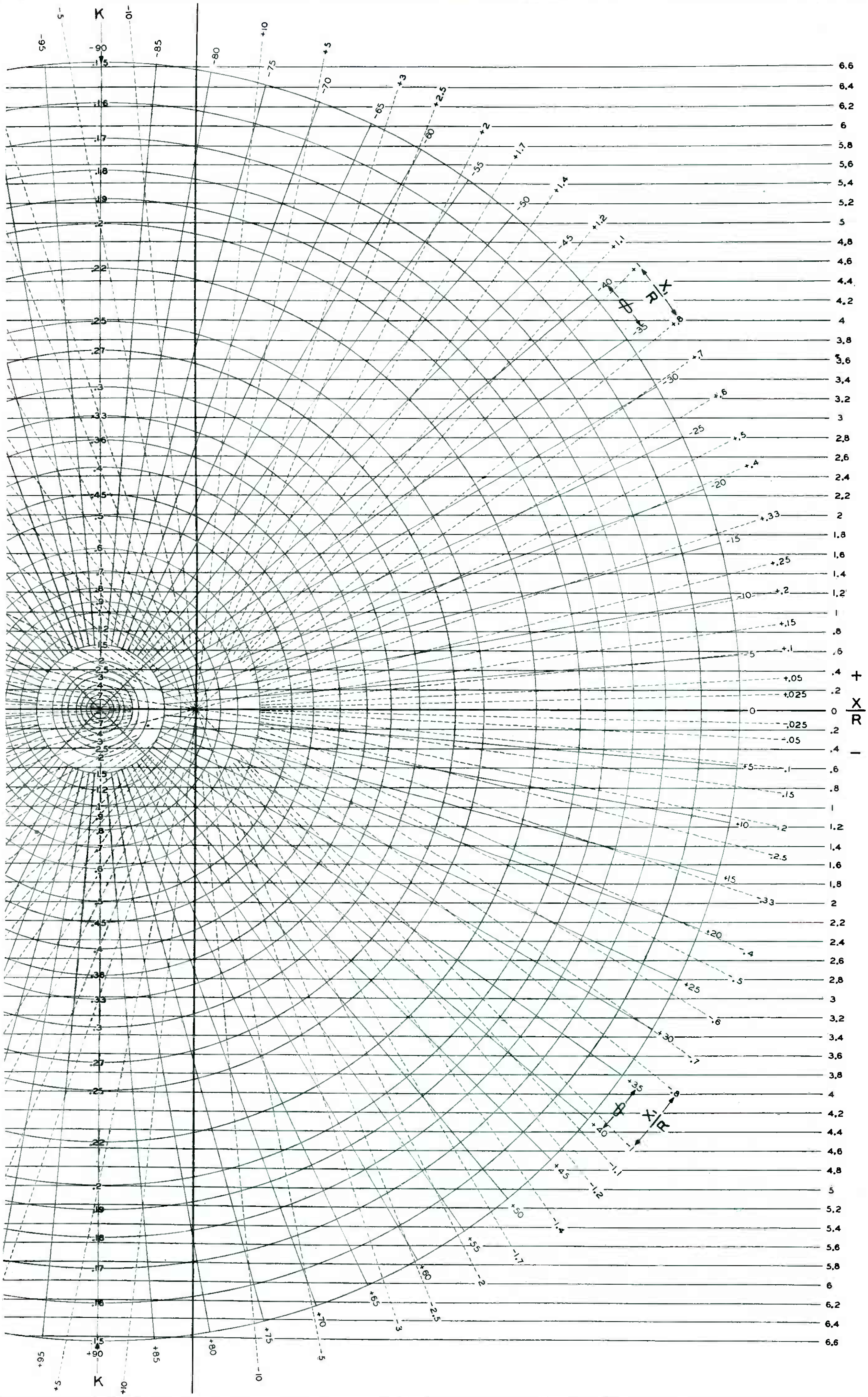


FOR:- X = 0 & $X_1 = \infty$

$E_0 = \frac{I_0 R}{K}$, K = 1

$$I_2 = K \frac{E_0}{R} \angle \phi$$

$$I_2 = \frac{E_0 X_1}{R(X_1 + X) + J(X X_1)}$$


K
X/R
+
−
Φ
X'/R
K

Temperature Measurement

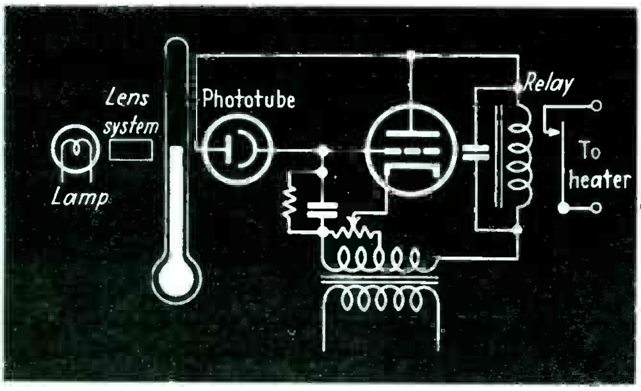


Fig. 1—Photoelectric temperature controller using a mercury thermometer as the sensitive element

Electronics has played a conspicuous role in the development of temperature measurement and control instruments during the past several years. This is a bring-

TEMPERATURE is a phenomenon of nature so well known that it is taken for granted and, in general, little thought is given to its implications. If the temperature of the earth's surface were to change as little as 100 degrees F. from its present average level for any extended period of time, animal and plant life would either disappear or some very radical changes would have to take place in the processes of life to withstand the new conditions. Although certain bacteria do not die at temperatures close to absolute zero, this is very much the exception among living organisms. If it is considered that the lowest temperature in nature is absolute zero (−460 deg. F.), and that the highest temperature is the temperature of the surface of certain far distant stars (about 60,000 degrees F.), a temperature change of 0.17 percent of the measurable range of natural temperatures would cause life to disappear from the earth. This is something to think about. But don't worry about it.

All this is by way of introducing the subject of temperature and indicating its importance to the human race. Historically, man first tried to control the temperature of his body by rubbing himself and by moving around. This is still a very common practice. Next he used fire to increase the temperature of his surroundings to be more to his liking and also to apply heat to cook his food. These also are common practices today. The first efforts to raise the temperature to a desired level, rather than to just raise it above the prevailing natural temperature, was undoubtedly to build a small fire for small increases and a large fire for large increases in temperature. All efforts in this direction were very naturally by man's own hand and not until the 19th century were automatic means developed for maintaining temperature at any given level. In the last few years the new tool with which we are primarily concerned, electronics, has been used. Electronic methods were applied very slowly at first, but there are signs now of greatly accelerated progress in using the advantages of electronics in the measurement and control of temperature.

The maintenance of proper temperatures in industrial processes has increased steadily in importance and has spread throughout many industries until it is difficult to name a product which at one time or another does not depend upon controlled temperatures. Naturally, very active work in developing instruments for the measurement and control of temperature has followed. Many companies are engaged in such development and more than a few have turned to electron tubes to help solve some of their problems.

Measurement Must Precede Control

Before any phenomenon can be controlled, it must first be measured. Therefore, it is necessary to discuss first the methods for measuring tem-

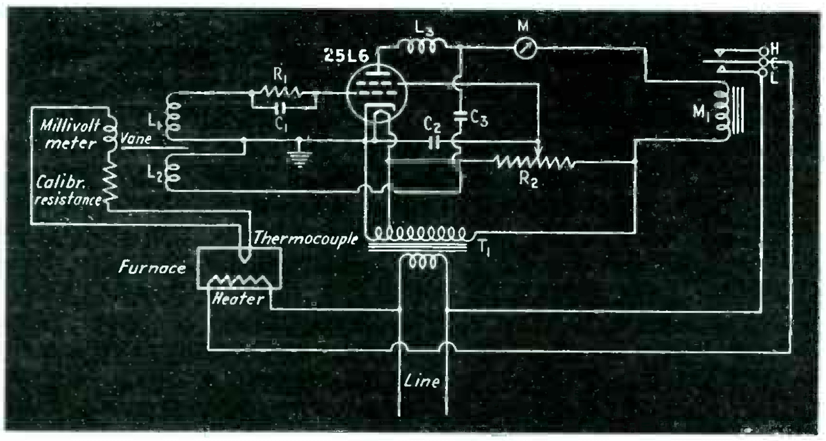


Fig. 2—In the Bristol electronic pyrometer a vane attached to the pointer of a millivoltmeter, operated by a thermocouple, passes between two coils of an oscillator circuit whose output changes to actuate the relay

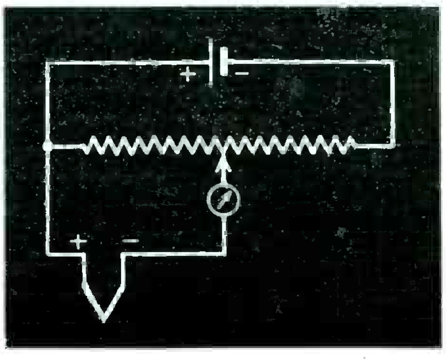
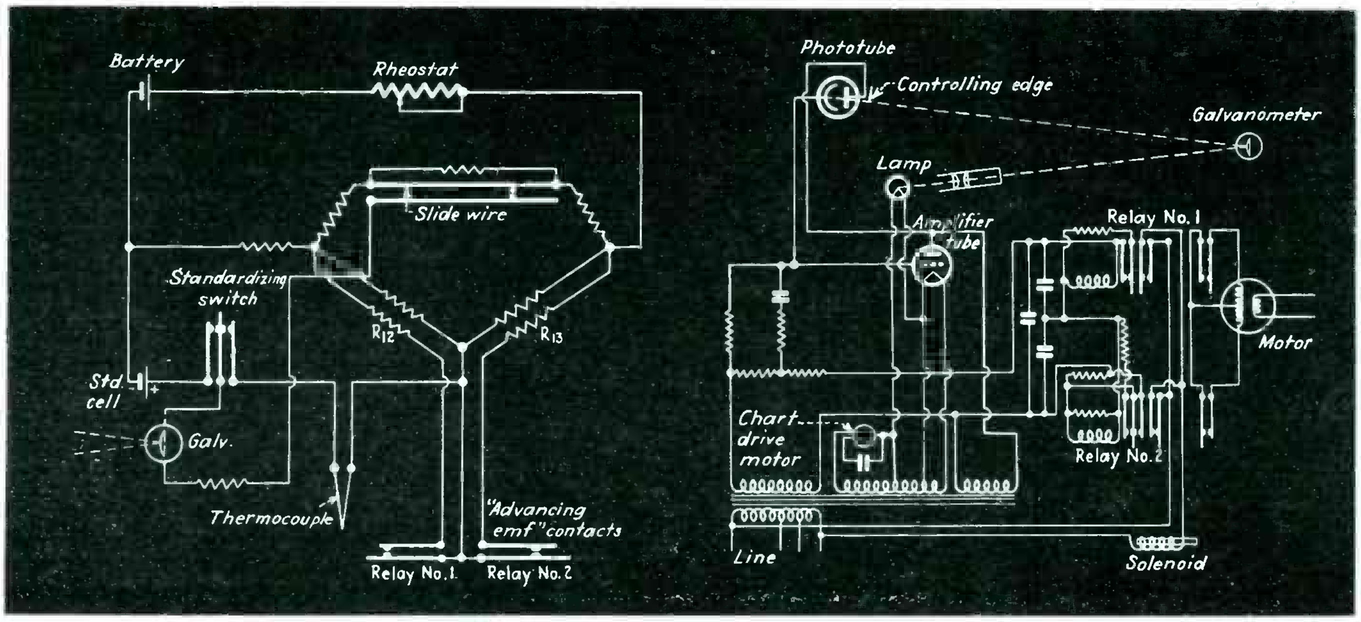


Fig. 3—The basic potentiometer circuit as it is applied to temperature measurement

and Control by Electronics

the-reader-up-to-date article with some background of temperature measurement and control in general, and a description of several electronic instruments

By CRAIG WALSH
Associate Editor, Electronics



Figs. 4 & 5—Circuit diagram of the Tagliabue photoelectrically balanced recording potentiometer. Exact balance of the potentiometer is indicated by zero deflection of the galvanometer. Any unbalance deflects it and the reflected light beam causes the photoelectric balancing circuit to operate and drive a motor to restore balance

perature and then the means for applying control. In some ways, temperature is much like voltage. It cannot be measured *per se*, it cannot be seen, it cannot be heard, it cannot be picked up, but, like voltage, if you come in contact with it, especially if there is lots of it, there's no mistaking its presence!

Because temperature cannot be measured directly, it must be measured by its effect. The most important effects for industrial purposes are: Expansion of a solid, liquid, or gas, generation of an electric voltage by a thermocouple, change of resistance of an electrically conducting material, difference of expansion rates of dissimilar materials, and change in radiation characteristics. By proper calibration, instruments using any of these physical changes can be made to measure temperature, or more strictly speaking, a change in temperature.

A common object is the glass thermometer in which a mercury column rises as the temperature increases. In cheaper thermometers, alcohol or some similar liquid is used. Another type of liquid expansion thermometer, frequently of the remote indicating type, uses a tube completely filled with mercury and fitted with a spiral at the indicating end. When the temperature increases, the mercury volume increases and consequently the pressure. The increased pressure causes the spiral to open somewhat and to move a pointer on a scale on the face of the thermometer.

Thermocouple. Thermocouples are very extensively used for the measurement of industrial temperatures. A thermocouple consists fundamentally of a pair of electrical conductors of dissimilar materials joined so as to produce a thermal emf when the junctions are at different temperatures. The junction which is to be placed at the location where the temperature is to be measured is called the measuring junction and the other junction is placed at a location whose temperature is known and is called the reference junction. A difference in temperature between the measuring and reference junctions causes an emf to be generated. This generated voltage is approximately proportional to the difference in temperature between the junctions and is of the order of millivolts. A sensitive galvanometer is used to measure it as an indication of temperature. Modern thermocouple instruments have many refinements for rapid and ac-

Fig. 6—A Tagliabue Celectray Recorder-Controller set up in a heat treating plant and regulating a pot type furnace in which the teeth of circular saws are hardened

curate indications including automatic compensation for variations in the temperature of the reference junction.

The measuring junction is usually placed in direct physical contact with the object whose temperature is to be measured, but this is not possible in all cases. Where the temperature is too high or where motion of the hot body prevents placing the couple at the point to be measured, the radiated energy may be directed to the couple, or to a thermopile (several thermocouples in series), with satisfactory results.

Resistance Thermometers. The change of electrical resistance of metals offers another convenient means for the measurement of temperature. In general, the resistance R_{t2} of a metal at temperature t_2 is expressed by the formula:

$$R_{t2} = R_{t1} \left[1 \; \alpha_{t1}(t_2 - t_1) \right]$$

where R_{t1} is the resistance of that metal at temperature t_1 and α_{t1} is the temperature coefficient at that temperature.

Platinum and nickel have very desirable characteristics for use in resistance thermometers, and are the most widely used materials for this purpose. Because corrosion is accelerated by exposure to high temperatures and corrosion decreases the cross-section of the wire, thereby increasing its resistance permanently, the resistance thermometer is limited to measurements lower than 300 degrees F. The low limit of its usefulness is −150 degrees F. The nickel resistance element is generally incorporated in a Wheatstone bridge connected to some measuring device. There are several such measuring devices and they will be described later in this article.

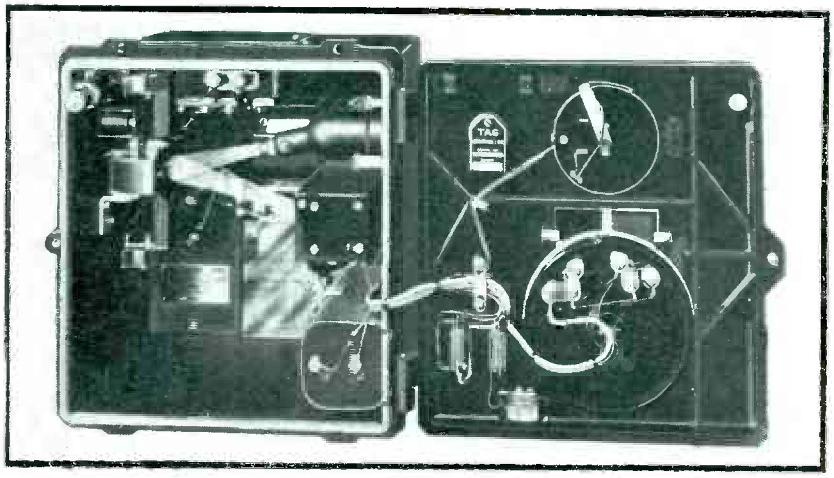


Fig. 7—Interior view of the Tagliabue Celectray indicating controller showing the mirror galvanometer, light source, and phototube unit in the case and the circular slide wire and battery rheostat mounted on the door at the right

Bi-metallic Strips. The difference of expansion of various metals is frequently used in temperature measurement and control, especially in domestic heating systems. A bi-metallic strip, made up of two pieces of metals having different expansion coefficients welded back to back, will curl with a change in temperature. Or if one end is fixed in position the other end will move, because of the different rates of expansion of the two metals. The strip may be formed into a spiral and the deflection of the strip may be used to move a pointer.

Radiation Pyrometers. Another means for determining the temperature of a body is its radiation characteristics which change with temperature. A thermocouple, a thermopile, a phototube, or a photovoltaic cell may be used to measure the radiation, and thus the temperature. The brightness of the body (light radiation) may be compared in an optical pyrometer with that of an incandescent filament, the current through which may be varied. The current is varied until the brightness of the filament is the same as that of the hot body. The temperature is then determined by reference to a calibration chart. Radiation and optical pyrometery are well developed and many instruments using these principles are in use.

These are the principal physical phenomena used in measuring temperature. Thus far, the only electronic device mentioned is the phototube. It is in the control process, maintaining the temperature at a desired level, that electronics plays such an important part. Electronic methods are used in temperature control for the same reason that they are used in other applications, i.e., tubes can perform certain types of operations better, faster, more reliably, or cheaper than by mechanical or electrical methods, or because a tube can perform operations not possible by other methods. Electronic circuits are not extensively used where quantitative results are required (from the circuit itself), but serve as relays controlling the application and direction of power. The reason for this is that while electronic circuits are used very extensively for measurements in the radio and communication fields, the presently used circuits do not posses sufficient accuracy for quantitative use in the field of temperature control. In radio, accuracies of the order of 1 or 2 percent are generally satisfactory, whereas accuracies of small fractions of a percent are guaranteed in industrial temperature controllers now used under widely varying conditions. This should not be considered a reflection on the abilities of electronic engineers or devices, but rather as a challenge to be met. The exigencies of the present world situation will be an additional spur to engineers to develop circuits and devices for use in applications where precision is a prime requisite.

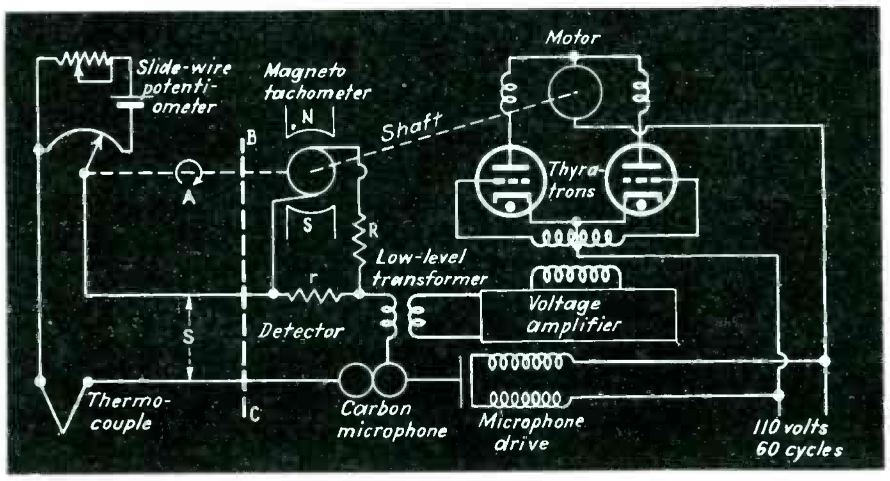


Fig. 8—Circuit of the Leeds & Northrup Speedomax in which the unbalance voltage is converted to a.c. by a driven carbon microphone. The speed of the balancing motor is regulated by the action of the magneto tachometer which generates a voltage in opposition to the unbalance voltage

Principles of Temperature Control

In any control process, the controlled phenomenon must first depart from its desired value before any correcting control can be applied. Secondly, for any given temperature to be maintained, the heat input must equal the heat loss. The simplest temperature control instrument permits heat to be applied until the temperature reaches the desired point, or a little higher, then the heat supply is removed until the temperature falls to a predetermined lower value when the heat is once more applied. The temperature then varies periodically between the upper and lower limits. In many cases an input of heat is maintained constantly which will not keep up the temperature to the desired level and an additional heat source is applied to take care of the variations.

Another system is that of proportional control in which heat input is proportional to the demand. That is, if heat is being lost at a low rate, heat is applied at a low rate and if heat is being lost rapidly thereby reducing the temperature by a considerable amount, the heat input is at a correspondingly high rate. In this method the system is continuously balancing itself at some temperature depending upon the demand requirements. If the demand is great the balance point will be some temperature somewhat lower than the desired value and some means is almost always provided for applying a load correction or an automatic reset.

Electronic methods may be applied to any of the temperature measuring phenomena for purposes

Fig. 9—The Leeds & Northrup Speedomax which converts the potentiometer unbalance voltage to a.c. by means of an a-c driven carbon microphone which is then amplified to drive the balancing motor

of control. Whether or not such methods should be used depends entirely on the individual application. Sometimes it is justified and sometimes it is not. An elementary method is to use a phototube and amplifier circuit in conjunction with a mercurial glass thermometer as shown in Fig. 1. A light source and lens system is mounted on one side of the thermometer and the phototube on the other at a level corresponding to the desired temperature. If the mercury column is below that level, the light will pass through the glass and fall on the phototube causing it to pass a current and actuate the amplifier and relay circuit. The heat will then be turned on. When the mercury column rises to the level of the light beam, the beam is cut off and the relay is de-energized.

This type of phototube device may also be used on circular scale thermometers where a hole is placed in the scale at the desired temperature. As the temperature rises the pointer covers the hole thereby breaking the light beam.

Electron tubes find their greatest application in the temperature control field in those instruments using the thermocouple or resistance thermometer as the temperature sensitive element. The thermocouple generates an emf of several millivolts when the two junctions are at different temperatures and some means must be provided for measuring this voltage. One method is to use a millivoltmeter which may be, and generally is, calibrated in degrees. The phototube method described above may be used to operate the relay controlling the heat application system or a light metallic vane may be attached to the pointer so that it will pass between two small coils which are connected in an oscillator circuit. Such methods are used by the Bristol Co., Illinois Testing Laboratories, and Wheelco Instruments Co., in some of their instruments. In the Bristol instrument, whose circuit is shown in Fig. 2, if the temperature is low, the circuit is not oscillating and the plate current is at its maximum value of about 10 ma. The relay is energized and heat is supplied. When the vane comes between the two coils oscillation starts and the plate current drops to a value of about 5 ma, the relay is de-energized, and heat is cut off. Tubes in this instrument have operated continuously for more than four years without replacement. Wheelco chose to vary the frequency of its oscillator when the vane moves between the coils. When the frequency is varied, the anode current changes and operates a relay which in turn controls the heat input.

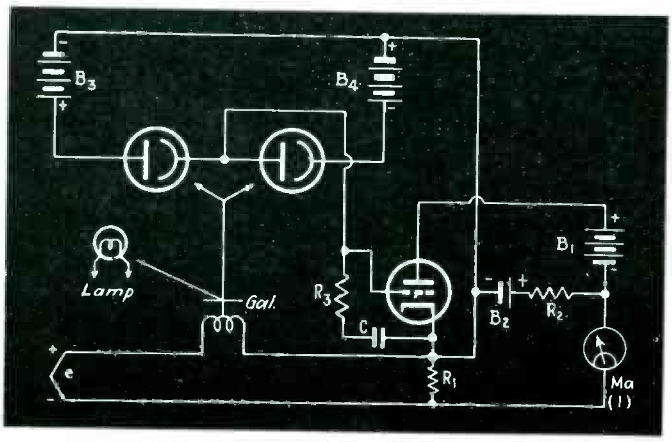
The Self-Balancing Potentiometer

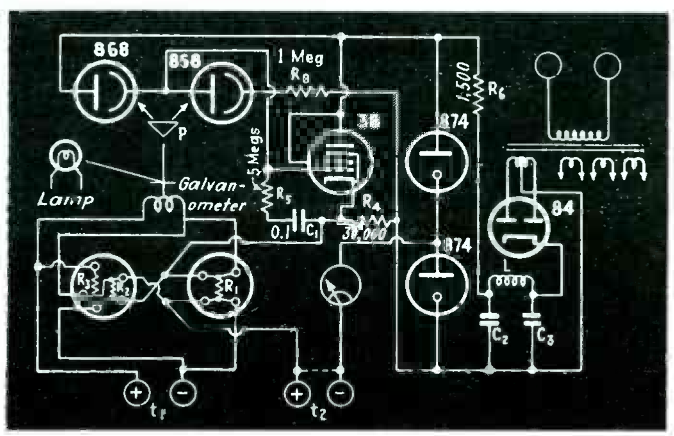
A very precise method of measuring the voltage generated by a thermocouple is by means of a potentiometer. The basic circuit is shown in Fig. 3. The thermocouple voltage is readily and accurately determined by measuring the length of the slide wire whose voltage drop is equal to the thermocouple voltage. When one side of the thermocouple is connected to the end of the slide wire and the other connected through a contactor to the slide wire at a point where the two voltages are equal, the potentiometer is said to be balanced. Several automatically balancing potentiometers have been developed and are available commercially. Some use mechanical means with contact springs mounted on a galvanometer, but others use electron tubes. Among the methods used for attaining balance automatically are a light-beam deflected by a mirror galvanometer and a system of relays to drive a balancing motor; the unbalance voltage of the potentiometer converted to a.c. and used to drive a balance motor; and a variable current proportional to the thermocouple voltage passed through a fixed resistor.

The C. J. Tagliabue Manufacturing Co. uses a light beam, a mirror type galvanometer, a phototube and amplifier circuit, relays and a balancing motor in their recording controller. The circuits of the temperature-measuring and balancing portions of the instrument are shown in Figs. 4 and 5. During periods of temperature change current passes through the mirror galvanometer and deflects the light beam away from its balance position, at the edge of the phototube cathode, or partly on the controlling edge and partly off. In this balance position one of the two relays is open and the other is closed and the balancing motor is inoperative. When the light beam is off the balance position it is either entirely on the cathode or entirely off and the relays are either both open or both closed and the balancing motor will operate to drive the slide wire contactor and recording pen to the new balance position.

The balancing circuit operates in the following manner. When the light beam strikes the edge of the phototube cathode it causes a sudden change in the current through the grid resistor in series with the grid condenser (Fig. 5). The change in voltage drop in this resistor is immediately applied to the grid of the amplifier tube, before the voltage across the condenser changes appreciably. This is because a definite time is required for the voltage across the condenser to change. As the charge on the condenser changes, the grid voltage continues to change in the same direction but at a much lower rate. Thus, the plate current of the amplifier tube increases suddenly when the light beam falls on the phototube and then increases at a lower rate to a still higher value.

The initial increase in plate current is set to be between the operating currents of the two relays connected in series in the plate circuit. These relays control the operation of the balancing motor. The motor operates in one direction if both relays are open and in the other direction if they are both closed. If one relay is open and the other closed, the circuit is balanced and the motor does not operate.





Figs. 10 and 11—Simplified circuit (left) to show the fundamental operation of the Weston photoelectric potentiometer and the actual circuit used in the commercial model (right). A variable current is passed through the standard resistor R_1 to balance the input voltage. A non-restoring mirror galvanometer deflects a light beam from one phototube to the other to change the plate current of the amplifier tube to maintain a balanced condition. The commercial instrument is a-c operated

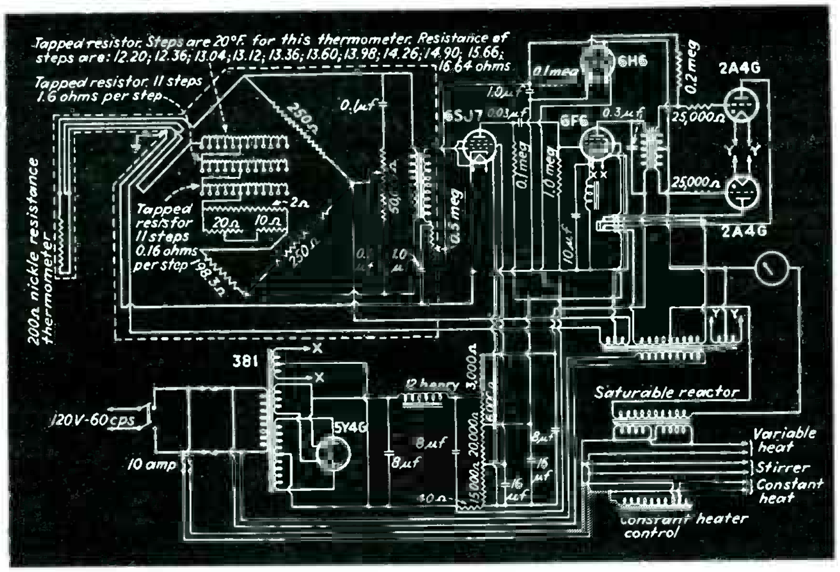
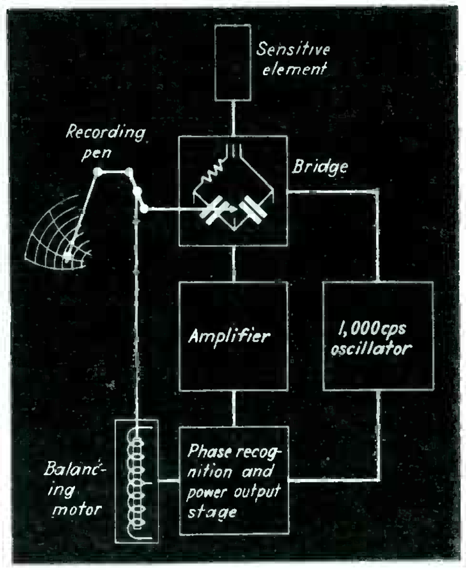


Fig. 12—Circuit diagram of the precision temperature controller constructed by the Shell Development Co. Any unbalance voltage in the bridge circuit caused by a change in resistance of the nickel thermometer is changed in phase and fed to the thyratron control circuit and then to the saturable reactor which controls the application of heat

Fig. 13—The sensitive element (resistance thermometer) of the Foxboro recorder is part of a bridge circuit having two resistance arms and two capacitance arms. If the bridge is unbalanced the voltage output is amplified and fed to a solenoid balancing motor which drives the recording mechanism and rebalances the bridge



Assume that the circuit is unbalanced and that the motor is driving the contactor and recording pen upscale. The galvanometer deflects the light beam off the phototube and both relays are open. An "advancing emf" is applied to the galvanometer so that the light beam reaches the controlling edge before the motor reaches the balance point. This is done to avoid overshooting the balance point. As the light beam enters the edge of the phototube, one of the relays closes and removes the advancing emf from the galvanometer causing it to stop quickly with a minimum of overshooting, and applies a braking current to the motor. Sometimes the motor stops before it reaches the balance point and the light beam swings back off the phototube. The motor then takes small forward steps until the balance point is reached. If the potentiometer becomes unbalanced in the other direction, the light beam moves onto the phototube until the entire beam strikes it. Then both relays close and the motor drives down scale and the same sequence of operations takes place in reverse.

Tagliabue has also developed an indicating controller using the same principle outlined above with the difference that the balance point may be set at any desired point on the scale and the instrument always balances to that point. Relays are used in this instrument to control the heat input to the unit being controlled rather than to drive the motor. A photograph of this instrument is shown in Fig. 7.

The Leeds and Northrup Co. and the Brown Instrument Co. use the unbalance voltage of the thermocouple and the potentiometer to operate the control circuit directly. In the L & N instrument the unbalance voltage is converted to an a-c voltage which is then amplified and delivered to the balancing motor. Speed control is provided by a magneto tachometer driven by the motor. The speed control is such that the speed of the motor is proportional to the unbalance of the system and it is necessary to avoid overshooting the balance point and causing the system to oscillate or hunt. The circuit is shown in Fig. 8. The d-c unbalance voltage between the thermocouple and the potentiometer is converted to an a-c voltage by means of a carbon microphone alternately compressed and released at 60 cps. The converted voltage is fed through a step-up transformer to the voltage amplifier and then to the thyratrons. Depending upon the phase, one or the other of the thyratrons will fire and drive the balancing motor in the proper direction to rebalance the circuit. The anodes of the thyratrons are connected directly to the two field windings of a d-c series wound commutator motor. The a-c component should be in phase with or 180 degrees out of phase with the anode voltage for proper operation. The tachometer voltage is introduced into the circuit so that the speed of the motor is controlled to maintain the sum of all three voltages in the circuit at zero. The Brown instrument is described in ELECTRONICS for August 1942, page 92.

In the photoelectric potentiometer manufactured by Weston Electrical Instrument Corp. a variable current is passed through a fixed resistor, the voltage drop across which is used to balance the input voltage (Figs. 10 and 11). In temperature measurement or control the input voltage would be provided by a thermocouple or a resistance thermometer with a Wheatstone bridge. The plate current of a pentode amplifier tube is passed through a standard resistor in opposition to the input voltage. When the two voltages are balanced the galvanometer (of negligible restoring torque) is undeflected. If unbalance occurs the galvanometer deflects and its mirror reflects a light beam to one of two phototubes through a system of prisms. The phototubes act as variable resistances in the grid circuit of the pentode amplifier tube to vary the grid

(*Continued on page 94*)

SPECIAL WELDING

Controlling small, bench-type spot welders . . . Designing controls for welders operated by high voltage power supplies . . . Handling series-capacitor power-factor corrected welders . . . Weld recorders and lock-out controls . . . Auxiliary program timing and heat controls

By M. E. BIVENS

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THE controls described in Parts I and II of this series provide control functions meeting the general demands of a-c resistance welding. There are, however, many applications which warrant or necessitate further diversification of design. For example, a variety of controls is required to meet the different conditions incidental to the resistance welding of materials ranging from 0.003 inch wire to 1 inch plate. Some of these controls are such that the welding current flow is less than one cycle; in others the current flow may be several seconds. In addition, some controls must be small and compact and, therefore, of limited capacity, while others may be operated from a 2300-volt power supply system or may be used with a power-factor corrected welder.

Controls for Small Welders

Small welders, such as bench welders for spot welding small parts may require either a large demand current for a portion of a half-cycle, or a comparatively small current of a few cycles duration. In the first case, half-cycle welding controls which include an ignitron fired to apply a single unidirectional impulse of welding current from the a-c power supply may be used. Heat control by the phase-shift method provides what is designated as a half-cycle of welding current, but which may be pre-adjusted to be from about 20 to 300 electrical degrees wide at the base of the current wave, depending upon the heat setting.

The schematic circuit of a half-cycle bench welder control which employs capacitor firing of the ignitron and which includes heat control is shown in Fig. 1. A charged capacitor is discharged through the ignitron ignitor at a definite instant during the power-supply voltage wave to initiate the single unidirec-

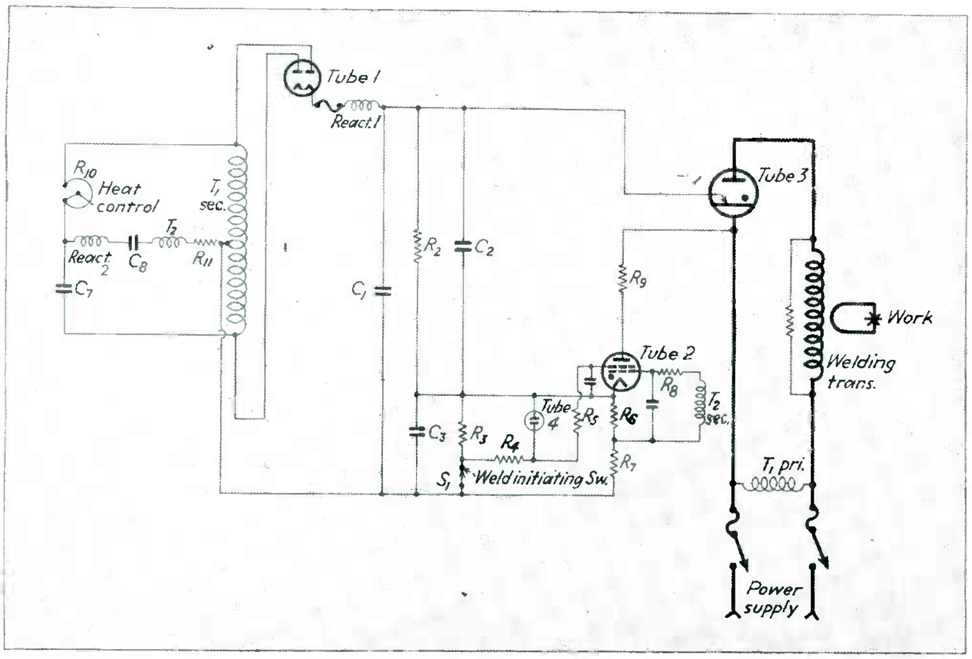

Fig. 1—Circuit of one-half cycle welding control having heat control

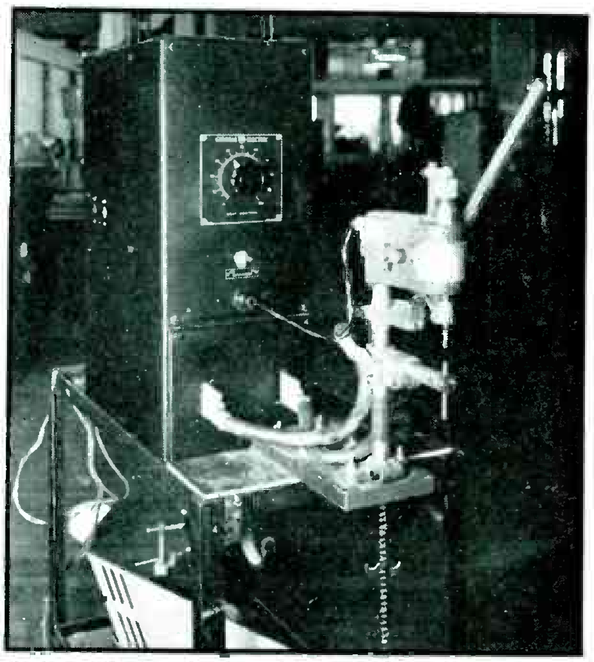

Fig. 2—Typical one-half cycle welding control with heat control

CONTROLS . . . . PART 3

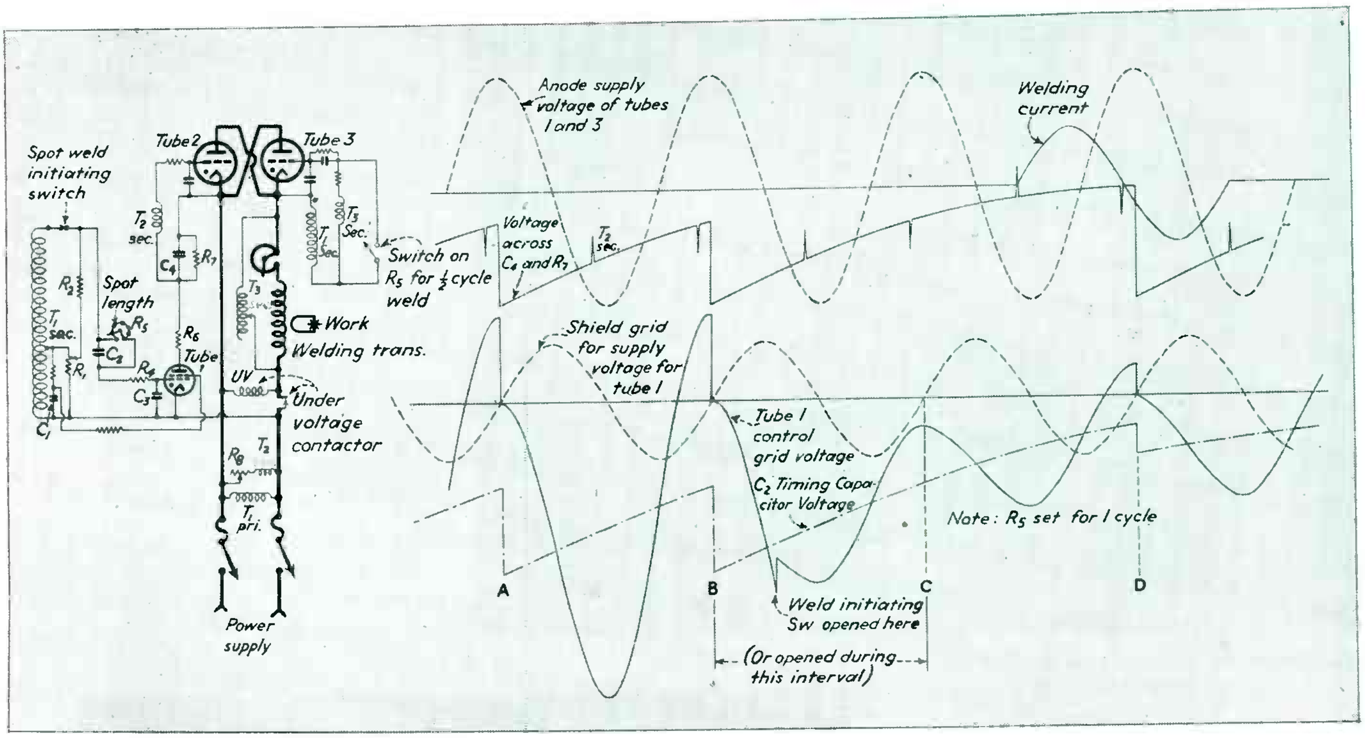

Fig. 3—Schematic diagram of spot-welder control for small welders, with waveforms

tional welding current impulse.

The voltage distribution of the rectified d-c control voltage across resistors R_2 and R_3 is such that most of the direct voltage is applied to the large capacitor C_2 and as a positive anode voltage for the firing tube 2. Capacitor C_2 normally has a large charge for firing the ignitron tube 3, the charge being released by the firing tube. Part of the direct voltage across the small capacitor C_3 is applied as a negative control grid bias on the firing tube. A peaked triggering voltage from transformer T_2 overcomes the control grid bias and attempts to trigger the firing tube in accordance with the heat control setting of the adjustable rheostat R_{10}. Tube 2 is prevented from firing by the negative shield grid voltage across the voltage limiting tube 4.

Opening the weld initiating switch S_1 removes the negative shield grid voltage and permits the control grid to trigger the firing tube when the next positive peak of control grid voltage occurs. The discharge of the firing capacitor C_2 through the power tube ignitor and tube 2 initiates the half-cycle of welding current. Following the discharge of C_2, the anode voltage of the firing tube is substantially zero and most of the d-c control voltage exists across C_3. The firing tube control grid is thereby biased sufficiently negative so that the peaked grid voltage from T_2 can no longer trigger the tube and no further operation occurs.

Releasing the weld initiating switch first applies a negative bias to the shield grid and then capacitors C_2 and C_3 immediately regain their normal charges. Thereby, anode voltage is again applied to the firing tube and the peaked voltages from T_2 attempt to trigger the firing tube, which remains non-conductive because of the negative shield grid voltage. In this manner, the welder applies a single unidirectional impulse or half-cycle of welding current each time that the weld initiating switch is opened. The purpose of the voltage limiting tube 4 is merely to limit the negative shield grid voltage applied to tube 2 at the instant the initiating switch is released. A typical half-cycle welding control, which includes a welding transformer, is pictured in Fig. 2.

The essential circuit of another spot welding control for small welders is shown in Fig. 3. This control uses hot-cathode power tubes (thyratrons) but is adjustable for timing spot welds of several cycles duration. It will be observed that the conventional rectified d-c supply for the control timing circuit is not required.

Tube 1 is the timing tube which normally charges its timing capacitor C_2 synchronously and the grid biasing capacitor C_4 for the leading power tube 2. The a-c anode and control grid voltage supplies for tube 1 are applied with polarities to make the anode and grid positive during the half-cycle when the anode voltage of the leading power tube 2 is negative. The shield grid voltage supply for tube 1 lags the anode voltage approximately 90 deg., so that tube 1 charges capacitors C_2 and C_4 during the crest of the positive half-cycle of its anode voltage, at instants designated as *A*, *B*, and *D* in the waveform sketch. The time constants of the charging circuits of C_2 and C_4 are a fraction of a millisecond. The time constant of the discharge circuit of the biasing ca-

Fig. 4A—Installation of spot-welding controls operating bench-welders

especially designed for small welders, it is provided with time adjustments for ½-cycle and from 1 to 10 cycles in full-cycle increments. The ½-cycle adjustment is the same as the 1-cycle spot length timing except that the trailing power tube is prevented from operating. An installation of controls being used for timing bench welders is shown in Fig. 4A while Fig. 4B shows one of another group of these controls with cover removed. The lower compartment or sub-base of the enclosing case is provided only for the purpose of enclosing the small welding transformer and heat-control rheostat. The upper part of the enclosing case which encloses the spot welding control may be reassembled for mounting directly beneath the bench.

High-voltage Controls

In contrast with the electronic welding controls just described, there are spot, seam, and pulsation welding controls for operating large

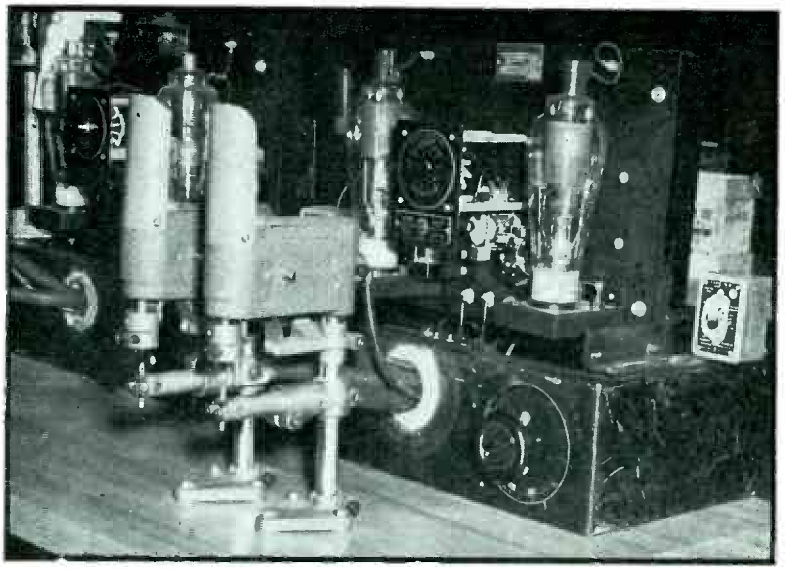

Fig. 4B—Typical spot-welding control, shown with cover removed

pacitor C_4 is approximately 1 cycle. The time constant of the discharge circuit of the timing capacitor C_2 is one cycle plus the spot length time setting of R_5. The phase of the peaked voltage furnished by transformer T_2 is adjusted by means of resistor R_8 to trigger the leading power tube at the power-factor angle of the welder, approximately one and one half cycles after the last synchronous charging of the timing capacitor C_2 and biasing capacitor C_4.

It will be observed that normally the timing tube synchronously and continuously initiates the first cycle of timing, but, because of one and one half cycles delay in the starting of the leading power tube 2, no welding current is initiated and the timing capacitor and biasing capacitor are recharged at a definite instant during each cycle.

Opening the spot weld initiating switch between points *B* and *C* of the waveform sketch prevents the timing capacitor C_2 from being recharged and causes the grid of the timing tube to remain negative with respect to its cathode because of the charge on C_2. This also prevents the biasing grid voltage being replenished on the leading power tube, which is triggered by the first positive peaked voltage from transformer T_2 that occurs after point *C*. This peaked voltage occurs at the power-factor angle of the welder. The grid of the leading power tube is triggered during each positive half-cycle of its anode supply voltage until the charge on C_2 decreases sufficiently to allow the timing tube 1 again to establish synchronously a high negative grid bias on the grid of the leading power tube. For a one-cycle spot weld, this occurs at point *D*. Tube 3 trails tube 2 in the manner explained in Part I.

Since this spot-welding control is welding transformers directly from high-voltage power supplies such as 2300 volts. The principal design features differentiating these control panels from those described in Parts I and II are the following: High-voltage insulation is provided between all circuit parts of the two firing tube circuits and between all parts of these circuits and ground. Firing tubes having higher voltage rating are used, and negative d-c hold-off grid-bias voltages, instead of a-c bias voltages, are applied to the grids of the firing tubes.

High-voltage controls are required for controlling series-capacitor power-factor corrected welders as shown in Fig. 5. This application involves several operating conditions and problems not encountered in ordinary applications of resistance welding controls. Capacitors are sometimes connected in series with the primary of the welding transformer to reduce the demand current drawn by large welders[1]. The capacitive reactance of the series capacitor neutralizes the inductive component of the welder impedance so that the resultant impedance of the combination is near unity power factor.

The application of series-capacitor power-factor correction to welding transformers requires proper coordination in the selection of the capacitor size and in the design of the welding transformer primary. Although the power-supply voltage may be regarded as low voltage, 460 volts, for example, series-capacitor power-factor correction may provide relatively high voltage, of the order of 1500 volts on the primary of the welding transformer. This requires a high-voltage primary and usually dictates the use of the high-voltage type of control panel. Giving due consideration to all design factors involved in a given application, series-capacitor power-factor correction provides a means of delivering the required welding transformer secondary current while drawing a smaller demand current from the power supply than would be drawn by a welder not designed for power-factor correction. The power supply furnishes only the energy component of the kva input to the welder, and voltage regulation of the power supply feeders is reduced to a minimum.

If the power factor is corrected to unity, the welding transformer primary current for the full heat phase-control setting is a sine wave in phase with the power supply voltage. In that case it is necessary to trigger the firing tubes and fire the ignitrons at the instants when the instantaneous value of the power-supply voltage is zero, or near zero. Therefore, in order to start up the control for welding at the full heat setting, it is necessary to either precharge the series capacitor or to make a preliminary welding operation on scrap material at a reduced heat setting to charge the series capacitor. At the end of each half-cycle operation of either power tube, the series capacitor is left charged with the correct magnitude and polarity to provide anode voltage for the next firing tube and power tube to be operated, even at the instants they are to be fired at the full-heat setting. At the end of each spot weld or current impulse, the series-capacitor is left charged and adds to the power supply voltage, insuring that the leading power tube for the next welding current impulse will be provided with anode voltage for operation even though the instantaneous value of the supply voltage may be low.

In the case of series capacitor power-factor correction, it is also necessary to shift the phase-controlled peaked grid voltage (heat control) to trigger the firing tubes over a different range, thus making it possible to obtain heat control over the conventional current range. The d-c hold-off grid bias is very desirable for holding the firing tubes non-conductive during parts of a cycle where the series-capacitor provides anode voltage, but where an a-c grid bias would be low. This insures that the tubes will be rendered conductive only by the phase-controlled peaked component of grid voltages furnished by the peaked voltage transformer T_2 in Fig. 5. Furthermore, considering firing tube 5 and its associated grid circuits for example, the peaked grid voltage for triggering the firing tubes at the phase-controlled full-heat setting occurs near the zero point of the power-supply voltage wave where there is a high value of d-c hold-off grid bias. Therefore, the turn-on component of grid voltage for elevating the peaked triggering voltages from transformer T_2 is provided by charging capacitor C_{12} during the preceding half-cycle when the a-c component of firing-tube anode voltage is negative. The discharge of capacitor C_{12} through resistor R_{18} during the following half cycle elevates the peaked grid voltage from T_2 to trigger the firing tube during the operating half-cycle of the supply voltage. The charging of capacitors C_{12} and C_{13} is controlled by control tube and timing circuits that trigger the firing tubes in accordance with the desired weld timing intervals.

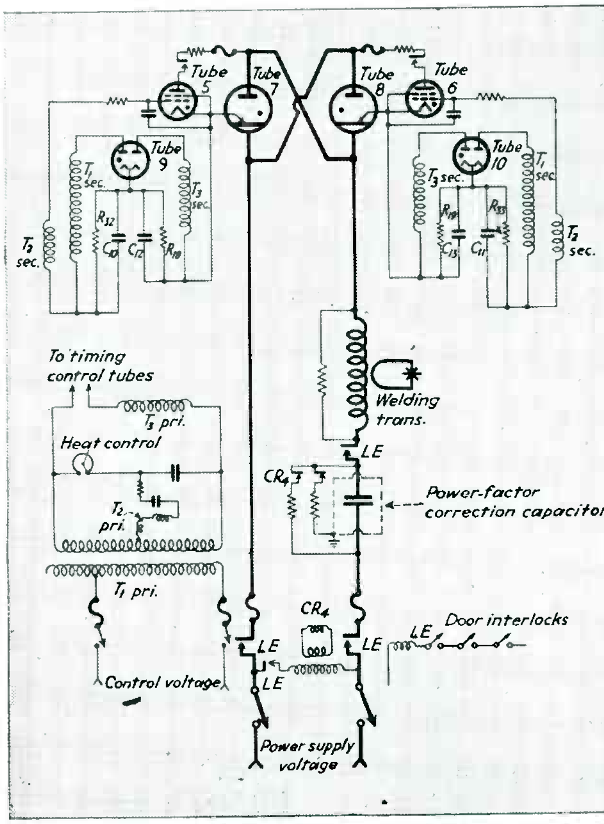

Fig. 5—Firing tube and power tube circuits of controls for high-voltage or series capacitor power-factor corrected welders

The control tube and timing circuits involve varieties of circuits for spot, seam, and pulsation welding, similar to those described in Parts I and II of this series.

Weld Recorder and Lock-out Controls

When a welder and its control are operating on a production line and adjustments have been made to provide the correct amount of welding current and the correct timing, the quality of the weld still depends upon the maintenance of normal conditions. Part II of this series de-

PUBLISHED

Spot Welding Controls (August, page 36)

Seam and Pulsation Welding (September, page 55)

SCHEDULED

Sequence Control Methods

Energy Storage Controls

Checking Welding Controls

scribed automatic heat-adjusting controls which insure that the chosen value of welding current is maintained in spite of variations of several factors that would otherwise affect the welding current. In cases where highest quality welds are of vital importance, and where maintenance of the normal value and duration of welding current within close limits must be assured, the weld recorder is used as a means of automatically comparing the product of current squared and time for each weld.

The heat input to a resistance weld may be expressed in terms of I^2RT where I is the welding current, R is the resistance of the work, and T is the duration of welding current. For a given set-up, the resistance of the work remains substantially the same for each weld, if the condition of the parts or work is properly controlled, so the heat input to the weld is proportional to I^2T. The weld recorder[2] is an instrument having a meter movement which produces a deflection proportional to the quantity I^2T where I represents the magnitude of the welding current and T its duration. It is thus an ampere-squared second-consistency indicator.

When a welding set-up has been completed to produce good welds under normal operating conditions, the weld recorder sensitivity control is adjusted to produce a definite deflection to indicate the normal value of I^2T for each weld. This deflection is recorded on a strip paper chart and if the deflection is less than, or exceeds, certain limits on the print bar, a contact is momentarily closed to initiate additional control circuit operations, such as ringing a gong and preventing further welding until the controls are reset. The gong ringing and the necessity of resetting the controls serves warning that the operation of the equipment should be checked.

A gong and lock-out control circuit, and a portion of the weld recorder circuit, is shown by Fig. 6. The operation of the weld recorder as an ampere-squared second-consistency indicator has been thoroughly explained in the article referred to in the bibliography. For the application of this instrument to welding controls, it is sufficient to explain that immediately following a weld, the instrument pointer rests under the print bar at a position indicating the I^2T input to the weld. Relay CR_6 is de-energized and causes relay CR_8 to be energized momentarily. CR_8 causes the print bar to stamp the pointer deflection on the paper chart and the instrument pointer is then returned to the zero position. The instrument pointer serves as one side of the contact WR and the print bar, with an insulated segment, serves as the other side of this contact. The current transformer in the primary circuit of the welding transformer delivers a current to the weld recorder during each weld. By means of the current range switch and sensitivity control, the weld recorder is adjusted so that the instrument pointer rests under the insulated segment of the print bar immediately following normal welds. Therefore, contact WR is never closed during normal welding but is closed momentarily in response to incorrect values of I^2T input to a weld.

Since the weld recorder requires some current for its operation, it does not respond to complete failures of welding current. The control circuits are arranged, therefore, so that during each weld, the weld initiating circuit is prevented from initiating another welding current impulse unless the weld recorder registers a correct weld.

Preceding a weld, only relay CR_5 is energized. When the spot-weld initiating switch is closed, relay CR_1 picks up and initiates the spot-welding control circuits and seals in through its own contact as long as the initiating switch remain closed. Relay CR_1 also energizes the gong and relay CR_4, which seals in through the CR_5 contact. The CR_4 normally closed contact in the initiating circuit will prevent any additional welds being made unless relay CR_4 is reset by CR_5. This means that some welding current must flow to cause CR_8 to drop out CR_5 and CR_4 or the gong continues to ring and the spot-weld initiating relay CR_1 cannot again be operated unless CR_4 is reset by means of the reset push button. Following a weld, relay CR_8 drops out relay CR_5 which in turn drops out CR_4, permitting additional welds to be made as far as this portion of the control circuit is concerned. The weld recorder prints the value of I^2T and, under normal operating conditions, contact WR is not closed. If the I^2T input to the weld is abnormal, contact WR is momentarily closed, causing relay CR_3 to pick up and seal-in, which continues to ring the gong and energize the lockout relay CR_4 until the initiating circuit is reset.

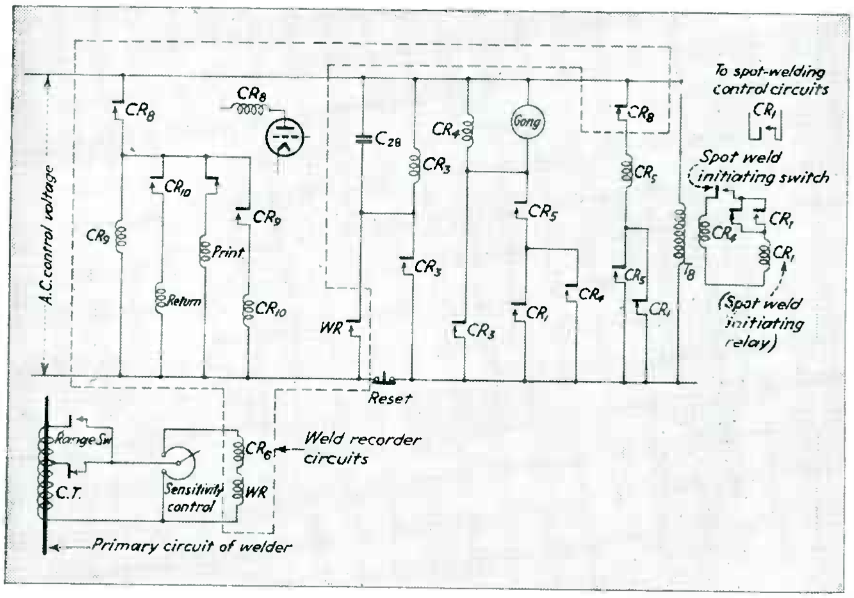

Fig. 6—Lock-out control circuits for weld recorder

Program Timing and Heat Controls

In some resistance welding applications, producing the highest quality weld involves a more complex process than previously described and requires special heat treatment of the work[3]. It may involve heat treating the work either before welding (preheat treating) or following the weld (post-heat treating).

Obviously there are definite advantages if the welding process requiring either preheat treating or post-heat treating can be performed as one continuous operation by means of welder current while the work is in a welding machine already equipped with a control capable of accurate timing and having phase-shift heat control. This is especially true in cases where the "cool" or "off" time between preheating and welding, or between welding and post-heat treating, is a factor affecting the quality of the weld.

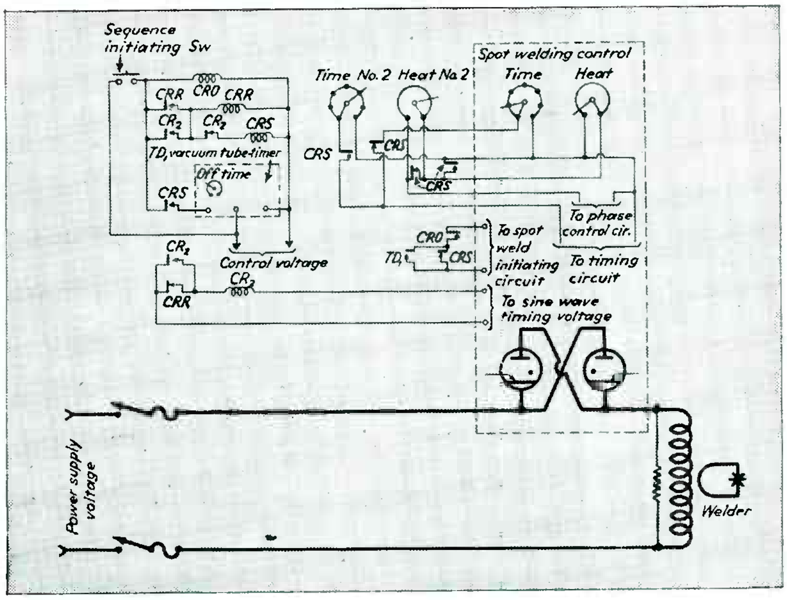

Fig. 7—Auxiliary control circuits for re-initiating spot-welder control for post-heat treating

By providing different timing intervals for the application of preheat current, welding current, off time, and post-heat current, and by providing different heat control settings for each of the current applications, the work can be caused to follow various temperature patterns. A simple auxiliary control circuit including additional time and heat adjustments can often be used to re-initiate a spot-welding control with selective time and heat settings for the different timing intervals and thus extend the use of the spot welding control to preheat treating or post-heat treating.

There are many variations of such control circuits but Fig. 7 shows a typical example. In this case the circuits shown consist of a welding transformer equipped with a precision spot-welding control having phase-shift heat control. The function of the auxiliary control is to cause the welder to be energized during two independently adjustable precision-timed intervals having independent heat settings and separated by a timed "off" period. Whether this involves preheat treating and welding, or welding and post-heat treating, depends upon the time and heat settings for the two welding current applications.

The operation of the control is as follows. Closing the sequence initiating switch initiates the spot-welding control, which operates in accordance with its time and heat settings. During this current application, the control circuit is energized causing relay CR_2 to energize relay *CRR*, which seals in through the sequence initiating switch and leaves CR_2 sealed in as long as the current application continues. At the end of the first current application CR_2 is de-energized and will not again be energized as long as the sequence initiating switch remains closed. When CR_2 drops out at the end of the first current impulse, relay *CRS* is energized and remains energized until the sequence initiating switch is opened. *CRS*, operating at the end of the first current application, initiates the "off" period timer and transfers the spot-welding control to the spot length time and heat settings of the auxiliary control. *CRS* also resets the initiating relay on the spot-welding control so that the next current impulse will be initiated at the correct instant during the supply voltage wave. The operation of the "off" period timer then re-initiates the spot-welding control for the second current application having independent timing and heat control. At the end of the second current application nothing further occurs until the sequence initiating switch is released. This resets relays *CRR* and *CRS* and allows CR_2 to be energized when the next sequence is initiated.

The application of similar auxiliary control circuits may be extended to provide various welding temperature patterns. More elaborate controls of special design have been built in experimental form to provide gradual variations in welding current during preheat treating, welding, and post-heat treating, and providing variations in timing patterns during each of the current intervals. These timing patterns may include pulsation welding at certain heat and cool intervals during preheat treating, spot weld timing for the weld, an off timing interval, and then pulsation timing at other heat and cool intervals during post-heat treating. Such controls are extremely flexible for providing various temperature patterns. It is preferable, however, that standard welding controls be used in conjunction with small auxiliary control attachments which also provide a large variety of temperature patterns for preheat treating, welding, and post-heat treating.

In many cases the auxiliary control can be applied to existing spot-welding applications and thereby greatly extend the utility of an existing installation if special temperature patterns are required for welding. If the spot-welding control is already equipped with a sequence control for pulsation welding, or if a pulsation welding control panel is being used, the design of the auxiliary control circuits is still further simplified.

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Reactance Tubes in F-M Applications

The behavior of reactance tubes, particularly with reference to their use in frequency modulation circuits is treated. Emphasis is placed on the physical operation of such tube circuits

By AUGUST HUND

Reactance tube circuits have the property of injecting reactances into associated networks. If the associated network is the frequency determining branch of a tube oscillator whose frequency is not stabilized, then the injected reactance may be used to change the frequency of the generated oscillations. But if the frequency is stabilized (as in a piezoelectric oscillator or in a carrier frequency amplifier which causes no appreciable back actions on the master oscillator) the injected reactance will cause a phase shift of the generated oscillations. Therefore, when the injected reactance varies, frequency modulation will be produced in the former case and phase modulation in the latter case.

The case of FM is of importance since some commercial f-m transmitters are based on reactance tube modulators and considerable frequency deviations can be caused directly with reactance tubes. Such tubes then provide convenient means for translating modulating voltages into proportional frequency variations. Since such tubes can also be employed for injecting fixed reactances into associated networks they are also used in some f-m transmitters for the stabilization of the center frequency of the master oscillator, whose frequency is being modulated.

It is the purpose of this article to bring out basic principles of reactance tubes and their actions on associated networks, especially with regard to their application in modulated oscillators or amplifiers.

Reactance Conditions in Tube Oscillators

Any oscillator which generates sustained oscillations of stable ampli-

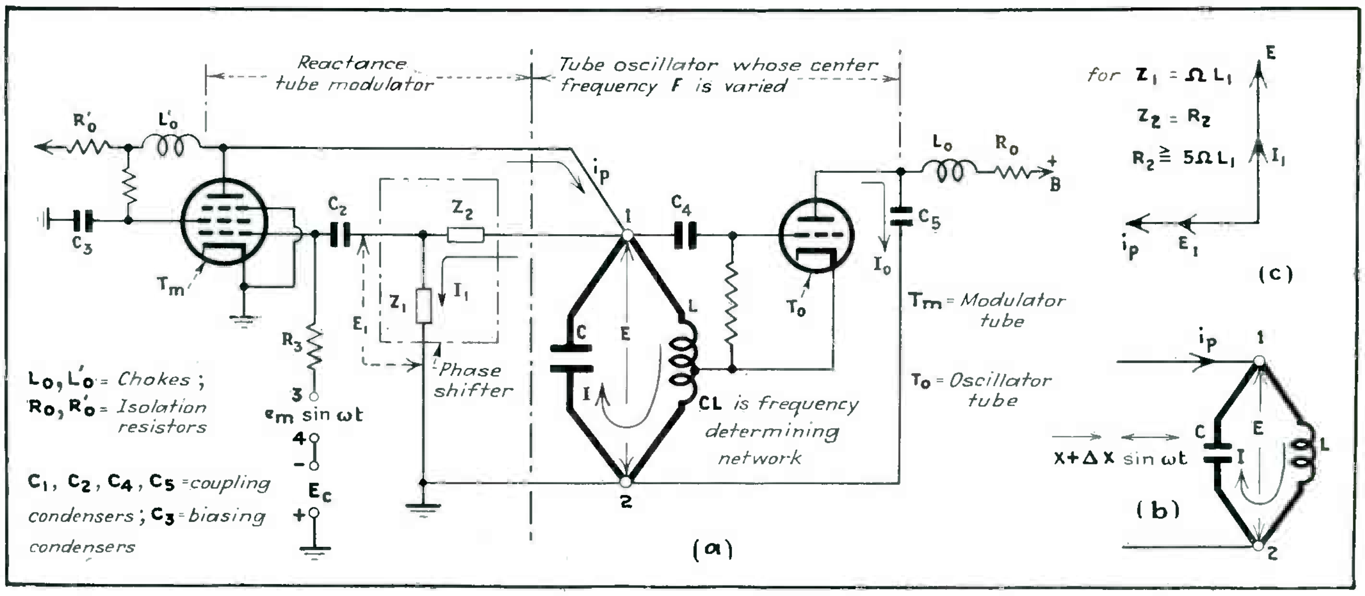

Fig. 1—Schematic wiring diagram of reactance tube modulator and associated oscillator tube. The assigned carrier frequency is $F = \Omega/6.28$; the modulating frequency is $f = \omega/6.28$

tude and fixed frequency, F, requires that the condition of energy balance as well as the condition of phase balance is satisfied. The former causes fixed amplitude of the generated oscillations, while the latter, which concerns us in this discussion, determines the frequency constancy. This can be readily understood from the actions taking place in customary tube oscillators, as is indicated in Fig. 1a for instance.

First let us examine the oscillator network to the right of terminals 1-2, where the tank circuit CL denotes the frequency determining branch associated with oscillator tube T_o. In case of sustained oscillations, both the driving dynamic voltage, E, and the circulating current, I, must have fixed amplitudes. Since the tank circuit CL also represents the plate load of the oscillator tube, oscillations remain sustained and of fixed amplitude only when the energy losses in this circuit are supplied through the coupling condenser C_5. The dynamic grid potential applied to the oscillator tube, T_o from the tank CL, over through the coupling condenser, C_4, must therefore trigger off such a dynamic plate supply current, I_o, that the amplitude of circulating current I remains sustained. This will satisfy the condition of energy balance.

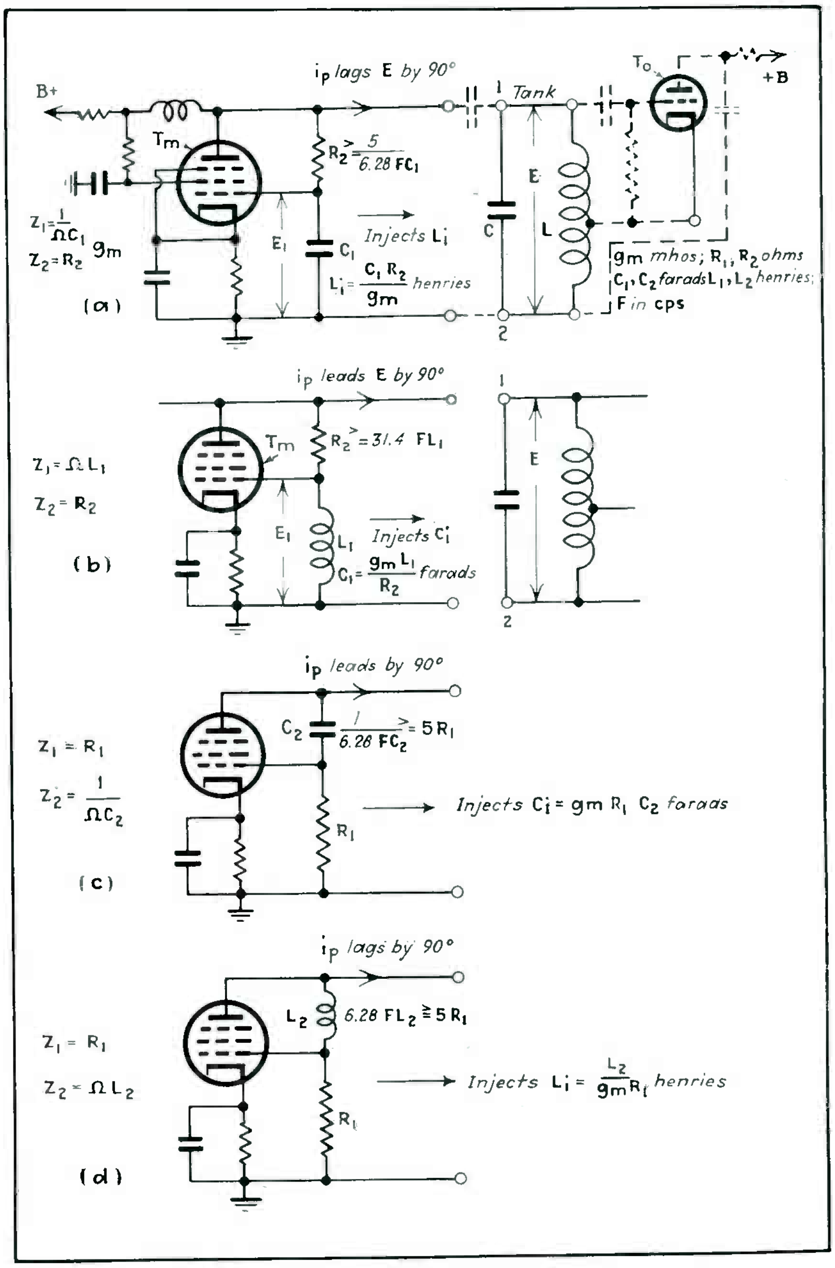

Fig. 2—Schematic wiring diagram of four types of reactance tube networks, with their design equations

Reactance Condition In Case of Current Resonance

Since the frequency of self oscillations, F, always assumes such a value that the total reactance around the 1-2-1 loop becomes zero, the value of F can remain fixed only when the original in-phase condition is preserved. This is readily understood from the following reasoning. Suppose the tank voltage E produces a grid potential such that the resulting dynamic plate current, I_o, leads the original dynamic supply current slightly. Then, each successive oscillation must also show a corresponding phase advance. The result is that the value of the oscillation frequency will be larger. In the same way when the I_o current lags the original dynamic supply current flowing through condenser C_5, each successive oscillation lags behind the preceding one slightly and the result is a lowering of the frequency F. Therefore, absolute frequency constancy requires that the grid voltage be 180 deg. out of phase with the dynamic plate voltage which causes the current I_o to flow since for such conditions the frequency F of the circulating current I is fixed.

Let us now consider the case indicated in Fig. 1b. The tank circuit CL is the same as in Fig. 1a except that the branch to the right of terminals 1-2 is of no concern in this discussion and, therefore, not shown. Looking into terminals 1-2 of Fig. 1b we have a network as in case of current resonance. For pure inductive and capacitive branches the total reactance across terminals 1-2 would be infinite in case of oscillations of natural frequency. Since any physical coil of effective inductance L_e has an effective resistance R_e, its impedance is of the form $Z = R_e + j\,\Omega\,L_e$ where $\Omega = 6.28F$. The reactance is proportional to the operating frequency F and L_e and may have a positive or a negative value depending on the magnitude of F. The resistive and reactive components of Z at any frequency are given by the expressions:

$$\left.\begin{aligned} R_e &= \frac{R}{[1 - \Omega^2 CL]^2 + \Omega^2 C^2 R^2} = \frac{R}{m} \\ X_e &= \Omega\,L_e = \Omega\left[\frac{L\,(1 - \Omega^2 C\,L) - C\,R^2}{m}\right] \\ &= \Omega\left[\frac{L - C\,(R^2 + \Omega^2 L^2)}{m}\right] = \Omega\, p/m \end{aligned}\right\} \quad (1)$$

The expression $Z = R_e + jX_e$ refers

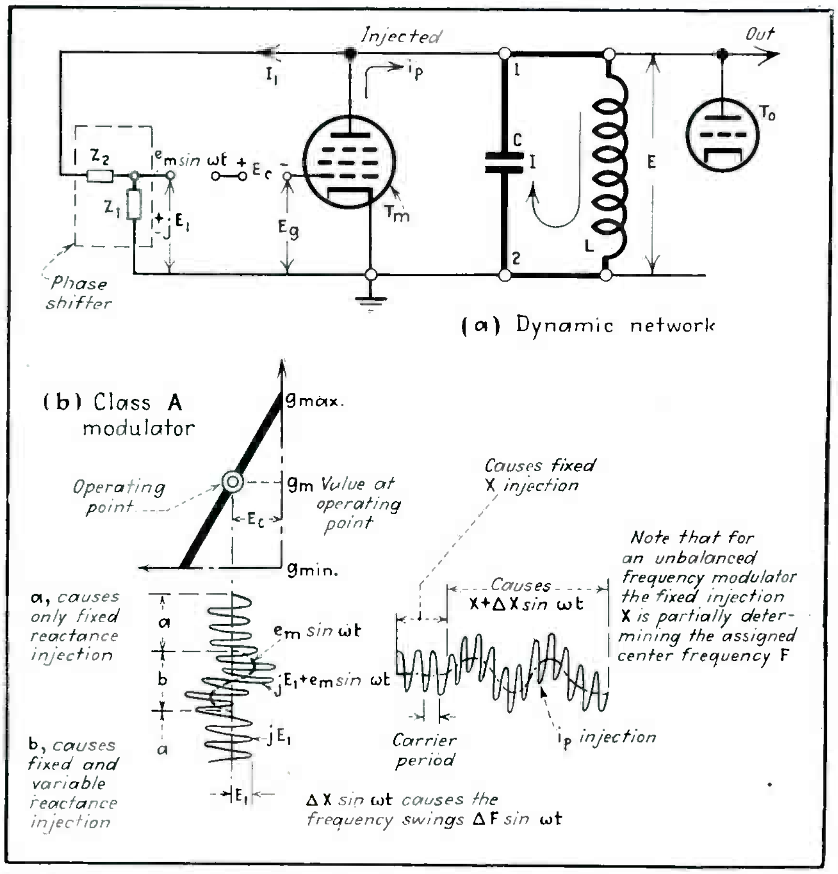

Fig. 3—Dynamic network of oscillator tube and reactance tube injector circuit (a), with wave forms of modulated and unmodulated signals illustrating variation of transconductance of modulator tube

to the equivalent resistance R_e and series reactance X_e when looking into the 1-2 terminals of the oscillator tank CL. We are only interested in the expression $X_e = p\Omega/m$ of Eq. (1) since for tube oscillations of natural frequency this reactance must vanish. This happens when p becomes zero, leading to

$$L = C\,(R^2 + \Omega^2 L^2) \qquad (2)$$

This is the exact expression required for tank resonance and shows that the impedance looking into terminals 1-2 of Fig. 1b is not infinite but has a finite value since

$$Z = \sqrt{\frac{R^2 + \Omega^2 L^2}{(\Omega RC)^2 + (\Omega^2 CL - 1)^2}} \qquad (3)$$

is the expression for the absolute value of the effective impedance of the parallel branches across terminals 1-2 holding for any frequency F.

Reactance Modulation

Of engineering interest in this discussion is, how the frequency, F may be varied by means of a modulating current or its corresponding voltage. Eq. (2) which is the criterion for zero reactance, that is, the natural frequency of oscillations, shows that we have three means of accomplishing this. One is by a change or variation of the value of C, the second by a variation of L, and the third by a variation in R. From a practical point of view, the latter variation is not as easy to accomplish as that in which either capacitance or inductance variations (in synchronism with a modulating current) may be injected across the terminals 1-2 of Fig. 1b.

From the discussion given above we learned that a leading current fed back through condenser C_5, in order to sustain oscillations (Fig. 1a causes an increase of the oscillation frequency F while a lagging current causes a somewhat smaller oscillation frequency. We have in the arrangement of Fig. 1b a means for changing the natural period of the CL-tank if we can inject a suitable current i_p into the tank circuit CL. It is to be realized that the current i_p now comes from a separate source rather than from the plate circuit of the oscillator tube T_o. When the current i_p of Fig. 1b is of same frequency as the tank voltage E but leading E by 90 time deg., then this injected current may be assumed as flowing through the capacitive branch since the original circulating current I is likewise leading E by 90 deg. in this branch. This means that the condenser branch carries more current than the inductance branch of the tank. This has the same effect as though the capacitance C had been increased to a value $C + \Delta C$ causing an oscillation constant $(C + \Delta C)L$ instead of CL. The result is that the tank in the oscillator branch of Fig. 1a will produce a current of frequency of $F - \Delta F$ rather than of F, where ΔF is the corresponding decrease in frequency produced by the injected current. On the other hand it is also possible to imagine that the 90 deg. leading i_p current flows entirely in the L branch of Fig. 1b which means that it is in antiphase with the original I-current in the L branch and, therefore, causes a smaller current in this branch than in the condenser branch. This is equivalent to saying that the effective inductance of this branch must have increased to a value $L + \Delta L$ causing an oscillation constant $C(L + \Delta L)$ which must be identical with the value of $(C + \Delta C)L$ in order to account for the same frequency change ΔF as above. Inasmuch as the first way is the more direct, the circuit may be considered to be changed by an amount ΔC and we may assume that a capacitance reactance X_c is injected across the capacitive branch of the tank.

In exactly the same way it is evident when we inject a current i_p which lags the tank voltage E by 90 deg. the result is equivalent to an inductive reactance injected across the inductive branch. If ΔL denotes the corresponding inductance variation which acts in parallel with a constant inductance L, the resultant inductance is $L_e = L\Delta L/(L + \Delta L)$ and the oscillation constant CL_e indicates that the oscillation frequency is increased to some value $F+\Delta F$. Hence, injection of a positive inductance ΔL across the 1-2 terminals causes an increase of oscillation frequency while injection of a negative inductance—ΔL causes a decrease in F. Hence, if ΔL sin $(6.28\ ft)$ is injected by means of a corresponding i_p current we have to deal with a corresponding reactance injection ΔX sin ωt which modulates the oscillation frequency sinusoidally. In a similar way, if ΔC sin ωt is injected across the terminals 1-2 of Fig. 1b we have likewise a reactance modulation.

Hence, in either case, whether

sinusoidal capacitive or inductive injections occur, we obtain sinusoidal frequency variations. When both sinusoidal capacitive and sinusoidal inductive injections of same respective maximum amplitudes are impressed across the 1-2 terminals simultaneously, the respective frequency excursions from the center frequency will be twice as large as that for either one alone. We have then the case of push-pull reactance injections.

From this discussion we note that for sinusoidal currents i_p of carrier frequency F which lead or lag behind the tank voltage E, by 90 deg. we have fixed frequency shifts of $\pm \Delta F$, respectively, from the natural frequency, F, of the oscillator tank. Since the i_p current which is injected can have a phase difference other than $\pm$ 90 time degrees with respect to the tank voltage E, such currents will inject equivalent impedances across the terminals 1-2.

Reactance Tube Modulators

Since it is good engineering practice to inject the i_p variations by means of a separate tube, such as the modulator tube T_m of Fig. 1a, the circuit performance is explained for a network as used in practice. In Fig. 1a it will be noted that the frequency determining network is part of the oscillator. Across the terminals 1-2 is connected a network which takes a comparatively small current I_1 from the tank circuit. The purpose of this current is to build up a suitable voltage $E_1 = Z_1 I_1$ across the shunt element Z_1 of a phase shifter Z_1, Z_2. This voltage is essentially applied across the control grid and cathode of the modulator or reactance tube T_m. The dynamic plate current i_p of the reactance tube is then equal to $g_m E_1$ and in phase with E_1 if g_m is the grid to plate transconductance of the reactance tube.

Suppose we desire to inject a fixed capacitance C_i across the condenser C. For such a requirement terminals 3-4 are shorted and only the varying voltage E_1 acts in the grid circuit of tube T_m. Since for a C_i injection, i_p has to lead E by 90 deg. the series element Z_2 of the phase shifter is an ohmic resistance R_2 which is at least five times the value of the reactance ΩL_1 formed by an inductance L_1 for the shunt arm Z_1 of the phase shifter. The voltage E_1 across this inductance is then 90 times degrees ahead with respect to the tank voltage E since for such relative dimensions of R_1 and ΩL_1 the small phase shifter current I_1 is essentially in phase with the driving voltage E. Since $i_p = g_m E_1$, the injected current i_p leads E also by 90 deg.

It is an easy matter to derive the formula for computing the injected fixed capacitance C_i in terms of known factors. Since E is the driving voltage for any currents flowing in the capacitance branch it must be also the voltage which drives the current i_p through the injected capacitance C_i. Hence, $E/i_p = 1/(\Omega C_i)$ and

$$\frac{E}{i_p} = \frac{E}{g_m E_1} = \frac{E}{g_m \Omega L_1 I_1} = \frac{R_2}{g_m \Omega L_1} \quad (9)$$

because E/I_1 is essentially equal to R_2 for $R_2 \geqq 5\Omega L_1$. We have then for the injected capacitance reactance

$$\frac{1}{\Omega C_i} = \frac{R_2}{g_m \Omega L_1}$$

and the design formula

$$C_i = \frac{g_m L_1}{R_2} \text{ farads} \quad (4)$$

if the grid-plate transconductance g_m of the reactance tube is in mhos, R_2 in ohms and L_1 in henries. In a similar way the other formulas given in Fig. 2 in connection with the reactance modulators are derived.

Any other types of phase shifters can be used in order to inject out-of-phase currents into the frequency determining network. It is not necessary at all that an electrical connection exist between the tube oscillator and the reactance tube modulator since out-of-phase currents can just as well be injected through magnetic coupling. In each case it is essential that the amplitude of the injected current be fixed so that no additional amplitude modulation occurs also.*

Fixed reactance injections have many applications. They are employed, for instance, for the stabilization of the assigned frequency in

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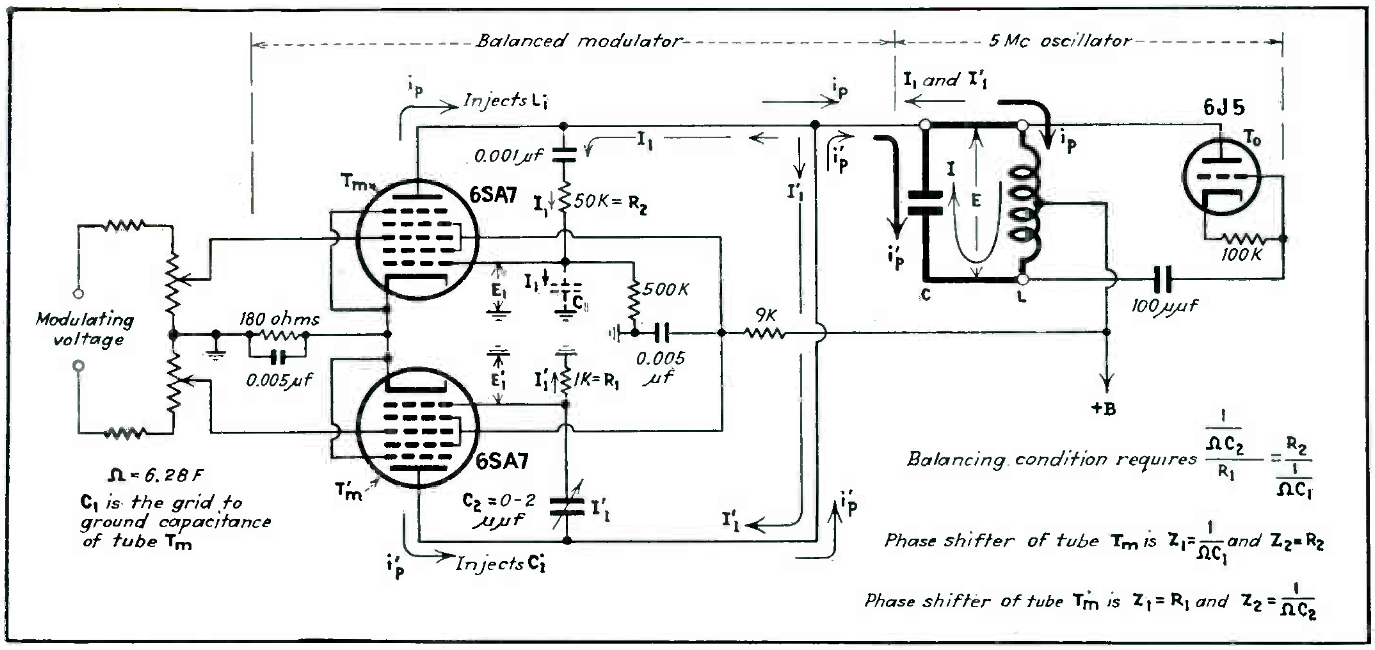

Fig. 4—Diagram of balanced modulator and oscillator tube to illustrate the current and voltage conditions which occur for a balanced modulator

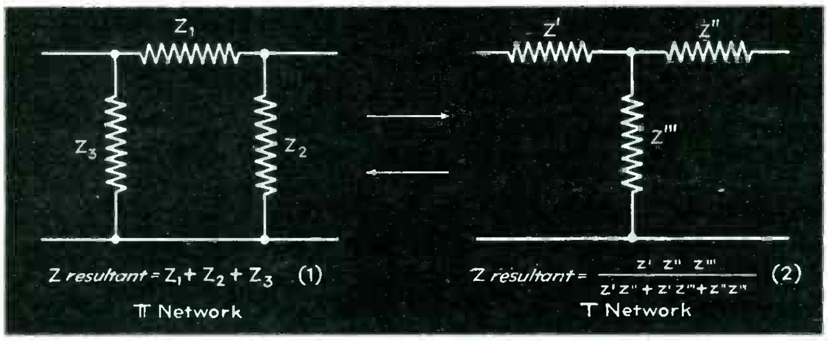

Fig. 1—The two networks with their equivalent impedances

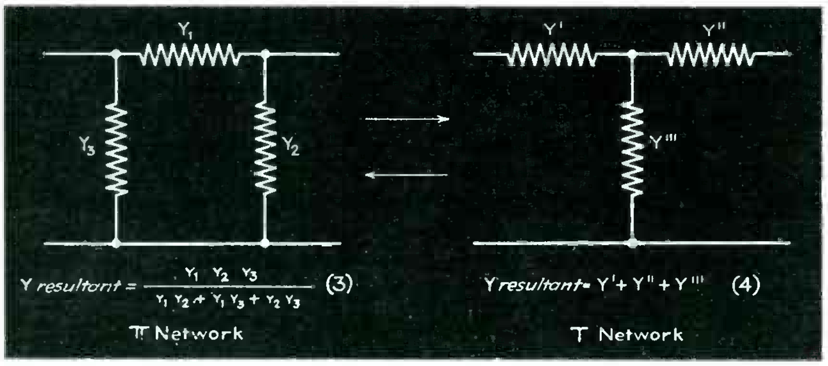

Fig. 2—The two networks and their equivalent admittances

"T" to "Pi"

By H. STOCKMAN *Cruft Laboratory, Harvard University, Cambridge, Mass.*

In communication work, as well as in power work, the transformation of a T network into a π network and vice versa is of great importance. The two networks are shown in Fig. 1 and the problem is simply to construct the equivalent T when the π is given or vice versa. The quickest way to perform the calculation is to use ready-made formulas. Usually students and engineers do not keep these formulas in mind, so there are two ways open; to derive the formulas or to look them up in a handbook. The latter way out usually means a considerable saving of time.

The formulas can be derived by the comparison of input impedances between specified terminals with the third terminal left free or connected to one of the input terminals. Three independent equations are needed for the determination of impedance relations.

Below the formulas are given as they usually appear in textbooks and handbooks.

Transformation π to T:

$$Z' = \frac{Z_3 Z_1}{Z_1 + Z_2 + Z_3}$$

$$Z'' = \frac{Z_1 Z_2}{Z_1 + Z_2 + Z_3}$$

$$Z''' = \frac{Z_3 Z_2}{Z_1 + Z_2 + Z_3}$$

Transformation T to π:

$$Z_1 = \frac{1}{Z'''}\left(Z' Z'' + Z' Z''' + Z'' Z'''\right)$$

$$Z_2 = \frac{1}{Z'}\left(Z' Z'' + Z' Z''' + Z'' Z'''\right)$$

$$Z_3 = \frac{1}{Z''}\left(Z' Z'' + Z' Z''' + Z'' Z'''\right)$$

If one formula is remembered for each direction of transformation, the remaining four formulas may be obtained by cyclic permutation, but there is still much to keep in mind.

A somewhat improved way of writing the relations is sometimes used. This involves working with admittances rather than impedances in the T circuit, using the notations Y', Y'', and Y''' instead of Z', Z'', and Z'''. The T to π formulas will then be of the same general form as the π to T formulas. Thus

$$\frac{1}{Z_1} = \frac{Y' Y''}{Y' + Y'' + Y'''};$$

$$\frac{1}{Z_2} = \frac{Y'' Y'''}{Y' + Y'' + Y'''};$$

$$\frac{1}{Z_3} = \frac{Y''' Y'}{Y' + Y'' + Y'''}.$$

In cases where mixed impedance and admittance expressions are not desirable, this way of writing is of interest only as a help in memorizing the formulas.

The author has found a form of writing the relations which is fairly simple to remember and works in the π to T direction as well as in the T to π direction. The student or engineer must know the simple equations in Fig. 1 for the resultant impedance of three impedances in series and for three impedances in parallel. (The parallel combination of the three impedances in the T network is not complete, but it is evident that Eq. (2) belongs to the T network and Eq. (1) to the π network.) The only formula to be remembered then is

$$Z = \frac{Z_{left} \times Z_{right}}{Z_{resultant}}, \qquad (3)$$

where Z is any one of the three impedances to be determined, Z_{left} and Z_{right} are the impedances on the left hand and on the right hand in the *known* network, and $Z_{resultant}$ is the resulting impedance in the *known* network. A few examples will show the simplicity of the transformation when the new formula is used.

Example. Transformation π to T. Find Z'':

$$Z'' = \frac{Z_{left} \times Z_{right}}{Z_{resultant}} = \frac{Z_1 Z_2}{Z_1 + Z_2 + Z_3}$$

Example. Transformation T to π. Find Z_3:

$$Z_3 = \frac{Z_{left} \times Z_{right}}{Z_{resultant}} = \frac{Z' Z'''}{\dfrac{Z' Z'' Z'''}{Z' Z'' + Z' Z''' + Z'' Z'''}}$$

$$Z_3 = \frac{1}{Z''}\left(Z' Z'' + Z' Z''' + Z'' Z'''\right).$$

A check of the available handbook formulas shows that the expressions obtained are identical with these formulas.

The transformation can be performed with admittances as easily as with impedances. Equation (3) is then written

$$Y = \frac{Y_{left} \times Y_{right}}{Y_{resultant}} \qquad (4)$$

and all impedance notations in Fig. 1 are replaced by admittance notations (see Fig. 2).

If the impedance Eq. (3) is used for π to T and the admittance Eq. (4) for T to π transformation, the "resultant" expression will be of simple form.

One advantage of using indexes "left", "right" and "resultant" is

Transformations Simplified

that the transformation will be independent of notations. Thus any system of notations of the type Z_1 may be used in combination with any system of notations of the type Z'—if, now, notations are needed.

Equations (3) and (4) are so simple that any student or engineer, who has once used them, finds it almost impossible to forget. The formulas have proven to be very efficient in practice. Once used to, the engineer will find that it is quite unnecessary to draw T and π symbols and to write down expressions for resulting impedances or admittances since the answers can be written directly. In fact the transformation is so easy that the engineer does not have the feeling of using a formula at all.

To show the importance of T to π transformations in radio engineering and demonstrate the use of the left-right rule, two problems are given below.

Problem 1. In the high-frequency amplifier shown in Fig. 3 critical coupling is obtained in the band filter for a certain value of the coupling condenser C. Determine this value of C for an input frequency $f = 75$ kc. (At this frequency stray admittance may be neglected.) Given are $L_1 = L_2 = 2000$ μh, $R_1 = R_2 = 6.5$ ohms and $R_g = 100{,}000$ ohms. The loading effect of the amplifying tube may be neglected.

Solution:

$$\omega = 2\pi\, 75 \times 10^3 = 471 \times 10^3$$
$$\omega^2 = 22.2 \times 10^{10}$$
$$X_L = \omega L = 942$$
$$X_L^2 = 8.87 \times 10^5$$
$$C_1 = C_2 = 1/\omega^2 L = 2250\ \mu\mu f$$
$$R_g' = X_L^2/R_g = 8.87 \text{ (a useful rule if } R_g \gg X_L)$$

If we redraw the diagram as shown in Fig. 3B and replace the π C_1C_2C by the T $C'C''C'''$, we obtain the circuit shown in Fig. 3C. Following the left-right rule in impedance form, Eq. (3) we obtain

$$Z''' = \frac{Z_1 Z_2}{Z_1 + Z_2 + Z} = \frac{1}{j\omega C'''}$$

where $Z_1 = 1/j\omega C_1$, $Z_2 = 1/j\omega C_2$ and $Z = 1/j\omega C$. For $C_2 = C_1$ the expression reduces to

$$C''' = 2C_1 + \frac{C_1^2}{C}$$

At critical coupling the optimal value of the coupling reactance is

$$\left|jX_{opt}\right| = \sqrt{R_1\,(R_2 + R'_g)} = 10 \text{ ohms} = \frac{1}{j\omega C'''}$$

C is then obtained from the expression for C''' above and comes out approximately $C = 24$ $\mu\mu f$. The equivalent circuits and the coupling network are shown in Fig. 3.

Problem 2. Draw the equivalent circuit of the video amplifier shown in Fig. 4 and replace the network so obtained by a T network, treating

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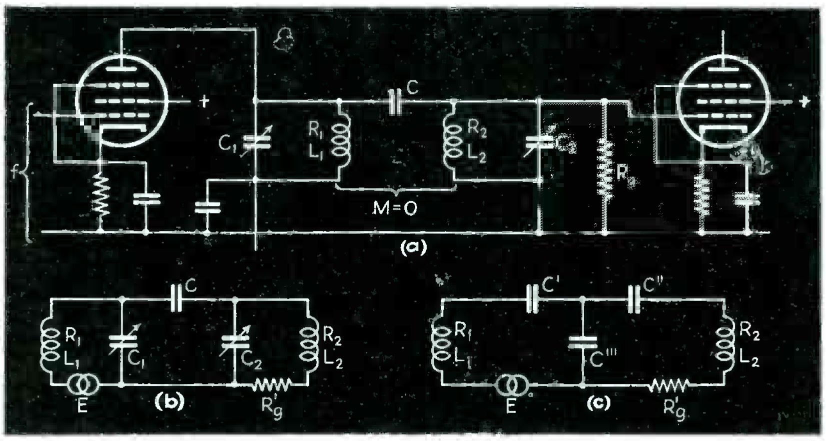

Fig. 3—Schematic diagram of high frequency amplifier. The problem is to determine C for critical coupling

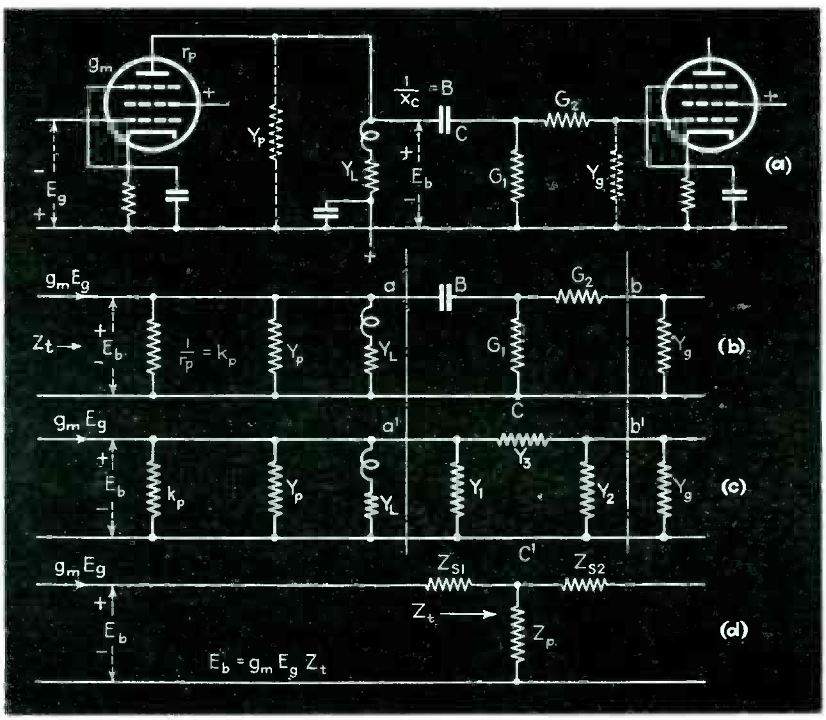

Fig. 4—Diagram of video amplifier. The equivalent T network of the amplifier, shown at (d) is to be determined

ELECTRONIC COUNTER For Rapid Impulses

By BERTRAM WELLMAN and KENNETH ROEDER

Tufts College, Massachusetts

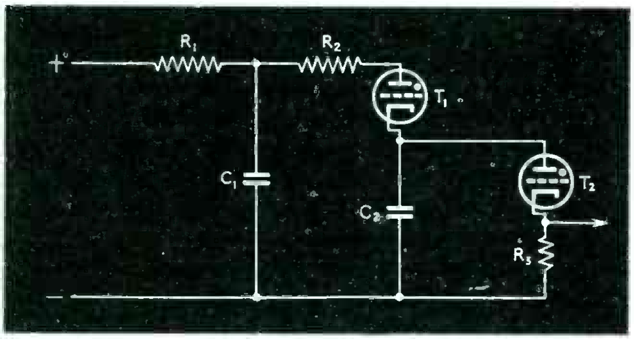

Fig. 1—Original circuit requiring a bias battery

IN a biological study of the spontaneous activity of nerves, it was necessary to obtain a continuous count of action potential spikes at rates of several hundred per second over periods of many hours. These action potential spikes are electrical discharges at the surface of single nerve fibers during activity. Their magnitude is typically a few millivolts, with a duration of less than a thousandth of a second. An electronic counter was constructed which employed two thyratrons to scale down the counting rate so that ordinary mechanical counters and recorders could be used. This electronic counter may find other applications where a relatively inexpensive means of obtaining a continuous count of rapid impulses over long periods is desired. In this study, a counting ratio of 300 to 1 proved convenient. Thus when pulses occur at a rate of 600 per second, the apparatus actuates a relay or counter twice a second. Other counting ratios may be obtained by varying the circuit constants.

A schematic diagram of the circuit is shown in Fig. 1. The small condenser, C_1, is charged from the power supply through R_1. The impulses to be counted are amplified and impressed on the grid of the thyratron T_1 with positive polarity. Thus C_1 partially discharges through T_1 at each impulse. The thyratron is usually considered to be a tube in which a negative grid potential can prevent the plate current from starting, but cannot stop the flow of current once it has started. While this is true for large currents, the grid is actually able to interrupt very low values of current. We have found that a value of 200,000 ohms for R_1 is high enough to insure that discharge current will become small enough to be stopped by the negative grid. R_2 is inserted to limit the discharge current to the safe rating of T_1. Each time that C_1 discharges the charge flows into C_2 which is a much larger condenser. As successive charges accumulate on C_2, its potential increases until the breakdown voltage of the second thyratron, T_2, is reached. The breakdown voltage of T_2 is determined by its grid bias, which may be varied to determine the counting ratio, or number of input impulses for each output impulse. The cathode voltage of T_2 may be applied to the grid of a vacuum triode which will operate a relay, mechanical counter, or other recording device.

The circuit in Fig. 1 was used in the first counters constructed, but it is open to one objection. The grid bias of T_1 had to be obtained from a battery connected to its cathode, while a transformer was used to produce the signal on the grid. The modified circuit, shown in Fig. 2, requires no bias battery, and is completely a-c operated. In this circuit C_2 is charged from the power supply through T_2 and loses a small part of its charge to C_1 each time an impulse reaches the grid of T_1. When C_2 has discharged to a certain point, it is recharged by the firing of T_2. The firing point of T_2 is determined as before by controlling its grid potential. The variable resistance, R_9, is used to set the counting ratio at a desired value. The switch, S, in the plate supply is turned on only when the cathodes have reached their operating temperature. In the circuit of Fig. 2, closure of this switch is followed by a single output impulse as C_2 is initially charged through T_2.

When the heaters of T_1 and T_2 were operated from the same filament winding on the power transformer, it was found that there was a current flow from cathode to heater which resulted in a continuous loss of charge from C_2 so that T_2 behaved as a relaxation oscillator, thus giving spurious output pulses when no input pulses were present. This cur-

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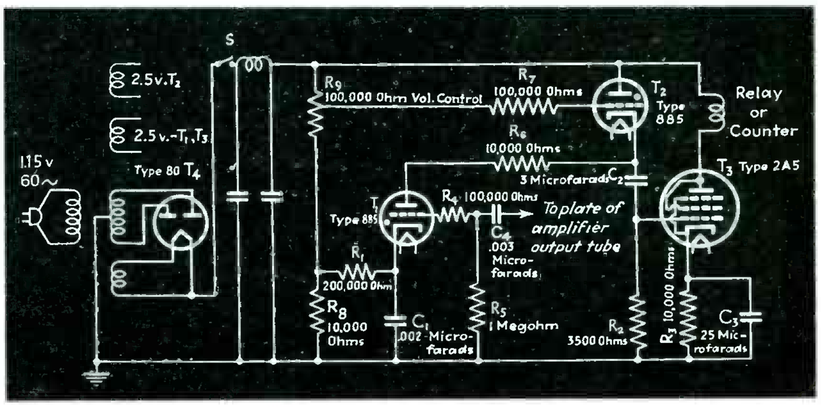


Fig. 2—Improved circuit which is completely a-c operated

Simplified Copper Wire Calculations

By LEONARD TULAUSKAS

THE usefulness of standard copper wire tables cannot be overlooked yet there are numerous occasions which arise when such tables are not readily available. In such cases much time and trouble can be saved if the engineer can determine resistance, diameter and area or cross-section as the need may be with any means on hand. This article will review three methods of deriving copper wire table data, all based on the fact that the American Wire Gauge is approximately a logarithmic function. These three methods are as follows:

1. Tabular.
2. Mechanical (Slide-rule).
3. Graphical.

The tabular method requires memorizing several simple facts. They are:

A—Increasing or decreasing the AWG number by ten increases or decreases the resistance ten times and decreases or increases the area (circ. mils) 10 times.

B—Increasing or decreasing the AWG number by three increases or decreases the resistance two times and decreases or increases the area (circ. mils) 2 times.

C—The resistance of No. 10 AWG copper wire is one ohm per thousand feet and the diameter is 100 mils. (This is very easy to remember if it is stated as "1 ohm of No. 10 is 100 mils diameter and 1000 feet long" as each quantity is ten times the preceding amount and the first figure is 1.)

With the information given above, a complete copper wire table may be readily constructed by calculation. Opposite AWG No. 10 and under the "ohms/1000 ft." put 1.00 and in the same row put 100 in the "diam. mils" column and 10,000 in the "circ. mils" column. By making use of the information in paragraph A above, the resistance and circular mils for 0, 10, 20, 30 and 40 may be determined and of course the diameter in mils may be found by taking the square root of the value obtained for circular mils. By making use of the relationship shown in paragraph B, the rest of the blanks may be filled in.

Comparison of this table with a standard copper wire table will show an accuracy of better than 5 percent at the points of greatest discrepancy and an average deviation of only about 1 percent.

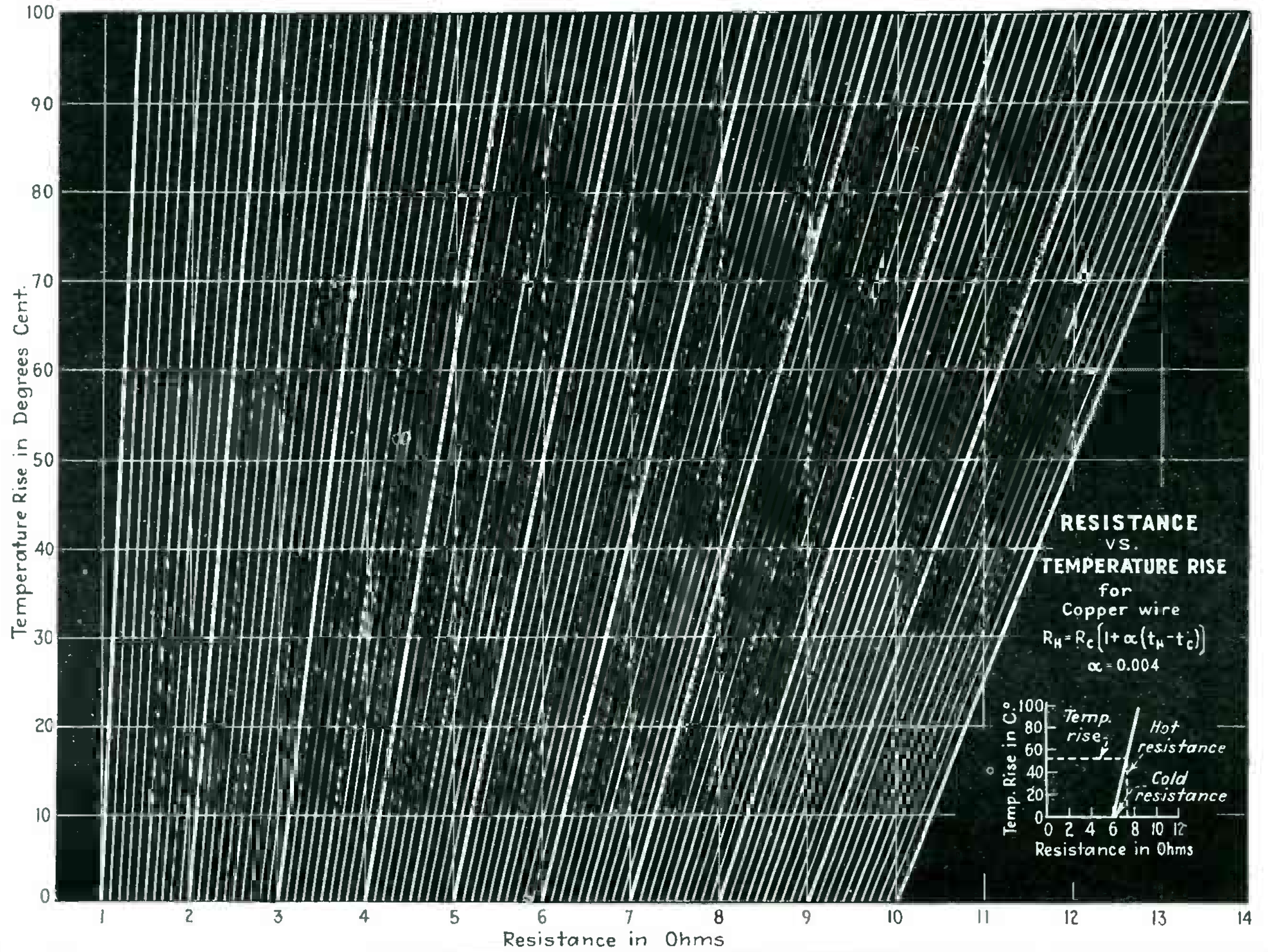
To make use of the mechanical method of establishing copper wire characteristics, a ten-inch slide rule with L and D scales is required. The L scale is the wire gauge scale having values of 0-10, 10-20, 20-30, and 30-40 from start to finish of scale. The corresponding resistance per thousand feet may be read on the D scale and the corresponding values of the D scale are 0.1-1.0, 1-10, 10-100, and 100-1000 ohms per thousand feet. Thus, to find the resistance of No. 9 wire the indicator is moved to 9 on the L scale and the resistance read on the D scale as 0.794 ohms per thousand feet. Likewise, the resistance of No. 16 wire is found by setting the indicator to 6 on the L scale and reading the resistance on the D scale as 3.98 ohms per thousand feet. For No. 23 wire, the indicator is set to 3 on the L scale and the resistance observed on the D scale as 19.96 ohms per thousand feet. For No. 35 wire the indicator is set to 5 on the L scale and the answer found on the D scale as 316 ohms per thousand feet.

Without changing the indicator setting, the cross-section of the wire in circular mils may be read on the CI scale. By extracting the square root of the cross-section so obtained, the diameter of the wire in mils may be obtained. This is most easily accomplished by transferring the CI reading to the left-hand side of the A scale if the wire size is between 1 and 10 or if the wire size is greater than 10 and starts with an even number or to the right-hand side of the A scale if the wire size starts with an odd number. Thus, 21, 24, etc., would make use of the left-hand portion of the A scale while 33, 38, etc., would utilize the right-hand half).

The graphical method requires a sheet of four-cycle semi-log paper with a single straight line as the locus. This graph is made so the equally spaced divisions represent wire size and the logarithmically spaced divisions the resistance. The locus is drawn by locating two points; 1 ohm for No. 10 wire and 1000 ohms for No. 40 wire and drawing a straight line through them across the entire graph. The locus for the cross-section in circular mils is similarly located by selecting 10 circular mils for No. 40 wire and 10,000 circular mils for No. 10 wire and drawing another line through them. The diameter of the wire in mils may be calculated readily from the cross-section.

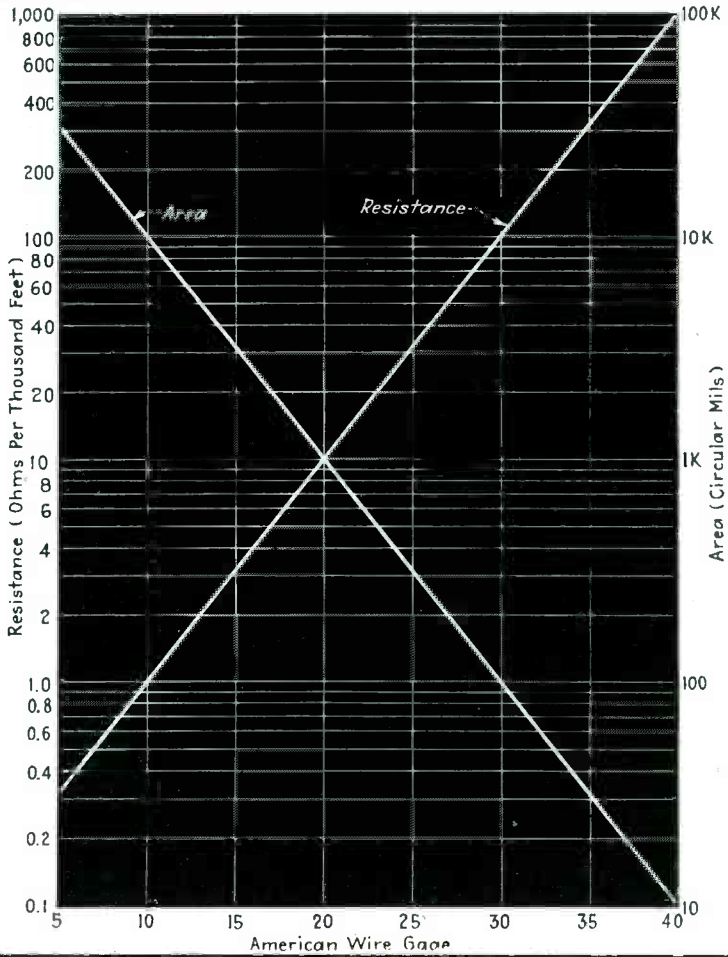
All the information supplied so far may be applied to square copper wire if all gauge numbers are increased by one while other quantities are left unchanged. Thus, No. 6 round copper wire has approximately the same characteristics as No. 7 square copper wire. Number 14 round copper wire approximates No. 15 square copper wire, etc. It must be emphasized that the above relationship is not exact; it is quite approximate but will suffice to serve as a guide on some occasions.

In conclusion, the writer wishes to submit a graph which has proven to be a time-saver for many years past. This is a resistance-temperature chart which should prove of value to those engaged in conducting heat runs of transformers, chokes, motors, etc. The manner of using this chart is almost obvious. In general, the two quantities determined by experiment are the cold resistance and hot resistance of the winding and the desired quantity is the temperature. The value for hot resistance is located on the abscissa and extended vertically until it intersects with a sloping line that corresponds to the cold resistance. The distance to the intersection is the temperature rise which may be read on the ordinate. If the room temperature has varied during the run, the corresponding difference is added or subtracted to the answer obtained above. For resistance values greater 1 or less than 10 and 1 respectively, the abscissa may be multiplied or divided by an appropriate multiple of ten respectively and the same operation performed on the ordinate to extend or lower the range.



Simplified Copper Wire Table

AWG	Ohms/1000 ft.	Diam. mils	Circ. mils
0	0.100	316	100,000
1	0.125	283	80,000
2	0.156	253	64,000
3	0.200	224	50,000
4	0.250	200	40,000
5	0.313	179	32,000
6	0.400	158	25,000
7	0.500	141	20,000
8	0.625	126	16,000
9	0.800	112	12,500
10	1.000	100	10,000
11	1.25	89.4	8000
12	1.60	79.1	6250
13	2.00	70.7	5000
14	2.50	63.3	4000
15	3.200	55.9	3125
16	4.00	50.0	2500
17	5.00	44.7	2000
18	6.40	39.5	1563
19	8.00	35.4	1250
20	10.00	31.6	1000
21	12.50	28.3	800
22	16.00	25.0	625
23	20.00	22.4	500
24	25.00	20.0	400
25	32.00	17.7	313
26	40.00	15.8	250
27	50.00	14.1	200
28	64.00	12.5	156
29	80.00	11.2	125
30	100.00	10.0	100
31	128.00	8.9	80
32	160.00	7.9	63
33	200.00	7.1	50
34	250.00	6.3	40
35	320.00	5.7	32
36	400.00	5.0	25
37	500.00	4.5	20
38	640.00	4.0	16
39	800.00	3.5	12.5
40	1000.00	3.2	10.0



TUBES AT WORK

Reducing Fader Leakage

By JAMES H. GREENWOOD

IN A RADIO STATION one common problem is the elimination of leakage of unwanted signals into the program being broadcast. There are numerous sources of such unwanted signals—power line hum, electrical apparatus fields, auditioning circuits, network and other programs when not being broadcast. There are also numerous ways in which these unwanted signals are combined with the desired signal—inadequate shielding, poor ground connections, presence of a ground connection at the wrong place. This discussion deals with one type of unwanted signal: the case in which an audition, rehearsal, or network program is present in the background of the broadcast program; or, more generally, the case in which any program which is available for broadcast manages to get on the air at low level when it is not desired.

Common Cause of Leakage

If program circuits have one common grounded side, stray capacities in lines and terminal blocks may introduce a signal from one circuit into another. Fig. 1a illustrates this condition. Two program circuits are shown, *A* and *B*, and all of the stray capacities existing between them. The common ground connection shorts out C_6. Capacities C_2, C_3, C_4, C_5 all resolve into shunting capacities on one circuit or the other. But C_1, taken with the common ground connection, forms a complete path between circuits *A* and *B* as in Fig. 1b. It will be noted that the condition is the same when circuits *A* and *B* have one common side, regardless of whether this is ground. The amount of signal flowing through this path is, of course, dependent on the size of C_1. It may be possible to reduce leakage sufficiently in this case by careful attention to installation, so that C_1 is kept at a minimum. Nevertheless, however small C_1 may be made, there is still a theoretical leakage. This leakage may be further reduced by removing all grounds from low-level program circuits. The condition then is shown in Fig. 2a. Stray capacities C_1 and C_6, taken together, form a leakage path between circuits *A* and *B*. But C_4 and C_5 also form a leakage path in the opposite direction. If the conductances of the two paths are equal, the resulting leakage will be zero.

The conductances of the two paths will be equal if $C_1 = C_4$ and $C_5 = C_6$. In practice, this means merely that each of the two circuits is completely symmetrical. There must be, of course, no grounds on either side of either circuit. Furthermore, there must be no more equipment connected to one side of either circuit than to the other side of the same circuit for in that case the capacity of one wire of the circuit to *anything* else would be greater than the capacity of the other wire to the same external object. However, the conductances of these two paths will also be equal if only one circuit is symmetrical. Let us suppose that circuit *A* is symmetrical, and *B* unsymmetrical. Then the capacities of each wire of *A* to any-

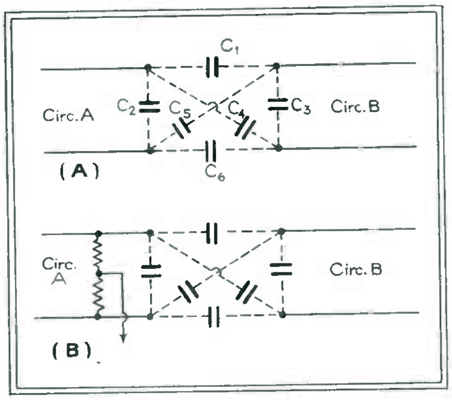


Fig. 2—(A) Balanced stray capacities between two program circuits with all grounds removed. (B) Leakage-reducing symmetry of circuit *A* is not disturbed by center-tapped resistor or transformer

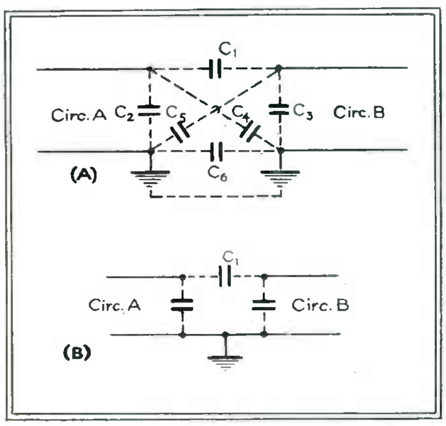
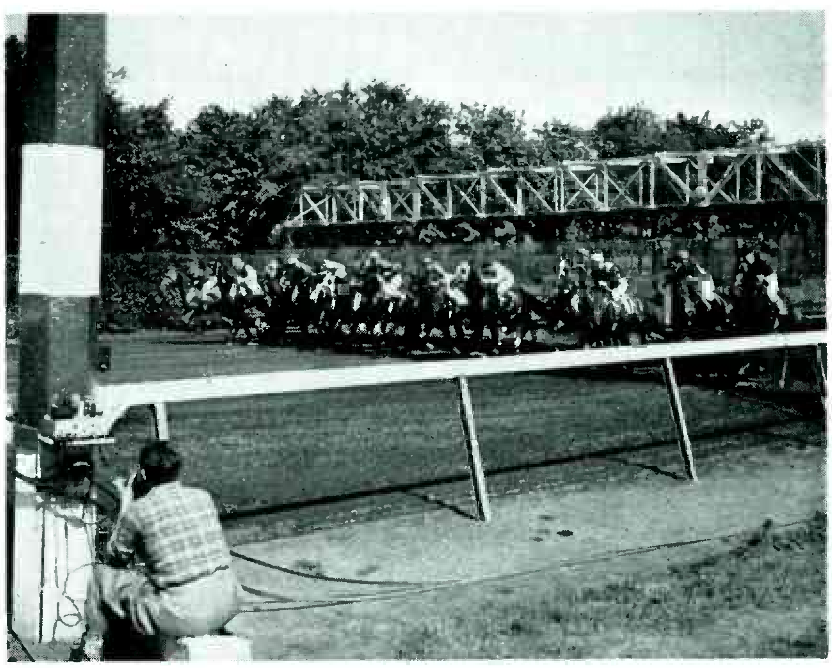


Fig. 1—(A) Stray capacities between two program circuits using common ground. (B) Leakage path formed by C_1, shunt capacities and common ground

JUMPING THE TIMER



The device at the left of this picture starts the clock to time the race at Belmont Park, N. Y. The race is not timed from the moment the horses break, but from the time they pass before the phototube in this instrument. Thus the horses are allowed to get under way or jump the clock, before the official timing starts

Electronic Engineers,
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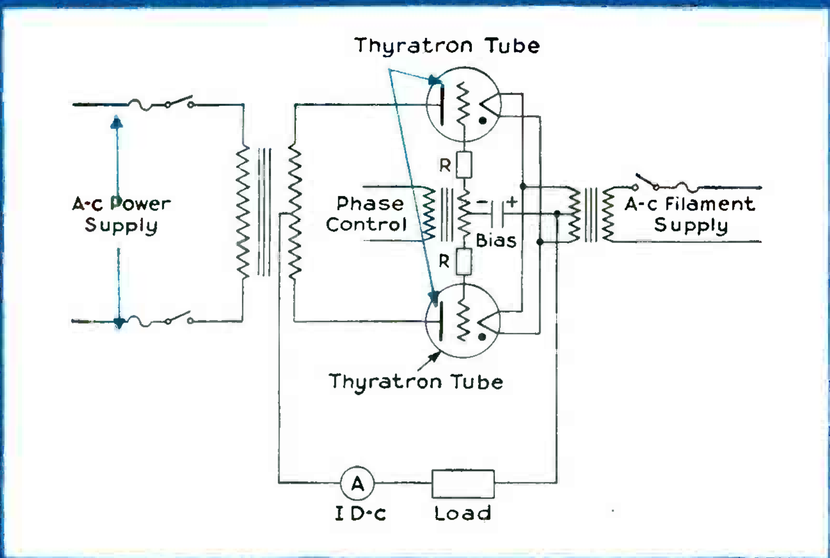

From this circuit can be built devices fundamentally the same, but which have myriad applications — such as controlling the speed of motors, maintaining the proper speed relations between two conveyors, and controlling and varying the intensity and color of light.

A thyratron is a hot-cathode, gas-discharge tube in which one or more electrodes are employed to control electrostatically the starting of the unidirectional current flow.

THE electronic circuit is entering more and more into industrial work as an automatic hand, an automatic eye, a new means of generating heat—control methods are being revolutionized. Results are showing that electronic-tube control is more accurate, more dependable, and often less expensive than ordinary electrical or mechanical methods. Electronic tubes are producing results heretofore unattainable.

The thyratron fits into the electronic picture as the industrial workhorse. Applications range all the way from amplifiers of minute currents passed by a phototube, to the control of large spot welders. Thyratrons have inherent characteristics that make them ideal for the task of converting electric power from one form to another. In many applications the thyratron is the power teammate of the phototube, with the phototube giving the orders in the form of grid voltage. Sensitivity, quietness, high-speed operation, durability as rapid-duty contactors, and general adaptability to automatic operation give thyratrons an extremely wide range of usefulness.

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Thyratrons

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1 AS CONTROLLED RECTIFIERS, to supply variable direct voltage or current from an a-c source of supply. This combination is used to control d-c motors, field excitation of generators, and various electromagnetic devices.

2 AS INVERTERS, to supply either constant or variable-frequency a-c power (up to a limit of a few hundred cycles) from a d-c supply.

3 AS FREQUENCY CHANGERS; to change a-c at one frequency to a-c at another frequency, such as 60 cycles to 25 cycles, or vice versa.

4 AS CONTACTORS—a circuit element that acts as a contactor is made by connecting a pair of tubes "back to back" so that in combination they pass alternating current—an arrangement used in many welding-control circuits.

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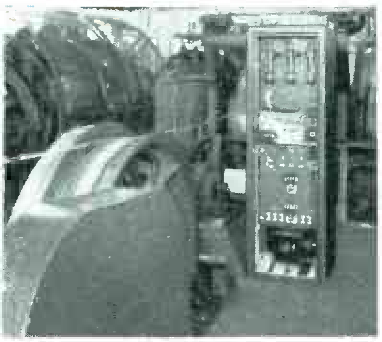
A QUICK-SELECTION CHART OF G-E THYRATRONS

Type No.	Price	No. of Electrodes	CATHODE		PLATE		Avg Amp	Grid Voltage for Starting	Temp Range Condensed Mercury, (Centigrade)	Shipping Wt in Lb	Ask for This Technical Data
			Volts	Amp	Peak Volts	Peak Amp					
GL-2051	$2.50	4	6.3	0.6	700	0.375	0.075	Neg		3	GET-984
GL-2050	3.00	4	6.3	0.6	1300	0.500	0.100	Neg		3	GET-984
FG-178-A	14.00	3	2.5	2.25	500	0.500	0.125	Neg	−20—+50*	3	GET-618
FG-81-A	11.00	3	2.5	5.0	500	2.0	0.5	Neg	−20—+50*	3	GET-465
FG-98-A	15.50	4	2.5	5.0	500	2.0	0.5	Neg	−20—+50*	3	GET-743
FG-97	15.50	4	2.5	5.0	1000	2.0	0.5	Var	40—80	3	GET-743
FG-17	9.50	3	2.5	5.0	2500	2.0	0.5	Neg	40—80	3	GET-428
FG-154	23.00	4	5.0	7.0	500	10.0	2.5	Neg	−20—+50*	6	GET-743
FG-27-A	17.00	3	5.0	4.5	1000	10.0	2.5	Neg	40—80	6	GET-428
FG-33	16.25	3	5.0	4.5	1000	15.0	2.5	Pos	35—80	6	GET-435
FG-57	15.00	3	5.0	4.5	1000	15.0	2.5	Neg	40—80	6	GET-428
FG-67	15.75	3	5.0	4.5	1000	15.0	2.5	Var	40—80	6	GET-438
FG-95	19.00	4	5.0 †5.5	4.5 5.0	1000 1000	15.0 40.0	2.5 0.5	Var Var	40—80 40—80	6	GET-743
GL-429	47.50	4	5.0	10.0	1000	40.0	3.0	Var	50—70	9	GET-962
FG-105	38.00	4	5.0	10.0	1000	40.0	6.4	Var	40—80	9	GET-743
FG-172	35.00	4	5.0	10.0	1000	40.0	6.4	Var	40—80	9	GET-619
FG-41	92.00	3	5.0	20.0	10000	75.0	12.5	Neg	40—65	9	GET-436
GL-414	92.00	4	5.0	20.0	2000	100.0	12.5	Neg	40—80	9	

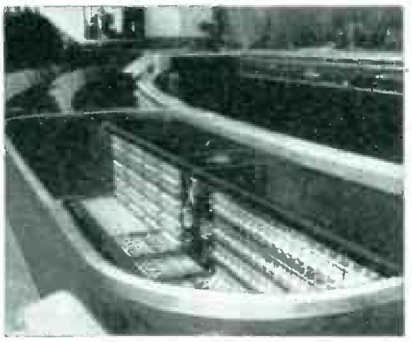
* These tubes are inert-gas-filled, and the temperature ratings are expressed in terms of the ambient temperature range over which the tubes will operate.

† These ratings apply only when the tube is used for ignitor firing.

G-E THYRATRONS AT WORK—ONE APPLICATION SUGGESTS ANOTHER



IN MOTOR CONTROL—the new answer to the long-felt need for a single, wide-range, stepless speed control for the operation of d-c motors from a-c lines.



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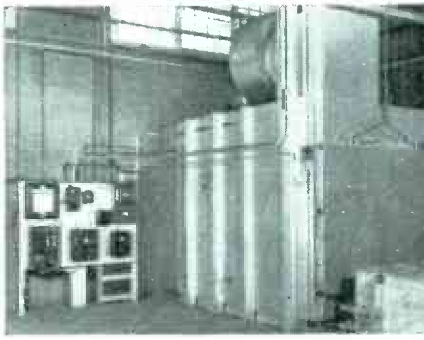
IN WELDING CONTROL—the simplicity, sensitivity, and high-speed response of thyratron control results in fast, uniform welds; maintenance costs are cut.



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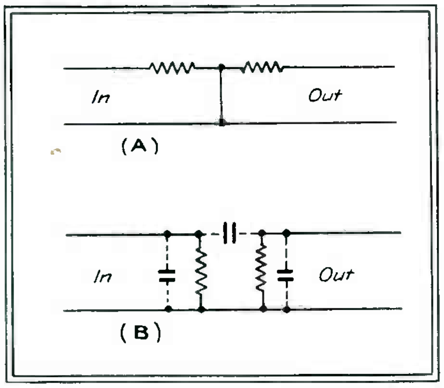


Fig. 3—(A) Common L-pad fader in "off" position. (B) Equivalent circuit showing stray capacities

thing else are equal. $C_1 = C_4$ and $C_5 = C_6$. The conductance of the path through C_1 and C_6 will equal the conductance of the path through C_4 and C_5. Furthermore, the symmetry of circuit *A* will not be disturbed by any connection to its electrical center. For example, the center of a symmetrical resistor or transformer connected across the circuit as in Fig. 2b will not disturb symmetry.

While these methods of analysis and correction may be, and have often been, applied to numerous cases of leakage, there is one common, special case which deserves mention here. One of the common types of faders used in speech-input equipment is the variable L pad. When it is turned off—to the position of maximum (or so-called "infinite" attenuation—the circuit is that shown in Fig. 3a. Rearranging elements slightly and showing stray capacities gives us Fig. 3b. It will be seen that this is essentially the same as Fig. 1b. In practice, the effects are also the same. Turning such a fader off does not completely eliminate the program. It continues in the background, sometimes objectionably. It is customary to provide additional switching means for eliminating the unwanted program, but this necessitates additional equipment and additional operations. Balanced faders of the variable H pad type are available and for some applications are necessary. But they are more expensive and, having more sliding contacts, require more maintenance. The common variable L pad is, actually, perfectly suited to many jobs except in the off position as mentioned above.

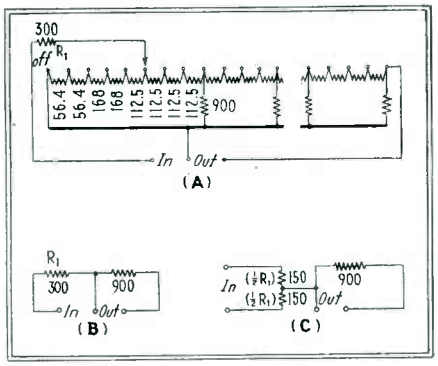


Fig. 4—(A) Common L-pad fader, shown in detail. (B) Equivalent circuit of fader for 600-ohm line in "off" position. (C) Modification of fader for symmetrical input

Simple L Pad Modification

One common variable L pad is shown in detail in Fig. 4a. Fig. 4b shows the simplified circuit in the off position. Fig. 4c shows a modification of Fig. 4b which will be seen to possess a symmetrical input. From its similarity to Fig. 2b and the above discussion of that circuit it is evident that stray capacities will not provide a leakage path from input to output. Fig. 5a shows how the fader of Fig. 4a is altered to accomplish this condition. Inspection will show that the normal operation of the fader is in no way impaired. Fig. 5b shows how to make this modification with the least disturbance of the parts of the fader. A resistor, R_2, equal in value to R_1 and essentially non-inductive at audio frequencies, is connected in parallel with R_1. Another resistor, R_3, of half the resistance of R_1, is externally connected in series with the proper side of the input circuit.

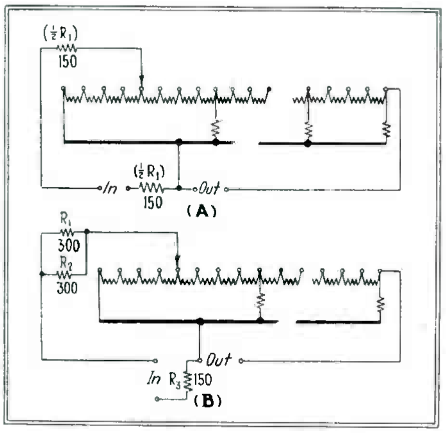


Fig. 5—(A) Common L-pad fader modified to provide balanced input in the "off" position. (B) Method of modifying with minimum disturbance to fader parts

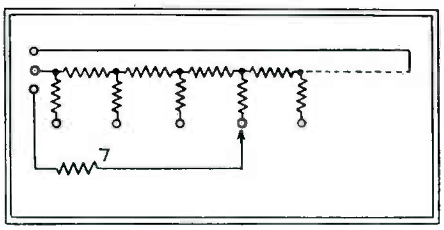


Fig. 6—L-pad fader type which cannot readily be modified to reduce leakage by the method outlined

Results in practice have been very gratifying. When a transcription is faded out before its completion and the announcer begins to introduce the next program, the listener no longer hears inappropriate musical background. This treatment may be applied to most faders, regardless of their impedance. The values of the added resistances would be proportional. (It is, of course, essential that the circuit connected to the input of the modified fader be completely symmetrical. Modification of the fader makes the fader symmetrical, but cannot eliminate the effects of lack of symmetry in the source.) However, there is a varitable L pad type of fader of different design, shown at Fig. 6, to which this treatment may not be applied.

• • •

A Phase Meter Calibrator

By DAWKINS ESPY*

When a directional antenna is used by a broadcast station the engineer in charge must see to it that the proper phase relationship is maintained between radiating towers. Instruments for measuring phase angle are available but it is often desirable to check their calibration. The writer has had occasion to design and build a suitable "phase standard" for such work at KECA.

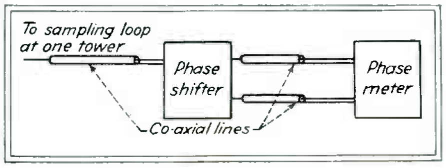


Fig. 1—Block diagram showing method of calibrating phase meter

Figure 1 shows the overall setup. It seemed logical to check the phase meter at approximately zero deg., 45 deg., 90 deg. and 135 deg. The problem resolved itself into one of securing such phase shifts and sufficient voltages of equal magnitude to operate the phase meter, without introducing too much mismatch.

The 0 deg. shift, utilizing the circuit of Fig. 2a, introduced little difficulty. However, due to the fact that the input line and the two output lines all had impedances of 70 ohms, paralleling the two output lines gave an effective impedance of 35 ohms. When this output impedance is connected to the 70 ohm input line it causes a two-to-one mismatch, or a loss of 3.4 db in voltage. This gives a 67 percent voltage transfer

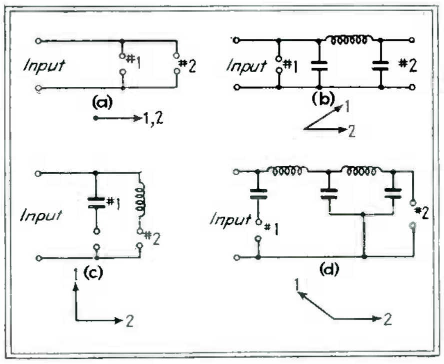


Fig. 2—0, 45, 90 and 135 deg. phase shift circuits, with vector diagrams

SIGNALS

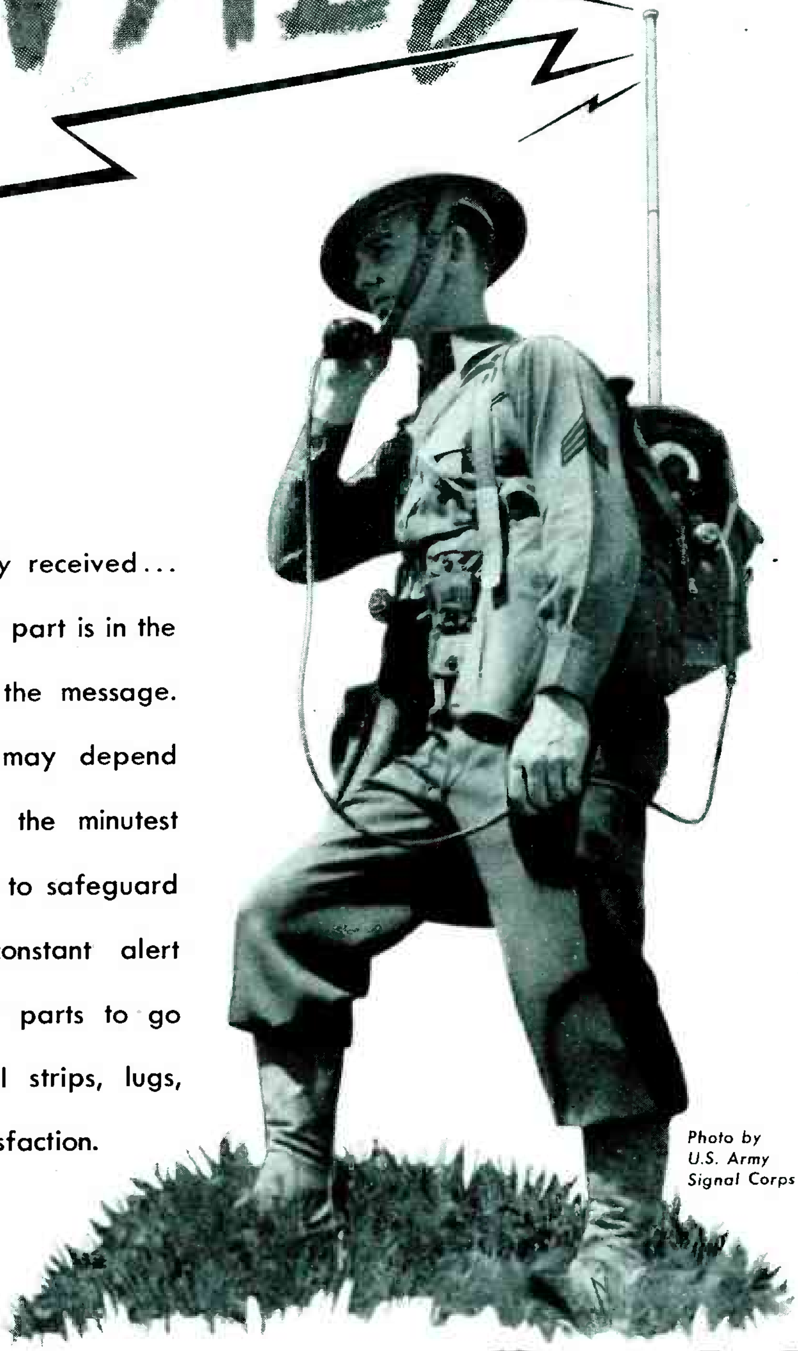
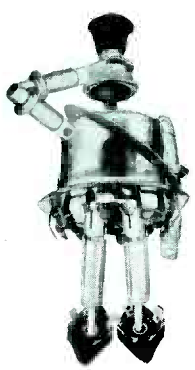


Photo by U.S. Army Signal Corps

A COMMAND... *perfectly* received... will be the signal for VICTORY. Our part is in the perfection of the transmission of the message. No one can foretell how much may depend upon so little — the perfection of the minutest detail. But it is comparatively easy to safeguard dependability — and to insure constant alert performance — in the choosing of parts to go into service. For sockets, terminal strips, lugs, connectors . . . it's CINCH for satisfaction.

Making our little parts important...for Victory— "Serves You and US".



CINCH

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and equal voltage on the output lines.

Several unsuccessful methods involving the use of resonant circuits were tried to obtain the 45 deg. shift before it was decided to use a π network as shown in Fig. 2b. The constants were determined from the formulas[1].

$$X_C = \frac{70 \sin \rho}{1 - \cos \rho} \qquad (1)$$

$$X_L = -70 \sin \rho \qquad (2)$$

where ρ in the phase angle

For 45 deg. phase shift the formulas gave $C = 0.0011$ μf and $L = 10$ μh. The coil used consisted of 28 turns of No. 28 enameled wire on a form one inch in diameter, spaced over a length of one inch. (All circuit values given here are for 790 kc.)

To obtain a 90 deg. shift the parallel circuit shown in Fig. 2c was used. The current through the resistance in the inductive branch lags the impressed voltage by 45 deg. and the current through the resistance in the capacitive branch leads the impressed voltage by 45 deg. where $R_2 = R_3$ as in Fig. 3.

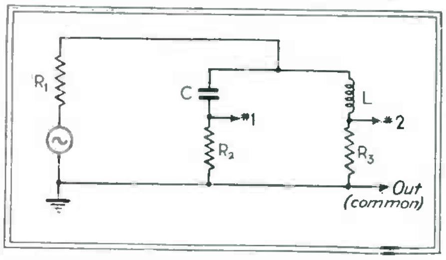


Fig. 3—90 deg. phase shift circuit in greater detail

The condition required to obtain a 90 deg. shift between the current and R_2 and R_3 is

$$R_2 R_3 = \omega L \left(\frac{1}{\omega C}\right) \qquad (3)$$

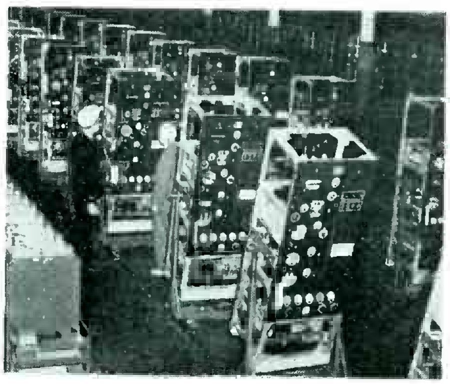
but $R_2 = R_3$ so

$$R_2 = R_3 = \omega L = \frac{1}{\omega C} \qquad (4)$$

For this condition the capacity is ap-

• • •

RADIO EQUIPMENT FOR THE NAVY



These rows of radio transmitters are for the Navy. Many ships have not one but a number of transmitters and receivers of various frequencies and power, as well as portable radio equipment and equipment for detecting ships and planes

This gives a 67 percent voltage transfer proximately 0.003 μf and the coil 14 μh when R_2 and R_3 equal 70 ohms. The coil used consisted of 15 turns of No. 18 wire on a two inch diameter form, close-spaced.

To get 135 deg. phase shift the 45 deg. and 90 deg. units were hooked in tandem, with the 90 deg. unit on the input side.

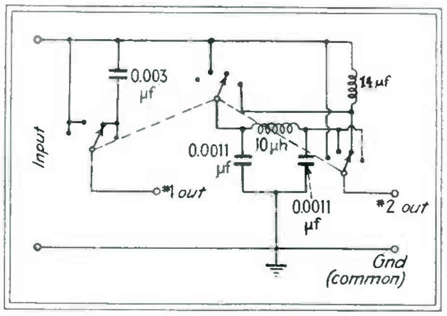


Fig. 4—Circuit diagram of the complete phase meter calibrator

The finished calibrator, shown in Fig. 4, gave 0 deg., 49 deg., 87 deg. and 129 deg. phase shifts. This was determined by "calibrating the calibrator" by means of the phase meter at a time when the phase meter calibration was known to be correct. It was, therefore, unnecessary to adjust the calibrator to obtain the precise angles originally planned as the device serves its purpose so long as the phase shift values are known. Once calibrated, the calibrator constitutes a standard with which the phase meter may be periodically checked.

The writer wishes to acknowledge the helpful suggestions of George Curran of the Research Department of KFI-KECA.

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* Research Engineer, Columbia University Div. of War Research. On leave from KFI-KECA Research Department.

[1] Brown, G. H.: Directional Antenna, *Proc. I.R.E.*, 25, pp. 131, Jan., 1937.

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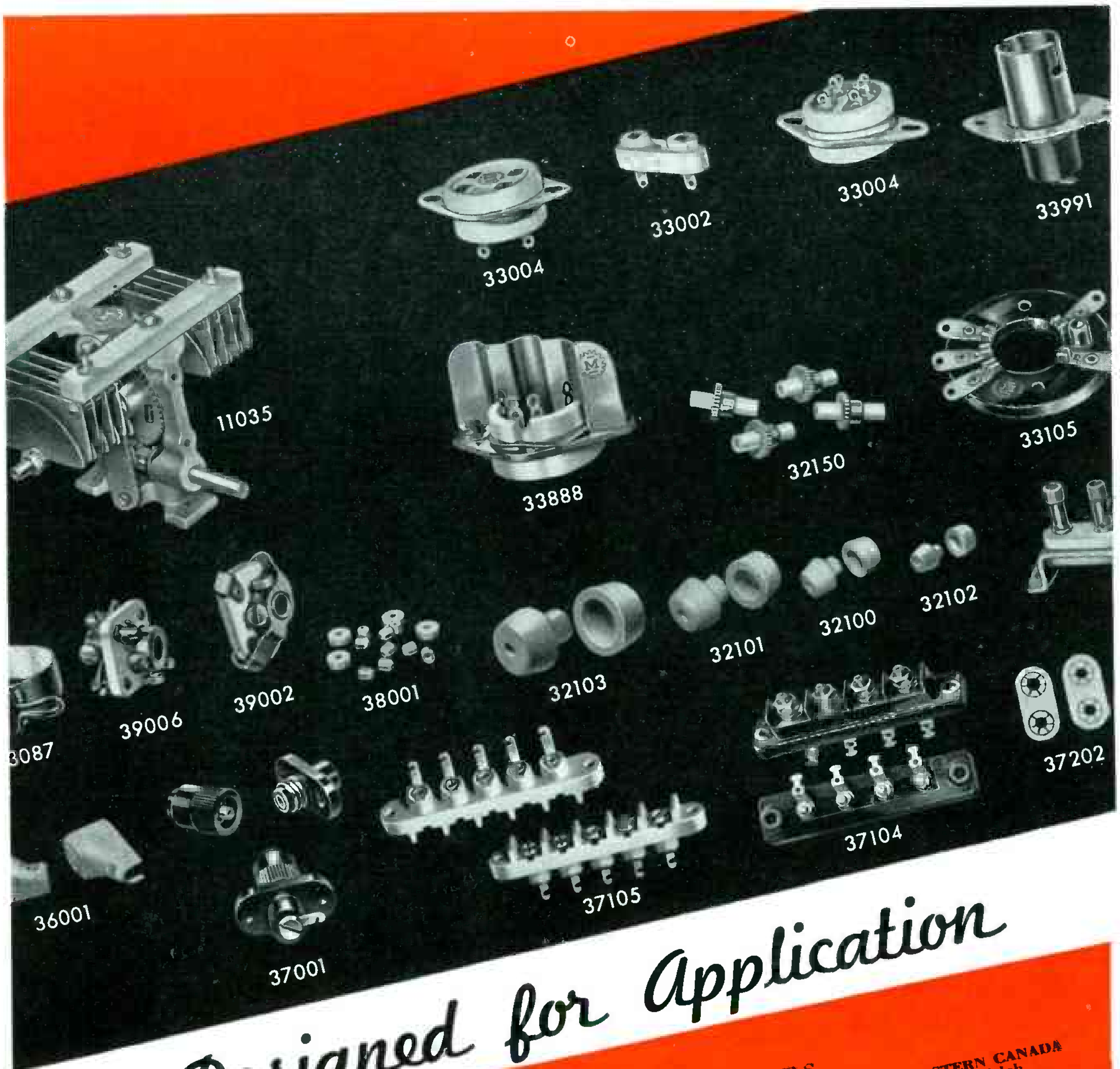
Low-Frequency Timing Circuits

By Clifford E. Berry

In recent years numerous electronic devices have been developed for generating timing impulses having periods from a fraction of a second to several minutes. Such devices find use in industrial process timing, intermittent life tests, welding control, and many other applications. This paper describes three simple circuits which the author has found to be extremely useful and reliable. A few applications are suggested; doubtless many others will occur to the reader.

Basic Circuits

In the circuits considered here, the periods which may be obtained are multiples of the period of the supply frequency; with a 60 cps supply,



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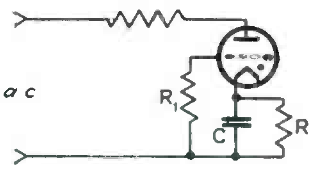

FIG. 1

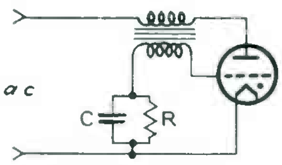

FIG. 2

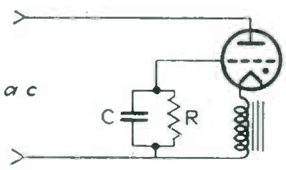

FIG. 3

Three elemental timing circuits. They differ only in the method employed to block the tube grid

periods of $n/60$ seconds are obtainable. In this respect these circuits may be considered as frequency dividers. Furthermore, all of the circuits operate directly from an a-c source without requiring d-c power supplies, which greatly contributes to their simplicity.

Consider first Fig. 1. A condenser C is connected in the cathode circuit of a thyratron, and is shunted by a leak resistance R. The grid is returned to the lower end of the cathode condenser through a protective resistor R_1. When the supply voltage is initially applied, there is no charge on the condenser, and thus no bias on the tube. Therefore the tube conducts during the first positive half cycle, and the condenser is charged to the peak of the supply voltage less the tube drop. The condenser voltage is of such polarity as to make the grid negative with respect to the cathode, and conduction during subsequent positive half-cycles of the plate voltage cannot occur until the charge on the condenser has been sufficiently reduced by the action of the leak resistance.

By suitable choice of the time constant RC the period may be adjusted over a wide range. Impulses may be obtained across a load resistor in the plate circuit, or a blocking voltage for other tubes may be obtained across the condenser. In using this circuit, it should be remembered that the peak inverse voltage to which the tube is subjected is nearly twice the peak of the supply voltage.

AN IMPORTANT STATEMENT TO THE PLASTICS INDUSTRY BY THE PIONEER PRODUCER OF POLYSTYRENE

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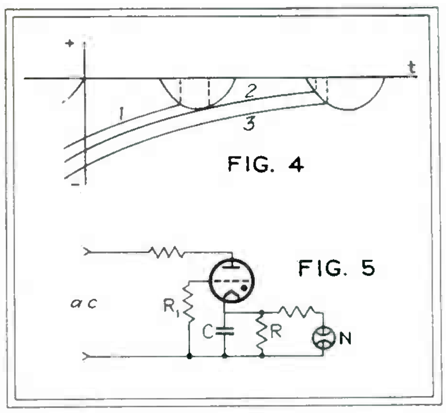
A second type of circuit is shown in Fig. 2. The grid rectifies its own blocking voltage, which is obtained from a transformer in the plate circuit. In some applications this method has an advantage over the first circuit, since heavy plate current can be handled without requiring that it flow through the condenser. The timing action occurs in the same manner as in the first circuit.

The third type of circuit is shown in Fig. 3. This circuit, like circuit 2, uses grid rectification, but the mode of operation is not so obvious. The circuit requires an inductive load, such as a relay or highly reactive transformer. The operation is as follows: Suppose the tube is conducting—as long as the current in the load is increasing the voltage drop across the load maintains the grid negative with respect to the cathode. When the current begins to decrease, however, this voltage reverses in polarity and a grid current flows, charging the condenser so as to block the grid for subsequent cycles. When the charge has leaked away sufficiently another firing cycle takes place.

Accuracy of Timing

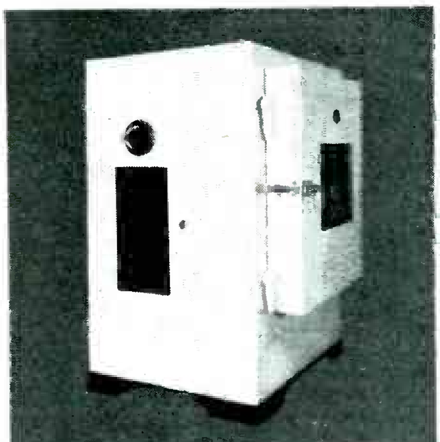
In all of these circuits, only certain discrete periods of operation may be obtained; however, since the time constant *RC* may be continuously variable, it is apparent that at certain values of *RC* there will be an indeterminacy of one cycle in the period. This is illustrated in Fig. 4, which shows the grid firing characteristics of a typical thyratron, together with three curves showing the blocking voltage variation. For curves 1 and 3 the timing is accurate, but for curve 2, slight random variations in operating conditions may cause shifting from one period to another. The same effect is produced by a changing supply voltage; hence it is important where precise timing is required to set the time constant carefully and to maintain the constancy of the line voltage.

A further source of inaccuracy arises



Grid firing characteristics of typical thyratron, with curves showing blocking voltage variation, and a circuit utilizing a neon lamp N to reduce timing inaccuracies caused by variations in the plate load

Down to the Burning Sands of the Desert!



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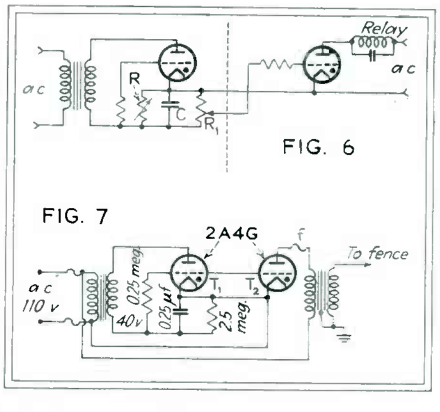
in the exponential variation of the blocking voltage. As the periods obtained become longer, the blocking voltage curve approaches the grid characteristic less steeply, thus rendering the timing more susceptible to small changes in operating conditions. This objection is not serious in most applications when considered on a percentage error basis.

If a varying plate load is imposed upon any of the circuits thus far considered, then the voltage to which the condenser is charged during any firing cycle is in part dependent upon the load and the timing is affected. This difficulty can be eliminated by connecting a small neon lamp across the condenser, so that under all conditions the blocking voltage has the same initial value. A protective resistor connected in series with the neon lamp prevents damaging surges from passing through it. Fig. 5 shows this arrangement applied to the circuit of Fig. 1.

Applications

All of the circuits described can be used directly for supplying control impulses to other apparatus. Furthermore, by modifications and additions many other useful circuits can be developed. For example, suppose it is desired to control a relay so that it is periodically on for a given number of seconds and off for a given number of seconds. This can be accomplished by the circuit shown in Fig. 6. In this circuit the part to the left of the dotted line is the simple timer of Fig. 1. A variable amount of the blocking voltage on C is taken from R_1 and used to block T_2. R controls the period and R_1 the length of time during which T_2 fires each period.



A circuit suitable for operating a relay intermittently and a circuit adaptable as an electric fence controller

Figure 7 shows a circuit which has been used successfully in electric fence controllers. T_1 provides the timing and T_2 provides half-cycle impulses to the fence transformer at one-second intervals. For protection, in case T_1 fails to operate and provide a blocking voltage for T_2, a fuse f is included in the plate circuit of T_2. This fuse blows immediately if T_1 fails; failure of T_2 results in no danger.

As mentioned earlier, all of these

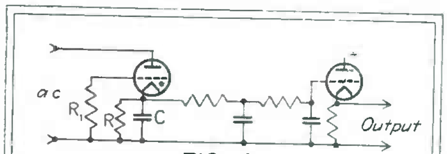


FIG. 8

One method of obtaining sub-harmonic voltages of approximately sinusoidal waveform and very low frequency from an a-c supply source

circuits are basically frequency dividers, and thus offer a means of obtaining sub-harmonic voltages of approximately sinusoidal waveform and very low frequency, which are useful for many purposes. All that is necessary is to provide suitable filters for the exponential voltage across *RC*. A circuit which does this is shown in Fig. 8, in which the circuit of Fig. 1 is followed by an *RC* filter and a cathode-degenerated buffer stage. Since a peak voltage of 100 volts or more is easily obtained at the input of the filter, high time-constant filter sections can be used without reducing the output voltage below a reasonable working value.

• • •

NAVY CODE SCHOOL

The Radio School for U. S. Navy Applicants, operated by WFIL, Philadelphia offers a pre-enlistment training course in code work, which turns over to the Navy Recruiting Service technically trained personnel. Before they are admitted to the class, candidates must pass the regulation physical examination at the Navy Recruiting Office. Navy enlistment is completed when the student graduates from the course with a speed in code of 20 to 25 words a minute. The graduates are then given preferential consideration by the Navy for a V-3 rating. The school operates three hours a night, five nights a week. The boys shown here are receiving code messages through the earphones and transcribing them on the typewriter. On the instructor's desk (not visible here) is a mechanism permitting the instructor to send to individual students at different speeds. In this way slow students may receive special attention; fast ones may advance more rapidly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Temperature Measurement and Control

(Continued from page 61)

voltage depending upon the direction and amplitude of unbalance. This causes a larger or smaller current to flow through the tube and also through the standard resistor to rebalance the circuit. The milliammeter in the plate circuit measures the current required to balance the input voltage and it is calibrated in terms of the input voltage. This instrument may be connected to an external indicating or recording milliammeter calibrated in degrees of temperature, or relays may be used with it for temperature control.

Resistance Thermometer Circuit

The resistance thermometer is used in a temperature controller capable of very precise control at about 240 degrees F developed by the Shell Development Co. When the temperature shifts from the desired value an unbalance voltage appears across the Wheatstone bridge across which 60-cps voltage is applied. This voltage is passed through a phase shifting network and a two-stage amplifier. The

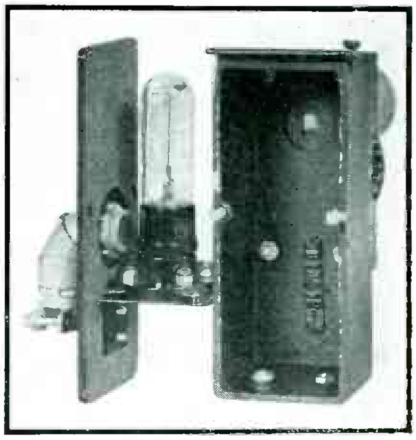

Fig. 14—This G. E. phototube unit of a radiation pyrometer is located where the radiation from the hot body can impinge on the cathode of the phototube and the amplifier unit is located at any convenient point

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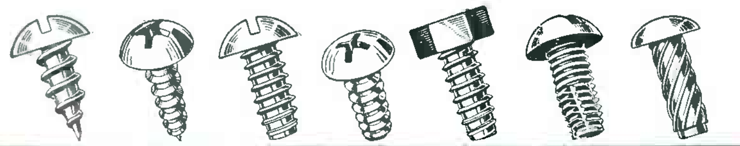

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amplified out-of-phase voltage is then applied to the grids of the two thyratrons as shown in Fig. 12. A voltage 180 degrees out of phase with line voltage is applied to the anodes. Whenever the temperature changes by a very small amount, this circuit is sensitive enough to cause the application of heat to return the temperature to the desired value. The anode current is passed through a saturable reactor, one winding of which is in series with the power line and an electric heater. To avoid overload in this circuit an automatic gain control operated by the output voltage is used. For a more complete discussion of this instrument see "Electron Tubes in Petroleum Research," page 20, April 1941 issue of ELECTRONICS.

The resistance thermometer is used in the Foxboro electronic recorder as part of a bridge circuit composed of another resistance, a fixed condenser and a variable condenser. A 1000-cps oscillator feeds the bridge circuit and also the

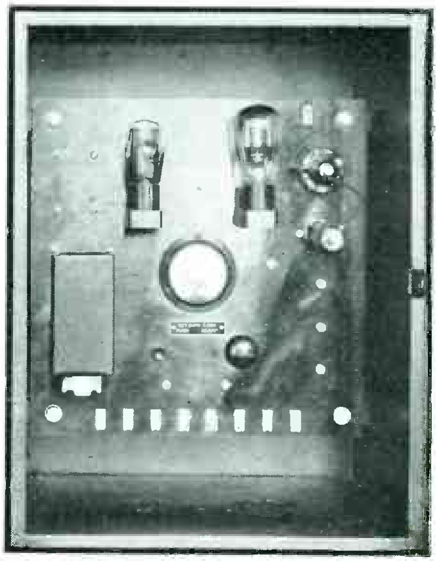

Fig. 15—The photoelectric radiation pyrometer manufactured by the General Electric Company

phase recognition and power amplifier as shown in Fig. 13. The amplifier supplies power for a push-pull reciprocating solenoid motor. The motor windings are two solenoid coils mounted coaxially and the core is suspended between the coils. This core is connected by a link to the recording pen and the rotor of the balancing condenser. Both driving coils of the motor are continuously energized and any un-

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balance voltage from the bridge is amplified and the currents through the coils are unbalanced. This causes the motor core to drive the variable condenser rotor back to balance condition, when the motor coil currents become equal and the core stops moving. The action of the motor is fully reversible as the direction of core movement depends only on the relative coil currents and is not affected by core position.

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Capacity Operated Relay Applied to Furnace Heat Control, ELECTRONICS, Nov. 1937.

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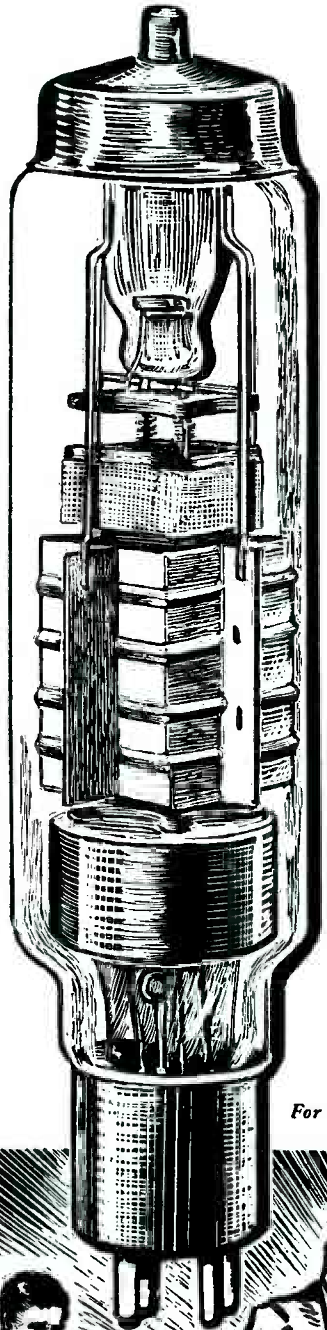

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DEVOTED TO RESEARCH AND THE MANUFACTURING OF TUBES FOR THE NEW ERA OF ELECTRONICS

THE ELECTRON ART

The Vacuum Type Trigger Tube Using Secondary Emission

To THE EVER-INCREASING number of electronic devices which have been originated since deForest first made use of a grid interposed between cathode and anode, A. M. Skellett of the Bell Telephone Laboratories makes an additional contribution in the August issue of the *Journal of Applied Physics*. Mr. Skellett's article, "The Use of Secondary Electron Emission to Obtain Trigger or Relay Action," describes a vacuum type of tube whose trigger operation is comparable to that of the thyratron. The new tube, which is presumably not yet in the stage of commercial availability, provides the features of the triode with a relay or on and off feature, resulting in an amplifier, oscillator, modulator, or other vacuum tube device which may be turned on or off abruptly at high or low frequency. In addition, it can be used to replace thyratrons in many of their circuits where very low plate impedance is not necessary and the secondary emission trigger tube is capable of much greater speeds of operation than the thyratron in such applications.

Following the trend of tube design in the last half dozen years, the new tube makes use of an electrode whose purpose is to control and direct the stream of electrons in certain specified and desired trajectories. A diagrammatic sketch of the electrodes for the new type of tube is shown in Fig. 1, in which the cathode, grid, and first anode bear a striking resemblance to the equivalent electrodes in the beam power tube. The electrons emitted by the cathode are accelerated toward the first anode by a positive potential applied to it. Their control is carried out in the usual manner by voltage variations on the grid. While many of the emitted electrodes are collected at the first anode, a slot in this structure enables about 10 percent of the electrons to come under the influence of the deflector electrode. In most of

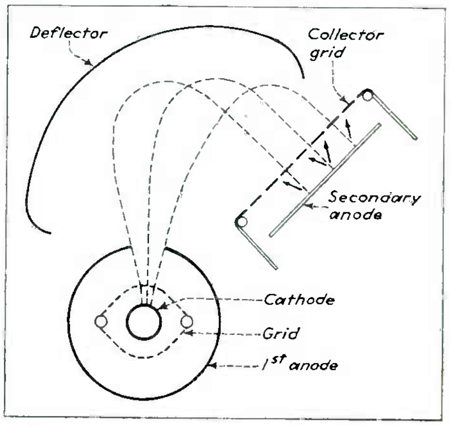
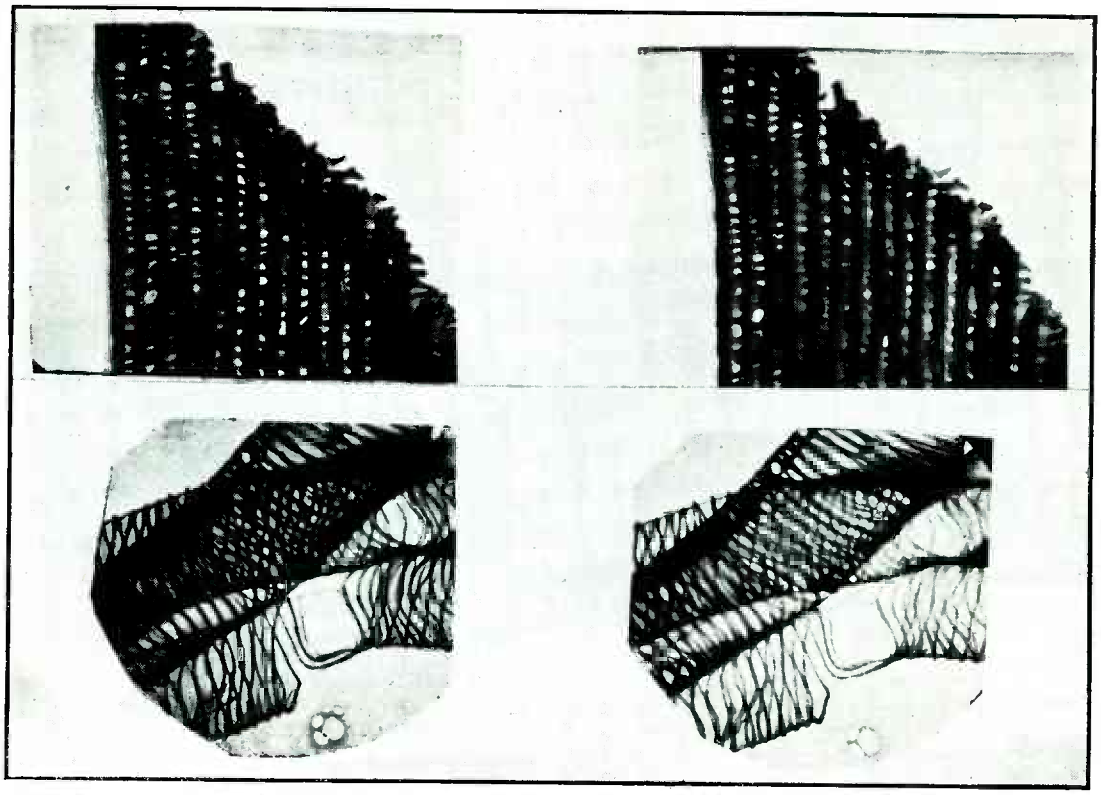


Fig. 1—Diagrammatic sketch of the elements of the secondary emission trigger tube

STEREOSCOPIC PICTURES FORM THE ELECTRON MICROSCOPE



These three-dimensional photographs of a particle of butterfly scale (upper) and a section of the windpipe of a mosquito larva made on the fluorescent screen of the RCA electron microscope are published for the benefit of those readers having access to stereoscopes. The pictures should be placed in the viewing position of the stereoscope to obtain the three-dimensional effect

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Manufacturers of Precision Lenses, Prisms, and Mirrors. Optical Design and Consultation the applications indicated by Mr. Skellett, the deflector electrode is maintained at zero potential as is the suppressor grid in pentode. The electrons which emerge from the first anode follow the trajectories indicated by the dotted lines, ultimately reaching the secondary anode which has a high positive potential applied to it. On striking the secondary anode, secondary electrons are emitted which are collected by a grid having a high positive potential and indicated in the diagram as the collector grid.

The voltage-current characteristics of the secondary anode are shown in Fig. 2.

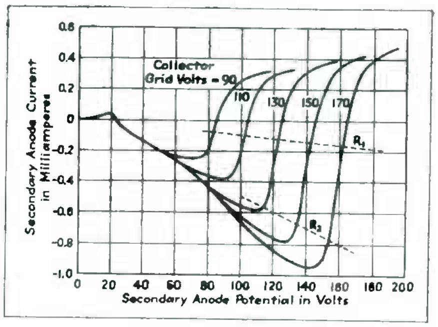

Fig. 2—Characteristics of secondary emission trigger tube, showing region of negative resistance

As the voltage of the secondary anode is increased from zero in the positive direction, the current is increased due to the collection of primary electrons. When the voltage reaches approximately 20 volts, energy of the primary electrons is sufficient to release secondary electrons so that the net secondary anode current decreases and is negative beyond about 23 volts. The current has a negative slope until the secondary anode potential has a value about 20 volts lower than the grid collector voltage. The current then rises with a positive slope, reaching saturation for high values of secondary anode voltage. The characteristics of Fig. 2 are similar to the dynatron characteristics first described by A. W. Hull in 1918. In the region of negative slope, the tube is unstable. If the voltage conditions are such as to make use of the negative slope, then the tube acts so as to bring the device back to a position of equilibrium in which the slope of the curve is positive.

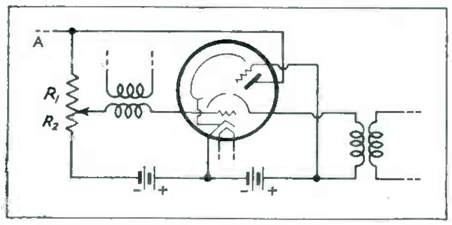

Fig. 3—Basic trigger circuit using new trigger tube. When voltage on second anode is momentarily raised, tube triggers and can then be utilized as an amplifier through the use of transformers shown

Several circuit applications are given

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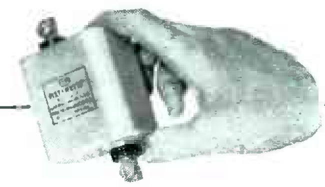

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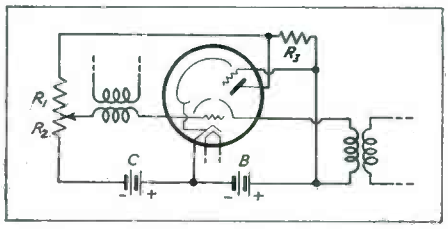


Fig. 4—Basic trigger circuit similar to that of Fig 3 but requiring smaller voltage to fire tube

by Mr. Skellett. Simple trigger circuits are shown in Figs. 3 and 4 in which the triggering impulse is shown applied to the control grid through a transformer. These circuits are identical except for the connections of the collector grid, and secondary anode. Fundamentally the circuit operation in the two cases is identical except that the circuit of Fig. 4 triggers on a smaller voltage variation than that of Fig. 3 and therefore may be regarded as being more sensitive.

In Figs. 5 and 6 are shown, respectively, the fundamental connections for a relaxation oscillator and a single tube multivibrator.

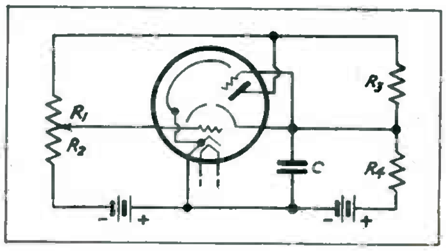


Fig. 5—Trigger tube as relaxation oscillator

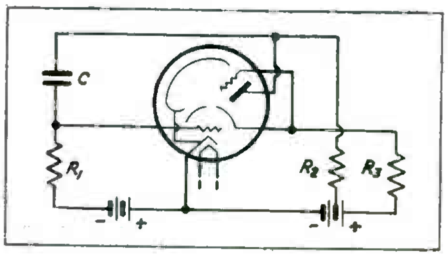


Fig. 6—Connections for using trigger tube as a one-tube multivibrator

In conclusion it is shown that although the tube described has been made up with triode structures, the application of the principle given in this article is possible for more complicated types of tube structures. It is also pointed out that if the deflector electrode is provided with a separate lead rather than being connected internally to the cathode, it may be used as an independent control of the triggering action.

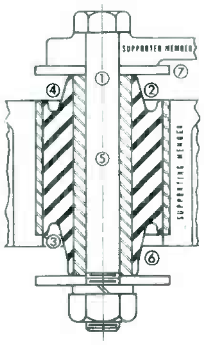
• • •

Transient Peak Voltmeter

THE JUNE ISSUE of the *General Electric Review* contains an article "Transient Peak Voltmeter," by J. C. Han-

VIBRATION CONTROL is only ONE REASON *for including* LORD MOUNTINGS in Electronic Assemblies

LORD BONDED RUBBER



1 **End Extensions**—Provide clearance between the metal members for free movement in shear.

2 **End Shape**—Throws flexing action away from the metal parts into the rubber body, preventing stress concentration at the edge of the bond.

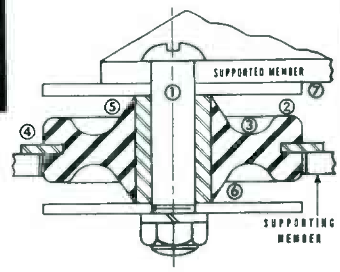
3 **Rubber-to-Metal Bond**—Lord Methods produce a high ratio of bond strength to working stress, resulting in a large factor of safety.

4 **Rubber Compounds**—Developed particularly for shear type mountings and may be changed in stiffness to suit a wide range of conditions.

5 **Center Sleeve**—Dimensions may be changed to meet any unique mounting condition.

6 **Sound**—Transference through Solid Conduction is cut off by Lord Mountings.

7 **Safety**—Metal washers, installed as shown, limit movement under ordinary overload or shock. If excessive overloads cause the rubber to fail, the suspended member will not be released without breaking one of the metal parts.



1 **End Extensions**—Provide clearance between center metal member and rubber Snubbing Shoulders for free movement in shear.

2 **Snubbing Shoulders**—Arrest shock movement and supply a cushioned stop on contact with metal washers.

3 **End Shape**—Throws flexing action away from metal parts into the rubber body, preventing stress concentration at the bond.

4 **Rubber-to-Metal Bond**—Lord Methods produce a high ratio of bond strength to working stress, resulting in an ample factor of safety.

5 **Rubber Compounds**—Developed particularly for shear type mountings, may be changed in thickness of cross section and in stiffness to suit a wide range of conditions.

6 **Sound**—Transference through Solid Conduction is cut off by Lord Mountings.

7 **Safety**—Metal washers, installed as shown, make up an interlocking system of metal parts, which limit and cushion excessive movement under conditions of overload or shock.

LORD Bonded Rubber Mountings offer many advantages for the simplification of design, reduction of weight, speedier and more economical construction, and greater operating efficiency of mechanical equipment.

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Lord Mountings are made in a wide range of standard sizes; in Plate Form for loads ranging from a few ounces up to 300 pounds each and in Tube Form from a few pounds up to 1500 pounds each. Typical methods of installation and design features of these mountings are shown above. The wide selection of load ratings makes possible the correct choice of mountings where unequal load distribution exists.

Experienced Lord vibration engineers will be glad to show you how Lord Mountings can help in the design of products essential to our war effort. Bulletins 103 and 104 describe standard Lord Mountings and contain helpful engineering information on vibration control. Write for your copy.

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IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION cock and B. R. Shepard, describing an instrument which will indicate the peak values of volt transient and recurrent voltage, with the use of a recurrent voltage indicator and without the necessity of recording and developing film traces.

The equipment consists of a direct-coupled amplifier with three input connections to accommodate the standard, sensitive, and super-sensitive galvanometer used with magnetic oscillograph. A block diagram of the essential elements of the transient peak voltmeter is shown in Fig. 1. Two capacitors are charged by the positive and the negative values encountered, and the charges are read through the

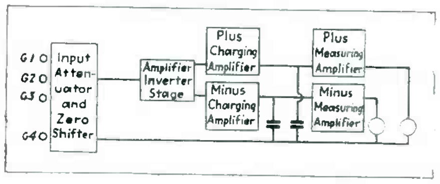


Fig. 1—Block diagram of essential elements of transient peak voltmeter

special block amplifiers on two panel instruments. The indication is maintained on the instrument for approximately 30 seconds after the occurrence of the peak, and accurate indications are obtained for peaks lasting 1 millisecond or longer. After each test the two instruments are set back to zero by means of push-buttons on the panel and the instrument is then ready for another operation.

Fundamentally, the method of measuring the peak voltage is to charge a condenser to the peak of the transient voltage and then measure the charge or voltage on the condenser after the passage of the peak. In the measurement of transients, the condenser must hold its charge for an appreciable length of time and accordingly the leakage of the condenser and associated circuits is extremely important since it determines the length of time that the peak voltage can be read after the transient has passed. This time can be made 10 to 15 seconds or longer by means of the circuit shown in Fig. 2.

The leakage is reduced to a very low value by isolating the condenser with the vacuum tube V_2 and V_3. The

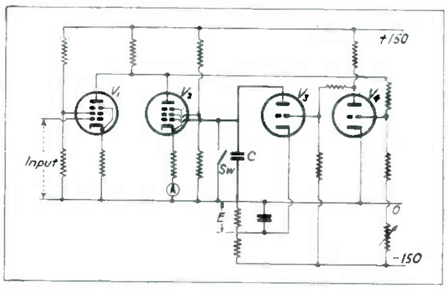
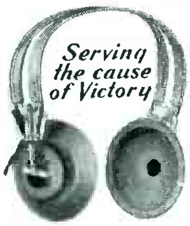


Fig. 2—Schematic diagram of the circuit connections of the transient peak voltmeter

Selected *for* Dependability



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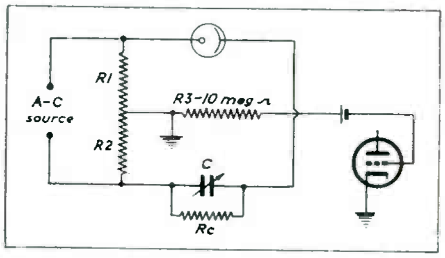
condenser C, is charged by the plate current which flows through the tube V_3. When the tube is not charging it is biased to plate-current cut-off so that there will be no leakage. The charge or voltage on the condenser is measured by the plate current in the tube V_2. The condenser voltage is likewise the grid voltage of this tube, and therefore, the plate current of V_2 will be an indication of the voltage on the condenser. Tube V_2 is operated at a point of very low grid current so that the charge on C will not leak off.

• • •

Recording Low Intensity Flashes

IN THE APRIL ISSUE of the *Review of Scientific Instruments*, Charles Butt and Robert F. Alexander, in an article "A Method of Recording Low Intensity Flashes of Light," describe a circuit for recording low intensity flashes of light of luminous animals such as the firefly. Between an alternating current source and a high gain a-c amplifier, a phototube bridge circuit is inserted capable of blocking the a-c signal when the phototubes are dark. Light falling on the phototube allows the a-c signal to pass the bridge, the output of the bridge being amplified and recorded photographically by the use of cathode-ray oscilloscopes.

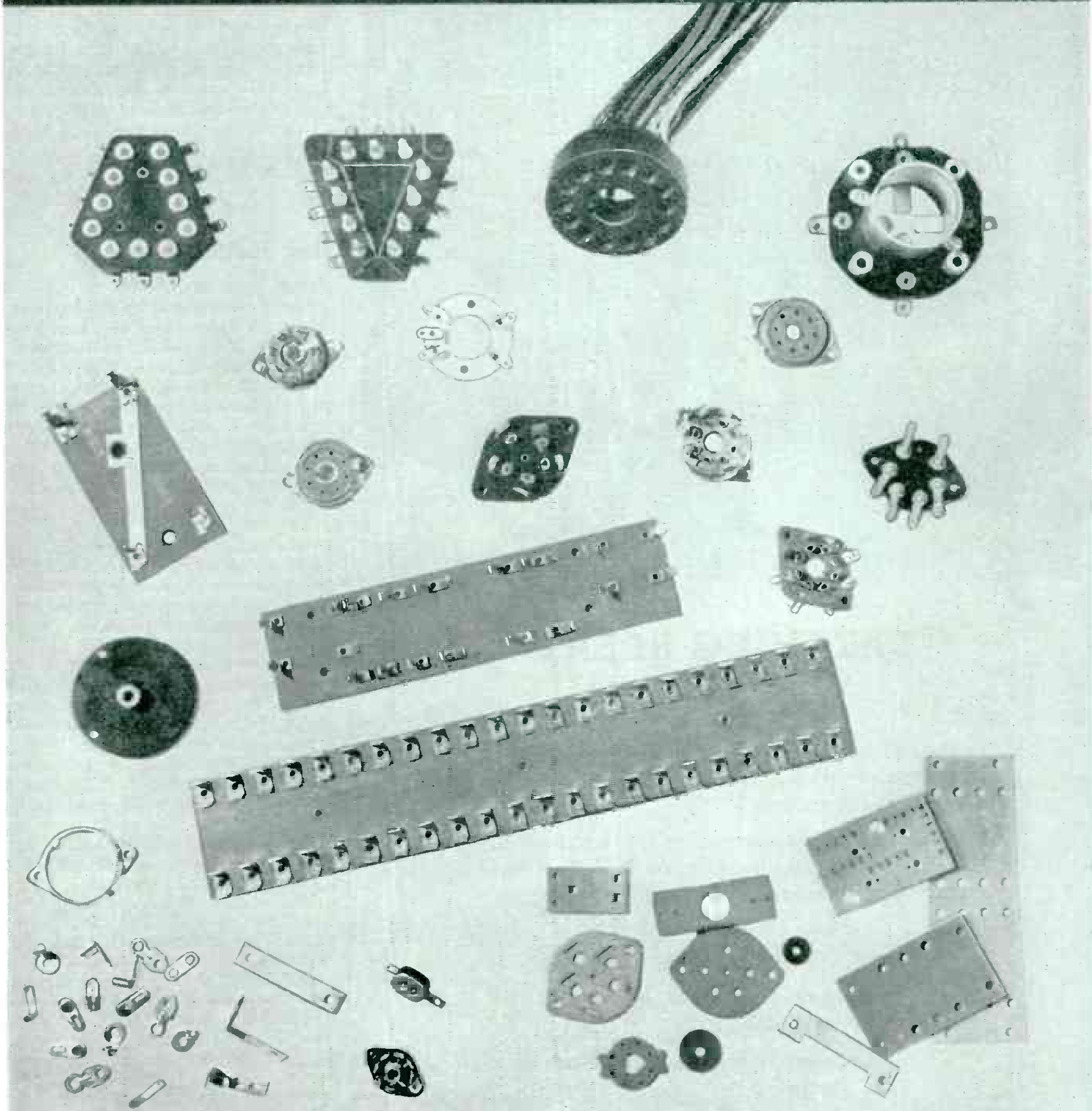


Bridge circuit for the determination of low intensities

The input bridge circuit is perhaps the most interesting feature of the entire method and is shown diagrammatically in Fig. 1. The source of power is fed to the two terminals at the left to the transformer which impresses an alternate voltage across the resistors R_1 and R_2. These resistors form one pair of arms of the bridge, while the phototube and the resistor R_3 in the condenser C forms the remaining two arms. The bridge indicator is formed by the resistor R_3 in conjunction with a high gain a-c amplifier.

Even when completely in the dark, the phototube has a certain resistance in shunt with its equivalent capacitance. These are balanced in one of the four bridge arms by means of the resistor R_c and the condenser C. The bridge is balanced by adjustment of the voltage divider so that R_1 is equal to R_2, and adjustment of the capacity,

FRANKLIN ELECTRONIC COMPONENTS



● Illustrated are a few of the parts which we are now making in large quantities for many leading manufacturers of radio, electrical, aircraft and electronic equipment and instruments. Our complete tool room and manufacturing facilities assure you prompt service on deliveries. Our skilled engineers—who understand Army, Navy and Signal Corps specifications—are available to discuss your design problems. Quotations made promptly from your blueprints. Check your requirements with us. We may be already tooled up to make the components you need.

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C. When properly balanced no voltage appears across the resistance R_3 when the phototubes are dark. However, when light falls on the phototube, the bridge becomes unbalanced and produces a voltage across R_3 which is amplified by a suitable amplifier. This amplifier consists of a four-stage capacity coupled amplifier employing a type 1851 tube in the first stage to obtain the desired high gain.

• • •

New Radio Standards

THREE NEW STANDARDS on radio have recently been issued by the Institute of Radio Engineers and forwarded to all members of the I.R.E. as a supplement to the *Proceedings of the I.R.E.* for July 1942. These standards are entitled "Standards on Radio Wave Propagation — Definitions of Terms," "Standards on Radio Wave Propagation—Measuring Methods," and "Standards on Facsimile—Definitions of Terms."

The definitions of terms on radio wave propagation are divided into three sections covering general definitions, definitions on noise, and definitions relating to the ionosphere and the propagation of waves through it. A complete index is provided.

The standard on measuring methods of radio wave propagation is divided into sections on "Methods of Measuring Radio Field Intensity," "Methods of Measuring Power Radiated from an Antenna," and "Methods of Measuring Noise Field Intensity." This standard contains a chart for the graphical determination of inverse-distance radio field intensity at 1 kilometer, using the equivalent radiated power method for ground wave transmission.

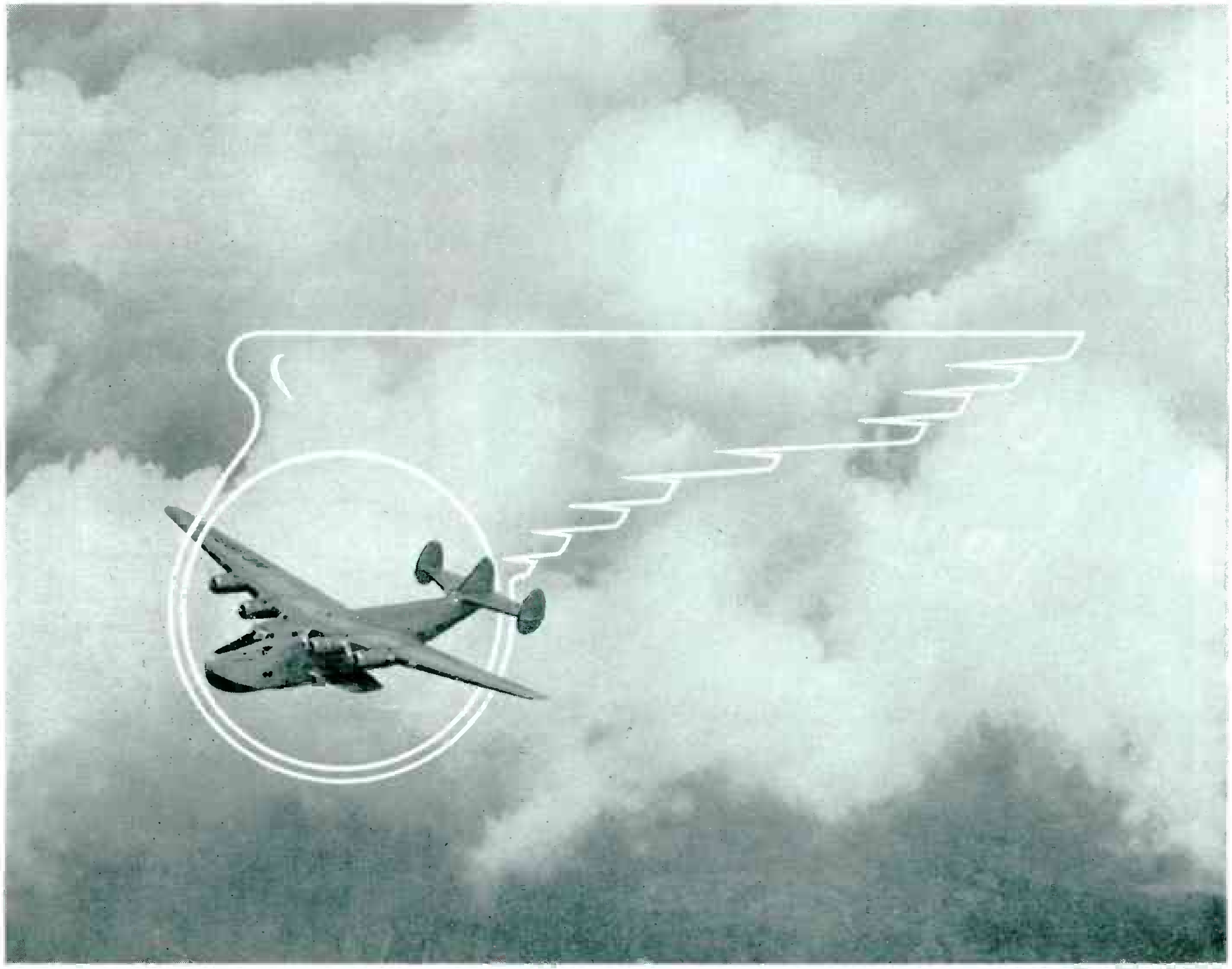
The standards on facsimile definitions are divided into definitions of terms on "Terminal Equipment," "Transmission," and "General."

Additional copies of these standards are available from the Institute of Radio Engineers, 330 West 42nd Street, New York City at 20 cents per copy for each set of definitions and 50 cents per copy for the standards on measurement methods of radio wave propagation.

• • •

Phototube Control Dynamometer Load

THE JUNE ISSUE of *Instruments* contains an article, "A Photocell-Controlled Dynamometer Loader," by R. R. Proctor, illustrating an application of phototubes which may have additional application in the industrial laboratory. In this application, a phototube is used in such a manner as to



Photographs courtesy Pan American Airways

Dependable Service

The maintenance of *all* types of radio communication systems requires accurate and reliable test equipment. The General Radio Company has always specialized in the design and manufacture of this type of equipment.

The accuracy and rugged construction of General Radio instruments have won for them particularly wide acceptance among airlines — including the world-wide Pan American Airways System—to whom reliable radio communication is vitally important. Wartime conditions have given the airlines an urgent and difficult transportation job, which means that test equipment must often be used "around the clock." General Radio instruments are built to stand up under these unusual demands.

General Radio standard-signal generator and output meter in use in the radio test and repair shop at Pan American Airways' hangar at LaGuardia Field.

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automatically control a dynamometer that the road loading of an automotive engine under acceleration could be duplicated in the laboratory. Figures 1 and 2 show respectively the general arrangement of the dynamometer and auxiliary equipment in complete sketch form, and the essential circuit arrangement of the phototube and thyratron controlled circuit.

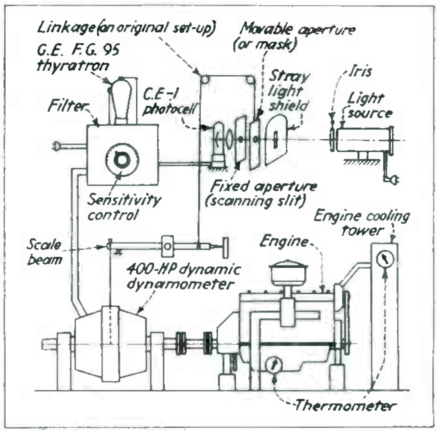


Fig. 1—Functional diagram of the various elements used in the phototube controlled dynamometer loading device

As can be seen from Fig. 1, light from a lamp passes through a number of light shields and apertures ultimately falling upon the surface of the phototube. This phototube is used in conjunction with a thyratron in a phase-shifting circuit such as the average power passed by the thyratron is dependent upon the light incident upon the phototube as shown in Fig. 2. The output of the thyratron feeds the field coil of the dynamometer as indicated in both illustrations. The movable aperture or disk would, in more refined models, be replaced by a circular or rotating disk or load diagram, is to alter the characteristics of the dynamometer in accordance with certain desired modes of operation.

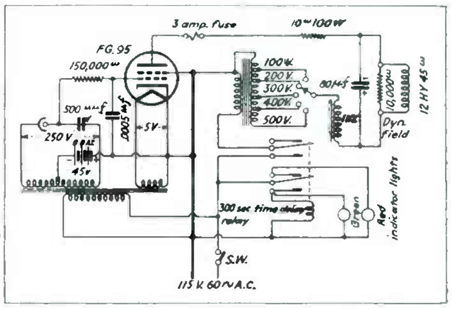


Fig. 2—Schematic diagram of the phototube and thyratron circuit

The type of dynamometer which has been used is of the heavy current type and has a characteristic similar to the speed-time curve of an automobile at low speed up to about 50 miles per hour. Operated at low speeds, no correction is needed in loading. The scale beam is down, the mask wide open and the light is adjusted to give the loading

necessary at 10 miles per hour. As the throttle is opened, the loading follows the dynamometer up to 50 miles per hour when the scale beam begins to rise, actuating the mask so as to reduce the amount of light reaching the phototube. From 50 to 65 miles per hour this constant load is maintained. If it increases slightly the upward motion of the scale beam cuts off the light from the tube and allowing the scale beam to return to normal position. From 65 to 70 miles per hour the load curve then follows the torque characteristic of the engine; in other words, acceleration begins to decrease even with constant load. Thus the time-speed curve of a car accelerates from 10 to 70 miles per hour at full throttle is duplicated on the dynamometer and data obtained by the use of this equipment has been found to show remarkable correlation with actual road test data.

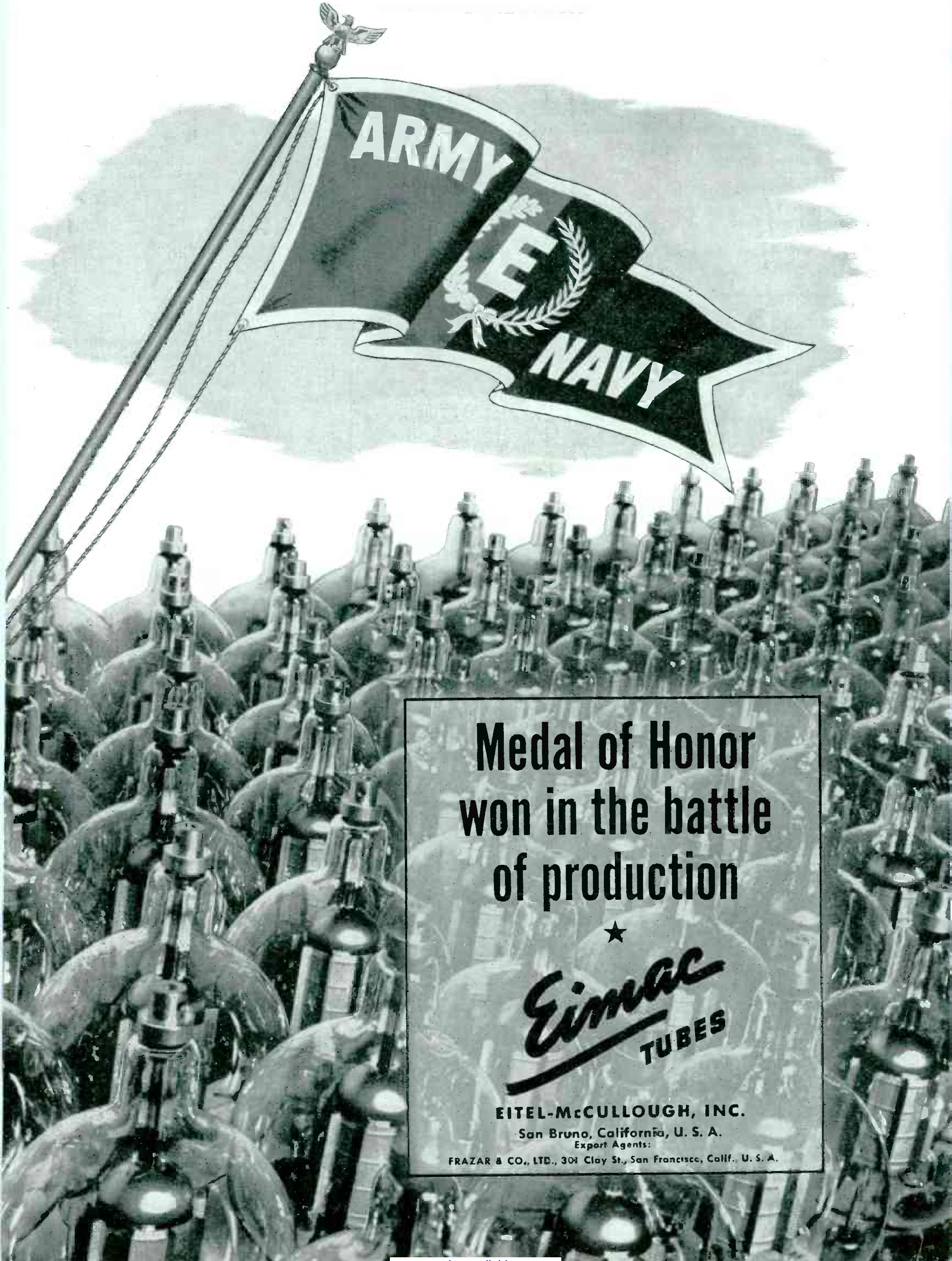
• • •

Voltage Surges in Rectifier Circuits

ALTHOUGH APPARENTLY of interest to the tube designer or engineer, the material contained in an article "The Cause of High Voltage Surges in Rectifier Circuits." by Albert W. Hull and Frank R. Elder in the June. 1942, issue of the *Journal of Applied Physics* will also be of interest to those who may encounter difficulty in the operation of the thyratrons.

In this article it is shown that high voltage surges are produced in apparatus associated with gas-discharge devices when, and only when, demands for current exceed the current carrying capacity of the gas or vapor. This current carrying capacity has a definite value which is a function of the vapor density and a cross-section of the conducting path. The limit is reached when, in some portion of the current path, all of the available atoms of the gas are ionized and are serving to neutralize space charge. Under this condition an unstable situation arises in which the ion moves to the wall, under the influence of the potential difference between space and walls that always exist, because of the higher mobility and temperature of electrons as compared to the ions. The space is thus momentarily left almost free of gas resulting in an interruption of the supply of electrons and hence an interruption in the flow of current. It is shown that surges are also caused by cathode extinction or the sudden extinction of the cathode spot on a mercury pool cathode or a sputtering hot cathode, or on an anode that is acting as a cathode during arc-back.

Commercial rectifiers and thyratrons are designed to carry their rated current, including liberal overloads, without surges. Gas limitations and the resulting surges set in only when these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ratings are exceeded. This may occur in one or two ways: (1) The vapor pressure may be allowed to fall below its specified value, thus increasing the current capacity; or (2) excessive current may be passed through the tube. The commonest cause is excessive currents which flow under short-circuit conditions. The occurrence of such surges and the consequences which follow them are caused primarily by neglect of short circuit consideration in the design of equipment. Surges will not occur in equipment designed so that maximum current demand, including short circuits, does not exceed the overload rating of the tube.

From these statements of the two authors, the designer of equipment may take the necessary steps to fortify himself against unnecessary breakdown when commercial thyratrons are operated in the field.

The article from which this abstract is taken includes a detailed discussion of the experimental procedure in arriving at the conclusion, and the overload conditions which were encountered in the experimental examination of various types of thyratron tubes.

• • •

Electronics in the Measurement of Dielectric Constants

IN THE APRIL ISSUE of the *Review of Scientific Instruments*, Boyd Hudson and Marcus Cobb describe "An Alternating Current Apparatus for Measuring Dielectric Constants." The equipment consists essentially of: (1) Crystal-controlled oscillators, (2) a variable capacitance tuned oscillator, and (3) the power supply. The article is largely confined to the description of the three units together with schematic wiring diagrams.

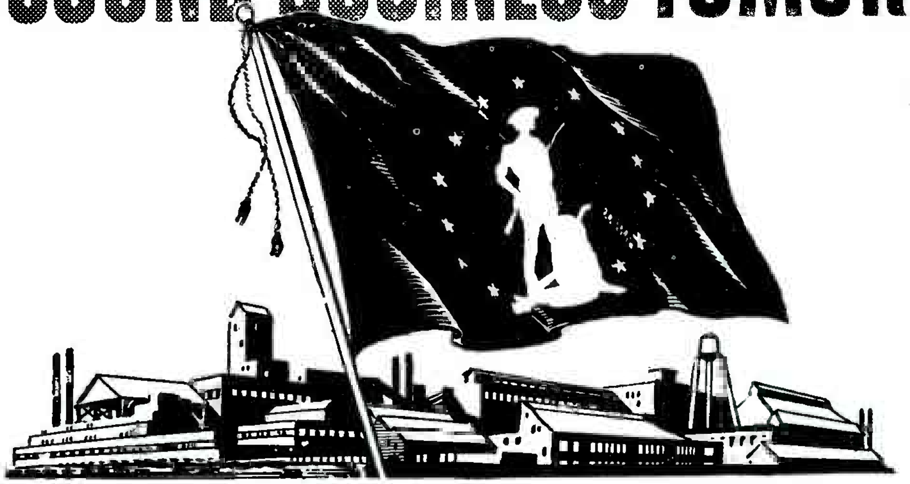
By properly choosing plate potentials and by using the line voltage that stabilizes, the effects of normal voltage variations has been eliminated.

• • •

Bibliography of Submarine Communication

A BIBLIOGRAPHY of 54 articles which have appeared in varous publications since 1914 and 62 captions from 1918 to 1940 on the general subject of submarine communication is contained in the July issue of *The Broadcast Engineers Journal*, 30 Rockefeller Plaza, New York City. It is quite likely that this bibliography may not be complete, but it should serve as a convenient starting point from which additional published material may be obtained.

FOR VICTORY TODAY AND SOUND BUSINESS TOMORROW



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ELECTRONICS

Radiation Instruments Using Geiger Müller Tubes

(*Continued from page* 48)

spurts consenser C is introduced. Regarding the mechanism of this capacitative smoothing effect, it is convenient to realize that the time constant represented by the product RC gives the time interval over which the meter reading represents an average. If we choose C as 0.5 μf, RC will be one second, and we obtain readings which fluctuate about as much as we would obtain in counting the pulses over a period of one second. At a counting rate of N per sec. the relative mean fluctuation can be expressed as $\frac{\sqrt{N}}{N}\frac{1}{t}$, where the interval over which we measure is t. With a counting rate of 1000 per sec., therefore, and $t = 1$ sec., we have for the mean fluctuation $\frac{\sqrt{N}}{N}$ 0.032 = 3.2 percent, which is sufficiently small.

Although the simplicity of the circuit shown in Fig. 8A limits the applications of the instrument, it is interesting to note its ruggedness, for instance when used with ultraviolet light sensitive GM tubes for the detection of very weak ultraviolet intensities. It is most notable, indeed, that an intensity of ultraviolet light which would cause a full-scale deflection in this instrument would, in a phototube, produce a current of only about 10^{-13} amperes which would surely be more difficult to measure.

It is clear that if a GM tube is operated in conection with a pulse integrating circuit which measures the average current, as the one just described, the measured current will vary with any variation of pulse amplitude although the number of pulses, i.e., the radiation intensity, may well be constant. Unless this effect is taken care of or known to be negligible in the particular measurements one is undertaking, means must be provided to equalize all pulse amplitudes before they reach the current measuring part of the cirsuit. Such equalization of pulse amplitudes can be accomplished in various ways, but these are well known.

By introducing further amplification of the counter pulses before measuring an integral current, the direct reading method can be applied to relatively low counting rates, provided the time constant of the integrating circuit is made long enough to make relatively steady readings possible. Figure 9 shows an instrument which was developed on these principles, and Fig. 8B represents the fundamental circuit diagram underlying its design. The sensitivity of this particular instrument is such that a full-scale meter deflection is obtained by 100 microgram-meter of radium, i.e., by the presence of 100 micrograms of radium at a distance of one meter From the Geiger Müller tube, or a source of equivalent radiation intensity.

It is not possible to cover any appreciable part of so extensive a field of radiation measurements and techniques within the space available. This article can claim only to present a summarized picture of the principle methods of such circuits. The scientific literature of the past few years contains an enormous amount cf detailed material.

FOOTNOTES

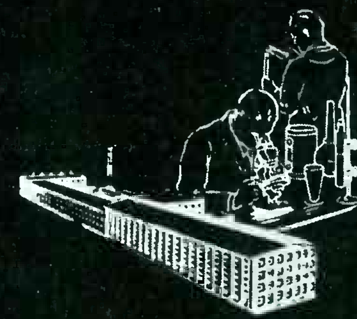
(1) ELECTRONICS, December 1941.

(2) The numerical estimates given here and further on are merely intended to give the reader an idea of the order of magnitudes which are involved, and are usually based on experience with small GM tubes of approximately 3 square centimeters projected cylinder area.

• • •

CANADIAN SOLDIERS LEARN CODE

Through an intricate system of wiring, an instructor can flash code signals to a class of fifty-eight men at one time. This is a scene in the "buzzer room" of the Camp Borden signal school



Condenser Problems SOLVED!

THE same engineering leadership that characterized Sprague peace-time activities has today long since been devoted exclusively—and on a greatly accelerated basis—to problems of winning the war. Following are a few of the Sprague developments which are proving helpful.

ELECTROLYTIC CONDENSERS FOR AIRPLANE USE—Yes—electrolytics can fly safely and perform faithfully, even at high altitudes and resulting low temperatures. Sprague has developed a special, fully proved type for this purpose.

PAPER CONDENSERS THAT STAND UP UNDER KILOVOLTS TO 90° C. It's not much of a trick to make paper condensers to stand high voltages at moderate temperatures—or much more difficult to make them to stand low voltages at high temperatures. Sprague engineering, however, has produced a unique combination of the two—high-voltage condensers (from 5,000 to 15,000 volts) with ambient temperatures of the order of 90° C.!

CONDENSERS THAT WILL STAND PULSE VOLTAGES—Sprague engineers have made a special study of this field.

PAPER CONDENSERS TO READ "OFF SCALE" ON MEGOHM BRIDGES—Sprague produces a special type that reads "off scale" on megohm meters.

SATISFACTORY MICA CONDENSER SUBSTITUTES—Sprague makes them—in paper condenser types—proved beyond all question of doubt in dozens of applications where only mica units were previously used.

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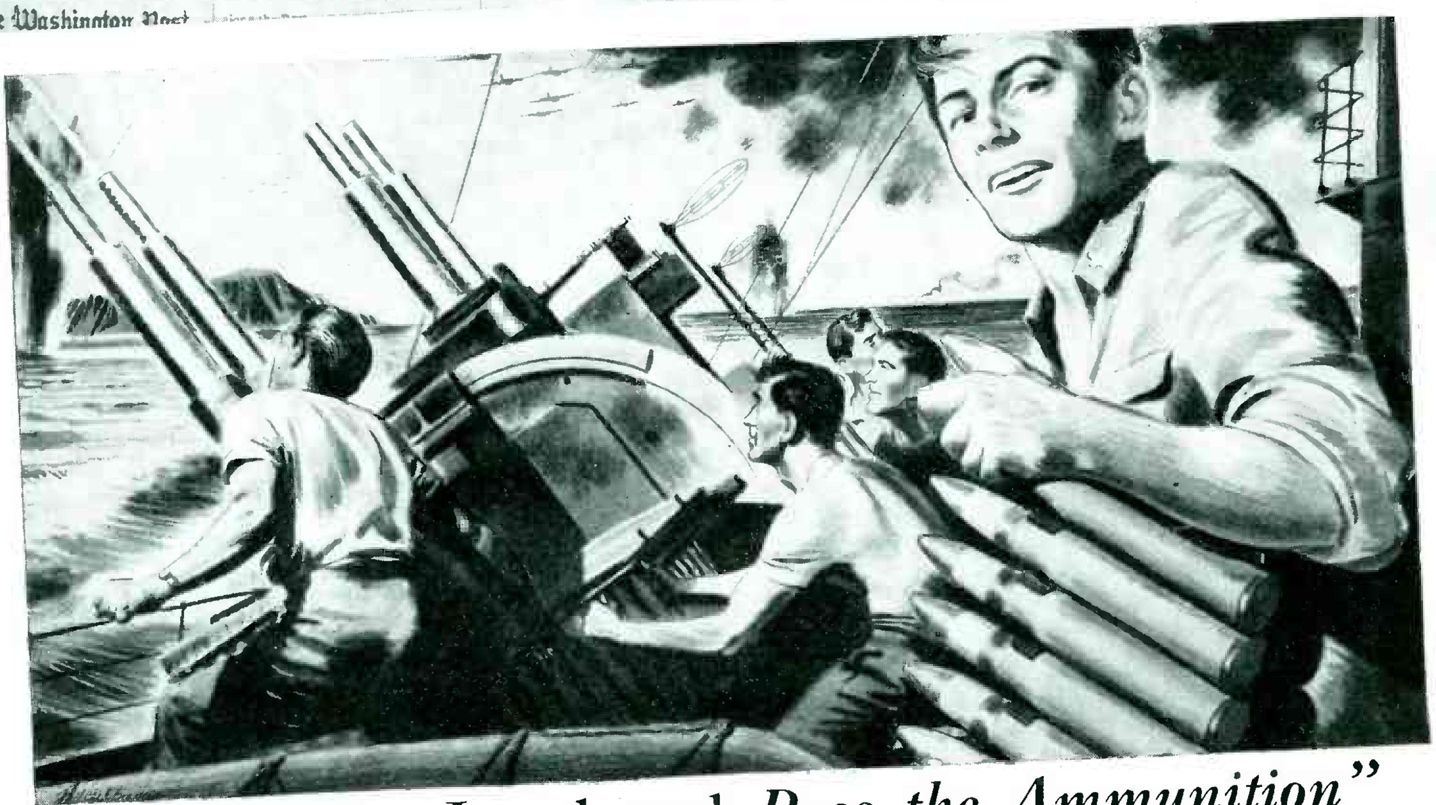


"Praise the Lord and *Pass the Ammunition*"

THIS Pearl Harborism,* uttered by a fervent Navy chaplain, will live in our school books long after today's headlines and swaying battle lines have passed into history.

It exactly expresses the unique combination of the spiritual and the practical which is inherent in our national character.

. . And America IS *passing the ammunition.* Starting with an atrophied military explosives industry in 1939, the Production for Defense program had raised the rate of "passing the ammunition" by 1400% at the time the chaplain spoke.

▶ Since then, according to an official statement of Donald Nelson:

"Explosives and ammunition are being made at many times the rate of last year as newly constructed plants come into operation. TNT is being made at a rate five times that before Pearl Harbor. Smokeless powder is being produced at a rate almost twice that before Pearl Harbor. One new plant is making more TNT today than the entire explosives industry produced in peace-time and there are several of this type of plant."

Incendiary bombs are vital ammunition in the kind of war we are in. America's chemical industry is far ahead of schedule in passing along that potent ammunition.

Magnesium is part ammunition, part construction material. You know it's now being taken from sea-water, but do you know that we are making at least 100 times as much magnesium now as we did in 1938?

100-octane gasoline isn't ammunition, but it's handy to have around in a war, because bombers using this product of American chemistry can carry an extra ton of what it takes to win.

Synthetic rubber is another necessity in passing the ammunition. The Chemical Industry faces the staggering job of producing more rubber than all the rubber trees in the world were able to pour into the American market prior to the war . . . 875,000 tons per year by 1944 is the goal. Those of us who have seen tank-factories and ship yards grow faster than the corn-crops they replaced believe the Chemical Engineers of America will do the job.

What is the secret of these amazing modern counterparts of the frontiersman's ability to turn from peace to war?

▶ One of the important answers is Chemical Engineering. We just naturally have more men and more machines that know how to make a molecule behave than any two nations on earth.

Starting after World War I, our chemical engineers used the experience gained in guncotton factories to develop the vast peacetime Chemical Industry which gave you rayon, lacquer, transparent wrapping paper, plastic telephones, knockless gasoline, shatterproof glass, synthetic vitamins, laboratory-fathered medicines, plastic tips for your shoe laces, nylon hosiery, and thousands of other comforts to help you live a peacetime Life of Riley.

This vast activity of making life more livable for peaceful Americans had created an enormous pool of management and production men in our chemical industries.

When war came, these men answered their country's call, by rearranging their peaceful atoms into bellicose molecules that would explode, fly, float, shoot or stop a bullet.

Today, fertilizer, salt, whiskey, rayon, even pine stumps are being turned into products of unrecognizable ferocity.

▶ When the war is over, it will be the imagination of the Men of Chemistry that will set our great new war-chemical plants upon a new era of peacetime fruitfulness. Even while the chemical engineer is breaking production records for war, he is planning for a peacetime production that will revert these molecules toward serving our daily lives. Chemical Warfare will become Chemical Welfare, through Imagination.

★ ★ ★

In recognition of the miracle of war production—accomplished through the cooperation of American management and labor with the W.P.B. . . . this 7th in a series of newspaper advertisements is published by the McGraw-Hill Network of Industrial Communication.

*Also title of Gene Lockhart's famous fighting song of World War II

McGRAW-HILL PUBLISHING COMPANY, *Inc.*

330 WEST 42ND STREET • • NEW YORK

NEWS OF THE INDUSTRY

Signal Corps enlarges training facilities. Experienced men needed by the Civil Service Commission and Coast Artillery School. Radio section of WPB consolidated. Progress of FM in wartime

Signal Corps Enlarges Training Facilities

THE SIGNAL CORPS IS keeping pace with the demand for trained radio men by the addition of additional training facilities throughout the nation. The Midwestern Signal Corps School at Camp Crowder, Mo., was formally dedicated and the first class graduated during August. Men will qualify as radio operators, radio repair men, telephone installers, linemen, and maintenance men at the new school. Major General Walter E. Prosser is the Commandant of the Midwestern Signal Corps School. With the opening of this new school, the Fort Monmouth Signal Corps School has been renamed the Eastern Signal Corps School. Another school for specialized technical training was opened by the Signal Corps at Camp Murphy, Fla., during July.

A new Signal Corps Replacement Training Center was opened in September near Walerga, Calif., about 12 miles from Sacramento. It is called Camp Kohler for 1st Lieutenant Frederick L. Kohler, Signal Corps, who was killed March 14, 1942, in the Far Eastern theater while serving with Lieutenant General Joseph W. Stilwell's military mission to China. Brigadier General Stephen H. Sherrill has been named commanding officer of Camp Kohler.

Under the sponsorship of the Signal Corps, the Illinois Institute of Technology is operating a school for the training of radio and electronics engineers, operators, and technicians. The school is impressive in both its size and the scope of its subject material. It has facilities for training several thousand men simultaneously and most of the courses last either 10 or 12 weeks, thereby allowing an enrollment turnover of four or five times per year. The subjects range from code instruction and radio fundamentals through the standard communication engineering up to microwave technique. Laboratory equipment, much of which is of new design and had to be specially built, is valued at $100,000.

New facilities for laboratory instruction in communication engineering were recently completed at Cooper Union according to Prof. Norman L. Towle, head of the Department of Electrical Engineering. The staff has been enlarged to administer the augmented courses. An interesting feature of the new laboratory is that much of the measuring equipment has been mounted on carriages so that test circuits in any part of the lab may be measured conveniently.

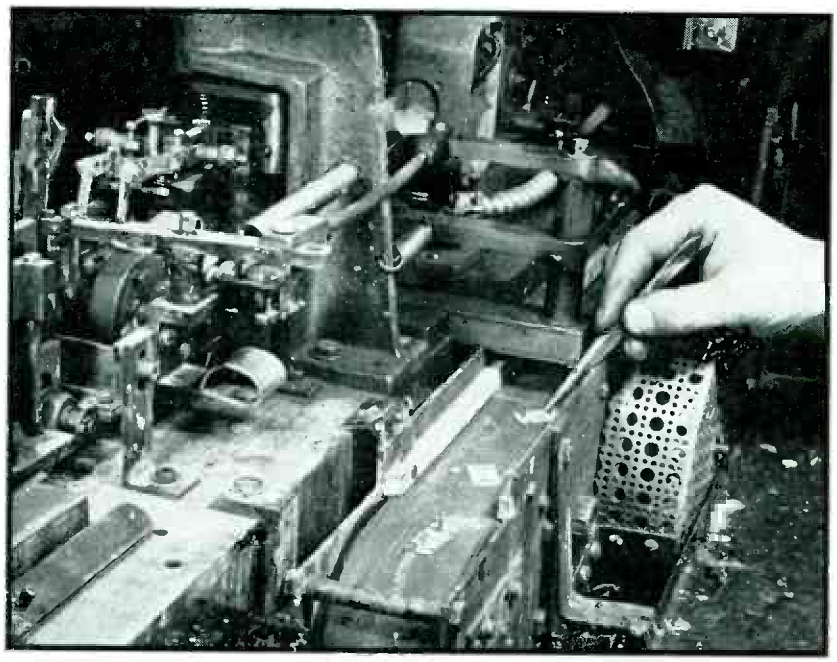
Editorial Ability Required

MEN WITH A FIRST CLASS experience in editing, writing, and publicity plus a knowledge of the iron and steel industry, engineering, machinery, aviation, radio, or allied fields are needed by the United States Civil Service Commission. Appointees will write and edit technical articles or popularize such material for the general public. Salaries range from $2300 to $4600 per year. Application should be made to the Administrative Examining Unit, United States Civil Service Commission, Washington, D. C.

The Coast Artillery School at Fort Monroe, Va., has a vacancy for a position as assistant editor with a salary of $2,600 per year. This position requires experience in teaching, preferably along engineering lines. The duties include the preparation of Coast Artillery subjects for presentation to trainees, and the preparation of technical manuals for the use of the Coast Artillery personnel. For further details write to Lt. Col. D. C. Tredennick, Director, Department of Training Publications, Coast Artillery School, Fort Monroe, Va.

For Government Contractors and Sub-Contractors

EVERY COMPANY DEALING directly or indirectly with the Army, Navy, or Procurement Division of the Treasury Department, as contractor or sub-contractor, should procure a copy of a government pamphlet wherein may be found for the first time in printed form a definite outline of the manufacturing and other contract performance cost items, and expenses of an administrative and distribution nature which are allowable under contracts with these three government agencies. The pamphlet, entitled "Explanation of Principles for Determination of Costs under Government Contracts", may be obtained from the Superintendent of Documents, Washington, D. C., for ten cents.



ANOTHER CASE OF THE SUBSTITUTE **material outperforming the original. The conveyor belt carrying the mica spacers for radio tubes in an RCA tube plant was formerly made of woven wire, but is now made of a synthetic resin known as Resistoflex. The new material has high resistance to flexing and abrasion and, in addition, the small parts do not get caught in or stick to the solid Resistoflex sheet as had occurred with the woven wire belt**

Air Conditioning for a rivet

. . . and YOU!

Silly? To air condition rivets? Not at all. When aluminum rivets are cooled to sub-zero temperatures they can be riveted faster and more perfectly . . . *speeding up airplane production.*

Many of us think of air conditioning only in terms of comfort for human beings. Yet today, air conditioning's most important job is to keep the *machines* and *materials* of war industry at desired temperatures and humidities.

To meet these wartime needs, revolutionary advances in air conditioning technique have been made. Temperature and humidity are maintained *far more exactly* than ever before. Equipment is more compact, more flexible.

With the coming of peace, this experience will be applied to the making of improved air conditioning equipment for all sorts of uses. *Packaged* air conditioners will be smaller, more compact, more economical—many more homes will have them. And in offices and factories, air conditioning will lower costs and increase efficiency. General Electric will be a logical source of all types of this new equipment for air conditioning, refrigeration, heat transfer and heating.

Air Conditioning and Commercial Refrigeration Department, Division 422, General Electric Company, Bloomfield, New Jersey.

Air Conditioning by

GENERAL ELECTRIC

Radio Section of WPB Consolidated

All radio communication equipment requirements, civilian and military, have been consolidated under the direction of the Radio and Radar Branch of the Aircraft Production Division. Formerly there were two groups that covered this field. The Radio and Radar Branch handled military requirements and the Radio Section of the Communications Branch handled civilian requirements. The latter section has been transferred to the Radio and Radar Branch and has been named the Civilian Radio Section. Frank H. McIntosh, who was chief of the section under the Communications Branch, will continue to be chief under the Radio and Radar Branch. Ray C. Ellis, chief of the Radio and Radar Branch, will head the augmented group.

FM Progress in Wartime

In spite of wartime requirements for both material and men several additions of equipment to FM broadcast stations have been made recently. Antenna arrays have been lately shipped to the following stations:—W47NY (Muzak), New York; W73PH (WPEN), Philadelphia; W67NY (CBS), New York; W57PH (KYW), Philadelphia; and W59C (WGN), Chicago. General Electric has delivered relay transmitters operating in the 340 to 350 megacycle band to W47A and W85A in Schenectady, W41MM in Clingman's Peak, N. C., and W75C in Chicago.

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THE "WALKIE TALKIE"

This photograph shows a "Walkie Talkie" being used by the United States Signal Corps at an outpost. The palm microphone, the head band receiver and the connecting equipment, which is manufactured by The Kellogg Switchboard & Supply Co., keeps the Army front line in touch with situations in the field

Brazil Seizes Undercover Transmitters

Although Brazil had officially broken off all relations with Axis countries early this year it has been plagued since that time with a number of illegally operated transmitters which gave shipping information to Axis submarines lurking off the Brazilian coast. Several of these transmitters have been located, some with the help of the FCC Radio Intelligence Service, and confiscated. A most vigorous hunt for such transmitters in Brazil is bound to follow the recent declaration of war with a consequent decrease of efficiency of submarine activity in the ocean off the eastern coast of South America.

IRE Nominees

Dr. Lynde P. Wheeler, chief of the FCC Engineering Department technical information section, has been nominated for the presidency of the Institute of Radio Engineers for 1943. Frederick S. Barton, chief of the British Air Commission's radio division in Washington, is nominated for the office of vice president. This office is generally held by a prominent radio engineer of some foreign country. There are six candidates for the three directorships to be filled this year. They are Elmer W. Engstrom, director of the RCA Laboratories at Princeton, N. J.; Frederick R. Lack, vice president and manager of the Western Electric radio division; Frederick B. Llewellyn, circuit research engineer, Bell Laboratories; Prof. Wilmer L. Barrow, Massachusetts Institute of Technology; Prof. Carl C. Chambers, University of Pennsylvania; and Harold A. Wheeler, Hazeltine Service Corp.

WPB Advisory Committee Studies Radio Tube Industry

The Radio Receiver Vacuum Tube Industry Advisory Committee of the WPB's Communications Branch Radio Section is studying a plan whereby the production of certain types of tubes will be concentrated in certain plants so that there can be large production runs of those types with the attendant advantages which come with steady operation. Also, some plants might concentrate on tubes for military purposes and others on tubes for civilian use. The civilian tubes might be "Victory Models" in which the greatest use possible of substitute materials would be made.

This committee includes M. F. Balcom, vice president, Sylvania Electric Products, Inc. (formerly Hygrade Sylvania Corp.); Henry Bonfig, vice president, RCA Manufacturing Co.; Roy Burlew, president, Ken-Rad Tube and Lamp Co.; Raymond E. Carlson, vice president, Tung-Sol Lamp Works, Inc.; and L. H. Coffin, president, Hytron Corp. Other subjects which will be studied by this committee are the problems of conversion, conservation, use of army and navy rejects for civilian purposes, and simplification of design.

Maj. Gen. Olmstead Honored

The annual Citation of Merit for 1942 of the Poor Richard Club was awarded to Major General Dawson Olmstead, Chief Signal Officer of the Army, on August 18 in Philadelphia. The citation reads, "For his work in the development of communications for the Army, in recognition of the difficult problems which have faced him and the courage and ability with which he has solved them, during these days when a global war fought in three dimensions requires communications facilities of a quality, a quantity, a range and a diversity unknown before."

In his talk following the award, General Olmstead outlined the importance of communications in modern warfare and declared that for every 100 soldiers in the Signal Corps there are required an additional 50 civilians. He described an airplane without a radio as a dead pigeon and a tank with defective communications as a blind horse.

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PREDICTS "ELECTRONIC AGE"

Col. David Sarnoff, president of the Radio Corporation of America now on special assignment by Maj. Gen. Dawson Olmstead, Chief Signal Officer, foresees a post-war electronics age in an address to Signal Corps graduates at Camp Murphy, Fla.

Ice Indicator for Airplanes

AIR-OPERATED pulsating rubber boots, or de-icers, have been used on aircraft for a number of years to break up ice on the wings before it can alter the shape, and therefore the characteristics, of the airfoil. The operation of these de-icers is rather critical with reference to the thickness of the ice. If the ice is too thin, it breaks up, but clings to the wing surface forming an excellent matrix for further accumulation. If the ice is too thick, much of the effectiveness of the de-icer is lost. To enable the pilot to determine the proper time to operate the de-icer, the Minneapolis-Honeywell Regulator Co. developed an ice thickness indicator which uses electron tubes and circuits. When the ice reaches a thickness of one-eighth of an inch (optimum thickness for de-icer operation) the pilot receives an indication and he turns on the de-icer. Or it can be made to operate automatically by the measuring device. Because of war conditions it is not possible to release circuit details at this time.

E. W. Ritter on Special Assignment to Signal Corps

E. W. RITTER, recently appointed as assistant to G. W. Cole, president of the Corning Glass Works, has been called to Washington for work in connection with the Signal Corps. It is expected that the assignment will require about three months after which Mr. Ritter will return to his duties at Corning. Until June of this year he was vice-president in charge of manufacturing and product engineering of the RCA Manufacturing Co.

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TRAINING COAST ARTILLERYMEN

In this radio communication lab at Fort Monroe, Va., men are taught theory and practice of radio communications. Gathered around a remote control transmitter is Warrant Officer M. G. Brasher, instructor; Corp. R. J. Smearing, Sgt. J. F. Lyons and Pvt. J. P. Fabynick

Western Union Develops Multiple Address Transmission System

In recent months a considerable portion of the traffic load of the Western Union Telegraph Co. has been the same message addressed to a large number of companies and individuals. To speed up the transmission of such messages Western Union engineers have developed a device which is installed in key cities such as New York and other large traffic centers. A signal is flashed when a multiple address message is coming into the office for distribution to a long list of addressees in a number of different cities, at which time the operator switches over the receiver from the usual printing operation to a new operation in which nine perforating instruments are connected to the receiver and each one perforates four tapes so that there are 36 identical message tapes. Then each tape, with the appropriate address, is sent through a transmitter on a trunk line to the city of destination where it arrives in the conventional form. An automatic check is made on the accuracy of each tape by a continuous comparison of all tapes with the master tape during final transmission.

Western Electric Dividend

The directors of the Western Electric Co. have declared a dividend of 25¢ per share on its common stock. The dividend is payable on September 30 to stock of record at the close of business on September 25.

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NEGRO TROOPS REACH HAWAII

Corp. Willis P. Goring operates the busy switchboard at regimental headquarters in Hawaii. He is one of the 1,500 Negroes who landed in Hawaii from the U. S. Under the command of Col. Chauncey M. Hooper, this is the first all Negro combat troop to reach Hawaii

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here

Contacts

GIBSILOY CONTACTS are available in laminated metals, resulting in lower contact costs and conservation of vital metals. The manufacturer uses Gibsiloy as the facing on the contact surface and an inexpensive base metal for the backing material. The Gibsiloy material is obtained by special processing of metal powders which do not naturally alloy with one another. Contacts are available in both inlay and overaly types, and may be purchased with either Gibsiloy or with fine silver or other precious metal contact surfaces, for a wide variety of contact applications.

Gibson Electric Co., Pittsburgh, Pa.

Control for Induction Motors

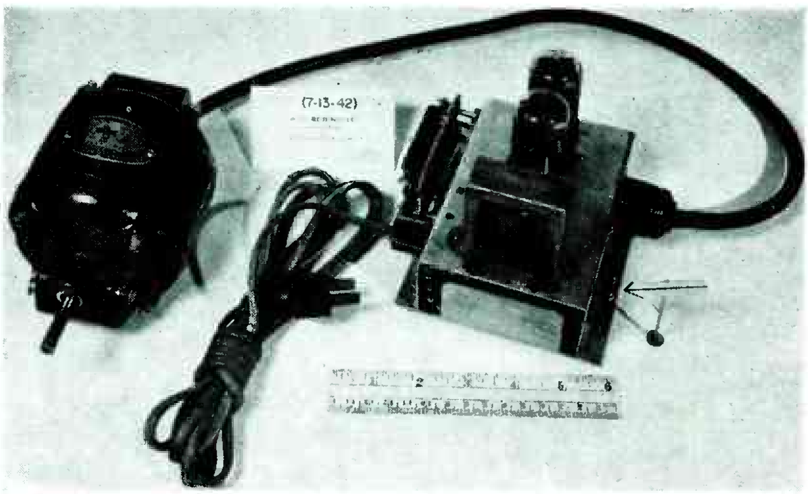
"MOTRON" IS AN ELECTRONIC instrument for use with a-c induction motors. The instrument will control the direction and the speed of rotation of conventional single and two phase induction motors. This is done by means of electronic control circuits of microwatts power, and is accomplished without commutating or interrupting the motor load current, and without mechanical or moving contact of any type. The Motron may be used in place of a relay or of a commutator reversing motor. Other applications include high altitude airplane operation, adjustable speed applications of extreme sensitivity for thread or wire winding, measuring, moving, controlling, and explosion-proof applications. Patent pending.

W. C. Robinette Industrial and Electronic Development, 804 North Chester Ave., Pasadena, Cal.

Polystyrene Sheets

BY MEANS OF THERMAL and mechanical treatment a new degree of toughness has been made possible in Polystyrene sheets. The new material has the same insulating properties as the former material (as well as resistance to acid) and its flexibility makes it usable for condenser manufacture, cable wrapping, or thin washers or windows for electrical uses. The sheets may also be used to replace hard rubber or mica in some applications. The material is available in ribbons or sheets in various thicknesses of from 1 or 2 mils up to 20 mils. Customer specifications will be considered.

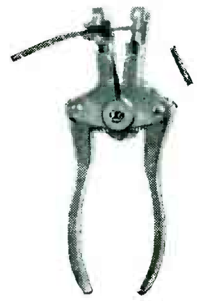
Plax Corp., P. O. Box 1620, Hartford, Conn.



The picture shows the details of the Motron as applied to a General Electric 1/50 hp stock motor, to which minor modifications have been made. The model of the motor is 5KH 15 AA 39 and is rated at 1/50 hp continuous duty, 50cps, 1425 rpm. The Motron and motor operate on 60 cps, 117 volts

Automatic Wire Stripper

THIS NEW UNIT instantly strips insulation from all types of wire, and it can



also be used as a wire cutter. All that is necessary to operate the tool is to press the handle.

General Cement Mfg. Co., Rockford, Ill.

Industrial Analyzer and Tester

TWO OTHER INSTRUMENTS FROM the same manufacturer include a new Model 500 industrial analyzer and Model 520 insulation and breakdown tester. The first instrument features an 8½-inch D'Arsonval type meter which uses a new type of Alnico magnet to provide an arc of 100 deg. This is a complete instrument which may be

Model 520 Tester

used as an insulation tester and which provides all the measuring services required for repair, maintenance, development and laboratory work.

Model 520 insulation and breakdown tester features a super-sensitive danger indicator which automatically glows to indicate leakages up to 1,000 megohms. The instrument supplies four voltage ranges of 250, 500, 1,000 and 2,500 volts. It instantly shows up shorts and opens.

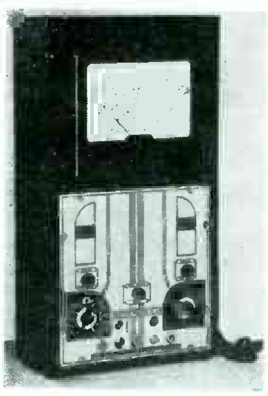
These two instruments are more thoroughly described in one bulletin available from Superior Instruments Co., Dept. O.R., 227 Fulton St., New York, N. Y.

Multitesters

Stock Model No. 423 multitester (for use in production line tests and commercial laboratory measurements) has a 3-inch meter which has movement of 395 microamps, or a sensitivity of 2,500 ohms per volt. The instrument itself has a uniform a-c d-c voltmeter sensitivity of 1,000 ohms per volt. Other features include an ohmmeter range of 10 megohms; each shunt and multiplier is individually calibrated to a close tolerance; all multipliers are individually matched in pairs with an overall accuracy of within 1 percent; suppressor type copper oxide rectifier is used for a-c measurements; and cabled or harness type construction is used

throughout. The instrument is completely self-contained, with necessary batteries.

Another multitester, by the same manufacturer, is a vacuum tube multitester (not a copper oxide rectifier type) designated as Model No. 662, which is an electronic voltmeter, ohmmeter and capacity meter combined. It furnishes accurate and comprehensive capacity readings directly in microfarads, with a measurement ratio of 40,000,000 to 1. There are no test leads to short, and no resetting is nec-



essary when changing ranges. The meter cannot be damaged by checking a live resistor, or by using a low range on high readings. Line voltage fluctuation errors are eliminated by the use of a VR105-30 regulator tube and associated circuits. Model 662 employes a sloping panel and a 4½-inch meter. An upright-style companion model, designated as No. 662-V-7, is also available with 8½-inch rectangular meter. Both instruments have similar performance characteristics and come complete with leads, batteries, tubes and pilot lights.

Radio City Products Co., Inc., 127 West 26th St., New York, N. Y.

Voltage Breakdown Tester

SIMPLE, POSITIVE, SAFE and quick means of testing voltage breakdown of materials or components may be accomplished by a voltage breakdown tester which comes in two models, both of which are continuously variable over entire range. Type P-1 operates on 0-4000 volts, d.c., and Type P-3 works on 0-10,000 volts, d.c. Housed in a metal cabinet with a sloping panel, the instrument consists essentially of a step-up transformer accurately controlled by a Variac; current-limiting resistors safeguarding the equipment in the event of a dead short; a relay indicating by means of a panel light when there is a breakdown; a meter providing direct-reading voltages; and the rectifier and filter circuit providing the high-voltage

d.c. A self-incorporated safety switch makes the power supply inoperative if chassis is removed from case or otherwise disturbed.

The high voltage is applied by means of a suitable fixture or by a test prod connecting with proper receptacle on the instrument panel, as well as by a second connection to the groundbinding post on the panel. The instrument connects with 110 volt 60 cps a.c. A ground clip goes on nearest grounded conduit or water pipe. A power switch turns the instrument on and off. To set the instrument for test, the Variac is rotated counter-clockwise until desired voltage is indicated on the meter. When material or component is tested, a warning light on the panel flashes on to indicate breakdown. A second light indicates that the instrument is alive.

Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.

Radio-Frequency Bridge

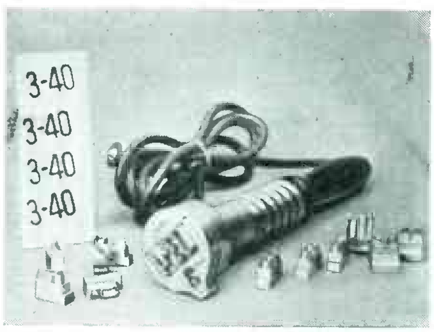
TYPE 916-A RADIO FREQUENCY bridge replaces the manufacturer's older model 516-C. This new model is a simple, accurate instrument which measures relatively low impedances in terms of their effective series resistance and reactance components. It can be used at frequencies up to 60 Mc. In addition to the greatly increased frequency range, the new bridge has two features that distinguish it from the older bridge, namely a considerably greater direct-reading resistance range, and a simplified dial for reading reactance. The resistance range, from zero to 1000 ohms, is covered on a single 8-inch dial with a scale that is roughly linear from zero to 1 ohm and logarithmic from 1 ohm to 1000 ohms. The resistance-dial reading is independent of frequency. The reactance range, from zero to 5000 ohms, is covered on a single 4-inch dial with a scale that is roughly linear from zero to 50 ohms and logarithmic from 50 ohms to 5000 ohms. The reactance-dial reading varies directly with frequency, the engraved scale being direct reading at a frequency of 1 Mc.

The wide frequency range covered by the new bridge permits convenient and accurate direct measurements of low impedances at frequencies extending up through the FM band to the top of television channel 1.

General Radio Company, 30 State St., Cambridge A, Mass., describes this instrument quite thoroughly in its publication the *General Radio Experimenter*, Volume XVIII, No. 3.

Electric Brander

CRYSTAL HOLDERS and other parts used by Signal Corps or communication equipment can be branded with a name, trademark, or Government emblem, with a new hand electric brander (No. 40) which is capable of branding materials of plastic, wood, fiber, or fabric. Letters and figures can be interchanged in the holder, and interchangeable dies can be substituted. The type and dies are available in brass, bronze, or steel. Anyone can operate the brander by simply plugging it into a light socket.



The Acromark Corp., 9 Morrell St., Eliizabeth, N. J.

Microphones and Switch

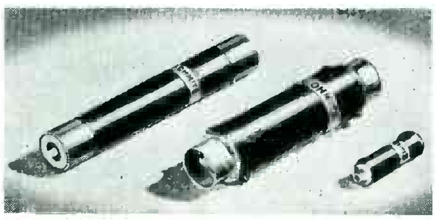
AVAILABLE, IN QUANTITY, to government contractors and subcontractors are standardized microphones for aircraft, ground stations and the like. These microphones include two new models designated as CU-1 and CU-2 (the manufacturer has discontinued the AR-1 series). Model CU-1 utilizes a three-conductor plug, and Model CU-2 uses UMIC plug No. 8. Each model has a three-way plug connection. Silver contact switches are utilized in both models. The assemblies are rugged, durable and lightweight, and come in plastic cases with moisture-proof cords, of single button carbon design. Motor noises are damped out with specially designed anti-noise construction. Button impedance is 200 ohms with an approximate output of 30 volts rms across the transformer secondary. A single throw, double pole, press-to-talk switch connects the microphone and relay circuit in proper sequence.

Also available is a standard microphone switch, designated as SW-141, which has been built to specifications and approved by the Army Signal Corps. The assembly is housed in a plain plastic case with a hanging eye at the top. The switch can be adapted for various communications devices for mobile units. It was designed specifically for use on cord assemblies CD 318 and CD 508, but can be used for other applications.

Universal Microphone Co., Inglewood, Cal.

Resistors

"FERRULE" TYPE RESISTORS may be interchanged without the use of tools. In its construction the resistance wire is wound evenly on a ceramic core which is protected by a vitreous enamel coating. The wire is then terminated on metal bands (or ferrules) which permit mounting on fuse clips. Special

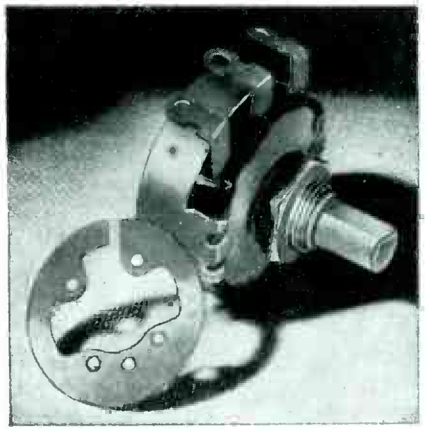


ceramic cores are available with special coating to allow the cores to withstand the temperature shock of repeated immersions alternately from ice cold water to hot water. Protective coatings which pass salt water immersion tests are also available. Units which meet Navy specifications can be supplied in a wide range of sizes, and in cup, sleeve or cartridge types.

Ohmite Mfg. Co., 4835 Flournoy St., Dept. 4-A, Chicago, Ill.

Non-Wire-Wound Potentiometers

SERIES 37 CONTROLS are made with a new stabilized element which gives the controls a high resistance permanence and immunity to climatic conditions. This new stabilized element takes the form of a resistive coating on a bakelite base, and is practically as smooth and hard as glass. The element is chemically treated during processing to eliminate all further changes in its



composition, and to stabilize its temperature and humidity characteristics; so that the controls have accurate resistance values even after continuous usage under adverse conditions. Another feature is that the controls may be used in place of wire-wound units for relatively low resistance values.

Clarostat Mfg. Co., Inc., 285 North 6th Street, Brooklyn, N. Y.

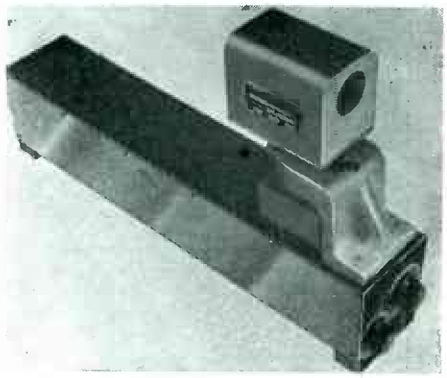
Fibre Combination Materials

THREE TYPES OF FIRBE combination materials include Seybolite fibre-graphite, Seybolite fibre-asbestos and Saybolite fibre-mineral. Fibre-graphite and fibre-mineral come in molded products or panels (sheets and boards) in non-laminated and laminated forms. Fibre-asbestos is mainly produced in thin panel form, and its electrical resistance runs into millions of ohms. Fibre-mineral is rated at billions of ohms electrical resistance. Dielectric strength for both these materials is about 20; and power factor is rated at 2.3. Fibre-graphite can be extruded into strong cans, in place of aluminum. Fibre-asbestos may be used as paneling and partitioning of electrical equipment in general. Fibre-mineral may be used as housings, paneling, or partitioning in electrical devices and switchboards, or as insulation in electrical transmission lines.

Literature giving complete data such as physical properties is available from Westport Products Co., Inc., (Licensee of Substitute Fabrication Materials, Inc.) Westport, Conn.

Registration Control

MODEL B-16 DUAL SCANNER registration control is a complete and flexible photoelectric instrument. While it has been especially designed for the packaging field, it can be adapted for use with a wide variety of materials wherever a material is fed to a machine in a continuous sheet or strip. It provides operation control on materials such as cellophane or glass, waxed paper, light paper or cardboard, cloth or fabrics, metal foil or metals. It accurately



cuts materials to specified lengths, definite length of printed matter or design, and actuates operation cycle on packaging machines.

The operation of the control is initiated by varying the intensity of the phototube illumination. One unit houses the complete control into a compact unit which can be easily mounted and installed, or removed for service or replacement.

United Cinephone Corp., Torrington, Conn.

Double Coil Relay

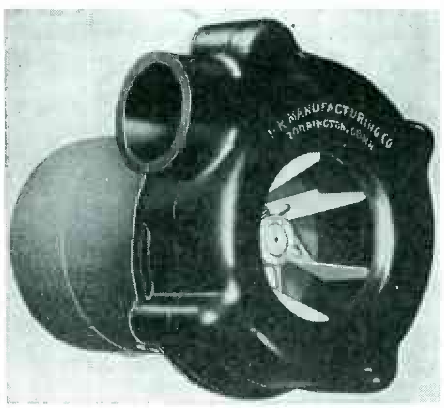
THESE RELAYS ARE mechanical latching double coil relays of the telephone type for applications in supervisory control equipment. The feature of this relay is that its contacts can interrupt the current to the coil being energized so that the coil is energized only momontarily, and as soon as the relay armature goes to its new position the relay contacts interrupt the current. The relay is energized only while the relay armature and the relay contact are going from one position to the opposite position. Another feature of the relay is that the armature must pass over a "dead center" and therefore the armature and the contacts must be in either their one position or in their opposite position, and there is no possibility of the contacts remaining in some intermediate position. Because of the "dead center" construction, the operation of the relay is unaffected by vibration or shock.

Other features include: positive toggle action; no sliding parts or delicate adjustments; mounting can be made in any position; positive and ample contact travel; adjustment of contacts to break operating coil circuits not critical; vibration cannot cause creeping of the armature; operating time in either direction is less than 0.005 second; the toggle spring is adjustable for any contact combination; contacts have wiping action and contact pressures are maintained in excess of 35 grams; contact springs are made from cold rolled nickel-silver stock, and contacts are of palladium and are welded to the springs; coils are wound for both alternating and direct current up to 220 volts; relay can be furnished with a 12-point plug, or it can be furnished in single stud mounting; many contact combinations are available.

Control Corp., 600 Stinson Boulevard, Minneapolis, Minn.

Blower Housing and Wheel

No. 2 BLOWER wheel and housing was designed primarily for use in restricted spaces and high temperatures encountered in airborn electronic units. The housing is made of high impact plastic capable of withstanding temperatures to 375 deg. F. The wheel utilizes two holding screws in the hub which are set



at an angle of 90 deg. Output is rated at 60 cfm at 7500 rpm. The unit has Universal mounting (with motor plate for any small motor) and is assembled with four 10/32 screws which may be used as bracket supports for various methods of mounting.

L-R Mfg. Co., Torrington, Conn.

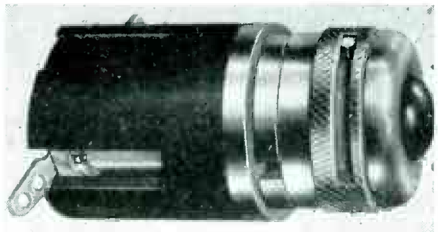
Large Photoelectric Cell

"GIANT" R-1000 SELF-GENERATING photoelectric cell is available for twilight switches, light barriers and other applications requiring a light sensitive element at a considerable distance from the control room. The new unit measures 7⅜ inches in diameter, and has a current output of 4000 microamps at 100 ft. candles.

Emby Products Co., 1800 West Pico Blvd., Los Angeles, Cal.

Panel and Signal Lamp

"DIM-E-ROID" IS THE NAME of a panel and signal lamp which was designed for use in instrument panels of military aircraft to eliminate the incorporation of transformers and resistors in electrical systems for the purpose of dimming intensity of signal lights. Polarized discs or a mechanical shutter control the light emission intensity without interference with the electrical circuit proper. The lamp is made of non-ferrous material and has a plastic



jewel, in any color desired for different signal purposes. Model No. 1920 is constructed with a mechanical shutter and Model No. 1874 operates by means of two opposed polaroid discs. Both models are similar in appearance and mounting dimensions. A slight turn of the head of the lamp changes the light intensity from very bright to very dim. Model No. 1920 can also be made, if desired, to change light intensity from bright to total blackout.

American Radio Hardware Co., Inc., 476 Broadway, New York, N. Y.

Literature

Capacitors. Dykanol capacitors for power factor improvement are described and illustrated in a 6-page folder. The enclosed box-type units, indoor rack-type and outdoor rack-type units are covered. Cornell-Dubilier Electric Corp., South Plainfield, N. J.

Wall Chart. A wall chart 21x27 inches, reinforced at top and bottom by metal strips, with an eyelet for hanging, explains, the uses of various types of self-locking nuts. There is a description of how and why they work, advantages to be obtained by their use and the method of application. Elastic Stop Nut Corp., 2332 Vauxhall Rd., Union, N. J.

Panel Instruments. Catalog 4120 describes and illustrates 3- and 4-inch panel instruments. The various types of cases are illustrated, dimensions and listings of shunts are described and dimensions and mounting details on all standard panel instruments are shown. Roller-Smith Co., Bethlehem, Pa.

Receiving and Transmitting Tubes. The RCA receiving tube booklet contains three charts. Chart I classifies receiving tubes according to their cathode voltages and function. Chart II gives characteristics of each of 329 receiving types arranged in numerical-alphabetical sequence. Chart III is a tabulation of "special purpose" tubes.

The 1942 RCA Guide for Transmitting tubes contains three major sections: transmitting tube data, transmitting circuit facts and transmitter construction.

Copies of the 1942 RCA Guide can be purchased from any RCA distributor or by sending thirty-five cents to Commercial Engineering Section, RCA Mfg. Co., Inc., Harrison, N. J. Requests for RCA Receiving Tubes and Allied Special Purpose Types can be obtained from the latter.

Spectrum Chart. A new seven-color wall chart of the entire electromagnetic spectrum has recently been published by the Westinghouse Research Labs. The chart is printed on heavy white cloth, approximately 30x40 in. and is bound at top and bottom in ⅜ in. black enameled wooden rods. Two metal rings are attached to the top binding rod for convenient hanging. Every part of the practical electromagnetic spectrum is analyzed in detail. A special glossary of the spectral terms is included. Copies maybe obtained for $2.00 from the Publication Section, 6-N-17, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Control Chart. This standard "Control Chart Method of Controlling Quality During Production" shows the manufacturer how he can keep track of his production process by means of a quality control chart. The chart carries a pair of control limits which have been computed from quality measurements made on a number of samples of the product. The new standard (Z1.3-1942) is $0.75 a copy, obtainable from American Standards Association, 29 W. 39th St., New York City.

Frequency Response Recorder. In the July 1942 issue of *Sound Advances* is a description of a frequency response recorder. The general physical construction, mode of operation, features of the recording circuit, detailed description of the individual parts are covered. Requests should be addressed to Sound Apparatus Co., 150 W. 46th St., New York City.

Replacement Sheets. This price list contains data on stock items listed in Catalog 42. The locking and plain terminal lines have been condensed, due to the war and the spring washers have been discontinued entirely. Also included are new pages for Catalog 42 to bring it up to date. Available from Shakeproof Inc., 2501 N. Keeler Ave., Chicago, Ill.

Plastics. "Designing Molded Plastic Parts," describes the design of plastic parts and gives general information on the application of: inserts, wall thickness, tolerances, shrinkage, holes and undercuts, ribs, bosses and fillets. Available from Section E-5, General Electric Co., Plastics Dept., Pittsfield, Mass.

A twenty-page illustrated booklet on vinylite resins describes the four major types of vinyl resins and the various plastic materials produced from them. The booklet contains tables of properties and charts showing the principal applications of vinylite plastics. From Plastics Div., Carbide and Carbon Chemicals Corp., 30 E. 42nd St., New York City.

A fourteen page booklet which tells of the use of extruded industrial plastics in war production. It mentions several possible applications, gives the general properties of plastics, and the various shapes and sizes in which it is available. E. D. Werner Co., Inc., 380 Second Ave., New York City.

A twenty-four page booklet "Bakelite Laminating Plastics" tells what laminated plastics are and describes the various types. It is illustrated with photos showing the manufacture of laminated materials and their uses in the electrical, automotive, aircraft and chemical industries. Bakelite Corp., 30 E. 42nd St., New York City.

Laminated plastics for electrical insulation, radio, electronics, aircraft, silent gears, railroad and automotive industries are described and illustrated in a new handbook on vulcanized fibre and phenol fibre. Requests should be written on company stationary to Taylor Fibre Co., Norristown, Pa.

Static Electricity. The nature and origin of the charges of static electricity arising in industrial processes are discussed and various methods of mitigation of the hazards which they introduce are suggested, Circular C438, an abstract, available from the Superintendent of Documents, Washington, D. C., price ten cents.

Mica. A detailed description of the characteristics of the various types of mica and the uses of mica is presented in Catalog 24. This catalog tells how the raw material is treated, shaped and molded by precision methods for industrial uses. Macallen Co., 16 Macallen St., Boston, Mass.

Graphic Instruments. In a current issue of *The Graphic* an article describes how a beam of light and a photocell in the breaching, coupled to a graphic milliammeter, improves the handling of boilers on steamships. Another item tells how a phototube aids in recording high temperatures. Copies of Bulletin No. 1214 obtainable from the Esterline-Angus Co., Inc., Indianapolis, Ind.

Insulation. This up to date catalog gives a general description of fiberglas inorganic electrical insulations. Catalog 13-Section C covers the various types manufactured, their characteristics and advantages. Catalog 13-Section D gives general information on insulating varnishes and compounds. It tells about the functions of the varnishes, types manufactured and the methods of application and objectives. Price data is also included. Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago, Ill.

Relay-Timer. Catalog F has been designed to serve as a guide to relay and timer selection usage. Complete electrical information, base dimensions, cover dimensions, coil data, magnetic structure diagrams and dimensions, contact diagrams and descriptions and mounting styles are included. Struthers Dunn, Inc., Juniper and Cherry St., Philadelphia, Pa.

Fluorescent Accessories. A 16-page catalog on fluorescent accessories contains general and technical information on fluorescent lighting principles. Complete dscriptions of fluorescent lampholders, starters, starter sockets, and details on how these accessories operate. Tests made on starters are described in detail. Also included is a two page insert on the G-E Master No Blink Starter which locks dead lamps out of the circuit and allows instant replacement. General Electric Co., Bridgeport, Conn.

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HANDY-TALKIE

This U. S. Army radio reconnaissance scout is using the brand new "handy-talkie" two-way radio set. This compact, hand held unit supplements and in some cases replaces the heavier and more familiar "walkie-talkie"

Electronic Counter

(Continued from page 74)

rent, which is only a small fraction of a milliampere, may be attributed to electron emission from the heater. It is, therefore, necessary to supply the heater current for T_2 from a small transformer or from a separate winding on the power transformer. This winding may be left ungrounded, or it may be connected to the positive side of the power supply. When this connection is used the loss of charge of C_2 is prevented. The recommendation of the tube manufacturer that the heater never be made positive with respect to the cathode is disregarded, but no damage to the tubes seems to have resulted.

Calibration Technique

Calibration was accomplished by utilizing the sweep pulse of a cathode-ray oscillograph as a signal. The sweep was locked at 300 cps and connected to the input transformer or grid of T_1 and R was adjusted until exactly one output pulse per second was obtained. Though a counting ratio of 300 to 1 was used in the experiments on ganglionic activity, other ratios could readily be obtained. The performance of the counter at different input frequencies is shown in Fig. 3. It will be seen that the counting ratio was within 3 percent of 300 to 1 for input frequencies of 50 to 600 pulses per second.

The electronic impulse counter has been used to drive an ink recorder

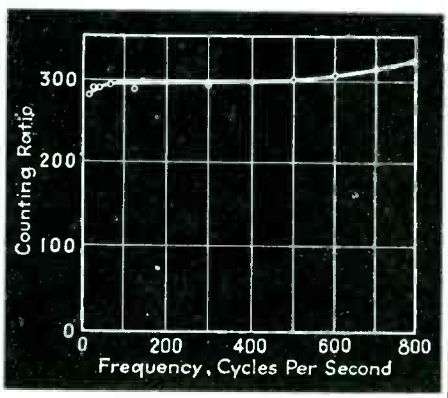

Fig. 3—Counter performance at different input frequencies

consisting of a 600-ohm magnetic loudspeaker minus the cone and equipped with a pen of stainless steel (hypodermic) tubing connected to an ink reservoir by rubber tubing. A satisfactory type of recorder for following frequency changes over hours or days consists of a stainless steel pen which is pulled across slowly moving paper by a solenoid and ratchet mechanism. Each pulse delivered by the counter momentarily energizes the solenoid and moves the pen out a short distance. A synchronous motor returns the pen to zero once every minute leaving a line which corresponds in length to the sum of the pulses during the previous fifty seconds. The process is automatically repeated, and the results are recorded in graphic form.

The apparatus, being entirely automatic, can be left running unattended, and minute-by-minute records of activity may thus be obtained over periods of twenty-four hours or longer. It was possible to keep an insect nerve-cord alive for 36 hours after removal from the body by dipping it into a physiological saline solution during the ten-second intervals between recordings. A solenoid was used to pull the electrodes out of the liquid during recordings so that the solution would not act as an electrolyte to short circuit the input of the amplifier.

The amplifier used was a standard public address unit which was found to have gain and frequency characteristics which were entirely satisfactory for this application. For the study of nerve action potentials nearly the full gain of a high-gain public address amplifier is required. With some amplifiers the gain is hardly high enough unless a one tube pre-amplifier is used.

The counting ratio can be varied over a considerable range by varying the setting of the potentiometer, R_9, but if ratios far different from 300 to 1 are required, the condensers C_1 and C_2 may be changed. The counting ratio may be increased by decreasing the value of C_1. It may also be increased by increasing the value of C_2, but it must be remembered that the time constant of the discharge circuit of C_1 must be small compared to the interval between the incoming pulses. This time constant in seconds is equal to C_1R_1 where C_1 is expressed in microfarads, and R_1 in megohms. If the time constant is not small enough the calibration will change for rapid impulses since C_1 will be only partially discharged between impulses. The time constant cannot be varied at will by changing R_1, because if values much lower than 200,000 ohms are used, the grid of T_1, may fail to regain control after an impulse.

Lower counting ratios may be obtained by decreasing the capacity of C_2, or by increasing the value of C_1. If C_2 or R_2 are varied, the time constant C_2R_2 should be kept small, because impulses received during the charging time of C_2 are not counted. However, the discharge must not be too fast, or the mechanical counter will not be able to register. It is also necessary not to use too low a value for R_2, or the safe plate current of T_2 will be exceeded. C_2 must be large enough so that at the slowest impulse rate which is to be registered, it will not lose too much charge through leakage. The leakage in the condenser itself is also a factor, so a well insulated condenser is needed, and electrolytic condensers would not be suitable.

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Errata

OUR ATTENTION has been called to certain errors which, unfortunately occurred in the article, "Amplitude, Frequency and Phase Modulation" by August Hund, in the September issue of *Electronics*.

Page 50. The term above the brackets in Eq. (4) should have read:

$$f \Delta \theta \cos 2 \pi ft.$$

Page 51. For conditions of PM and FM Eq. (7) should have read:

$$I_t = I_m \sin (\Omega t + \beta \sin \omega t)$$

Text immediately under Eq. (7) should read: "where $\beta = \Delta\theta$ for PM, $\beta = \Delta F/f$ for FM, and $K = i_m/I_m$ for AM".

Line 12, third column, should read: "much different for PM and FM as".

In Fig. 4, the term above the words "Modulating agency" should read $1/f$.

Page 54. Line 35, second column, B_1 should have read -0.3276.

In this issue Mr. Hund called our attention to certain changes in illustrations which were received too late to alter cuts. In the lower left-hand corner of Fig. 1, page 68, C_1 should be deleted. In Fig. 2(c), *gm* should, of course, be g_m.

Reactance Tubes in F-M

(Continued from page 71)

f-m transmitters. The center frequency stabilization is then based on the property that the transconductance of a reactance tube can be changed by varying the grid bias. Any slow drifts in the center frequency F can be made to cause direct voltages at the output of a frequency discriminator, whose polarity depends on the direction and whose magnitude depends on the magnitude of the drift. The output voltages vary the grid bias of the modulator tube and causes such **reactance drifts as** to bring the center frequency of the associated master oscillator to the assigned value.

With respect to variable reactance injections, reference is made to Fig. 3a showing the dynamic network of the tube oscillator which is being modulated by means of a reactance tube T_m. In Fig. 3b is shown the action for a class A modulator for which g_m varies linearly over the entire operating range. For balanced push-pull modulators the fixed injections cancel while the respective dynamic reactance injections are additive so that twice the frequency excursion is obtained. In Fig. 4 is shown a balanced reactance tube modulator with tubes and dimensions as often employed in practice. Tubes T_m and T'_m are like tubes and are excited by the tank voltage E causing the respective exciting currents I_1 and I'_1 which in turn cause the respective carrier frequency voltages E_1 and E'_1 on respective modulator tubes T_m and T'_m. These voltages cause the dynamic plate currents i_p and i'_p which are in phase with E_1 and E'_1, respectively. Hence, i_p lags E by 90 time degrees and causes, therefore, inductive reaction injections. The dynamic plate current i'_p leads the tank voltage E by 90 deg. and produces capacitive reactance injections. The combined effect is a push-pull reactance injection which for balance cancels the fixed injections and leaves only dynamic injections which cause twice the frequency swing.

SEE ALSO PAGE 142

* Many useful modulators with numerical values are described in a forthcoming publication on **Frequency Modulation.**

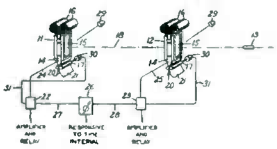
RECENT U.S. PATENTS

Each week the United States Patent Office issues grants to many hundreds of inventions that pass the acid test of that office. A few of those relating to electronics are reviewed here

Electronic Applications

Picture Reproduction. Progressively translating light intensities of successive portions of picture into impulses of a beam of light of uniform intensity, varying the length and spacing of impulses and width of the beam in accordance with light and shade of the picture. F. L. Wurzburg, Jr., Interchemical Corp. No. 2,294,643.

Projectile Timer. Two phototubes in light-tight enclosures spaced a certain distance apart. A projectile passing across the two phototubes ruptures the light-tight enclosure admitting



light in succession to the two tubes; and means for measuring the time interval between ruptures. Ulrich Uggers, G. E. No. 2,294,730.

Position Control. Positioning system using a reversible motor, electromagnetic clutch and brake all in connection with direction finding aircraft radio equipment. W. P. Lear, Lear Avia, Inc. No. 2,294,786.

Electric Chimes. Tone generators, tubes biased to cut-off, RC circuits to each biasing means and keyed so that a gradual decay of output can be secured, the decay period being long compared to the circuit closure period of the keying means. J. L. Hathaway, RCA, No. 2,292,757.

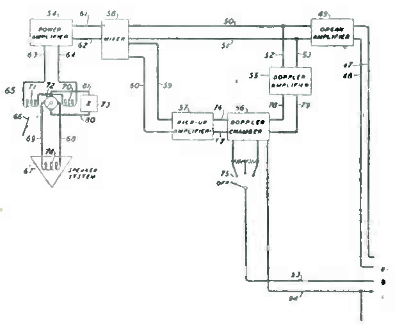
Timer. Time delay circuit utilizing time-constant circuit between grid and cathode of a tube having a.c. applied to anode and across resistor in grid-cathode circuit. E. M. Pritchard, The Prosperity Co. No. 2,292,846.

Medical Oscillator. A relaxation oscillator controlling the period of oscillation of another generator, means for applying interrupted and damped oscillations to a patient's body. A. W. Lay, RCA, No. 2,294,411.

Weave Straightener. Means controlled by a charge in a condenser for causing an electroresponsive device to have alternate periods of operation and non-operation and means for causing the periods of operation to increase and the periods of non-operation to decrease as the capacitor charge increases. Used in connection with means for straightening woven material T. M. Berry, G. E. Co., No. 2,288,387.

Heating System. Utilizing an electrostatic apparatus to heat material moving between pairs of charged plates. E. L. Crandell, Compo Shoe Machinery Co., No. 2,288,268 and 2,288,269.

Electric Organ. Generators producing a musical series of fundamentals and harmonics, means for confining each harmonic order to a separate circuit comprising for each harmonic order



normally balanced keying bridge networks and means for coupling the several bridge networks together to form the harmonic order circuit. W. F. Kannenberg, BLT Inc. No. 2,287,105.

Line Tracking Device. Means for having a light beam follow the line of a curve traced on a circular record. Philip Padva, Cannon & Co. No. 2,286,641.

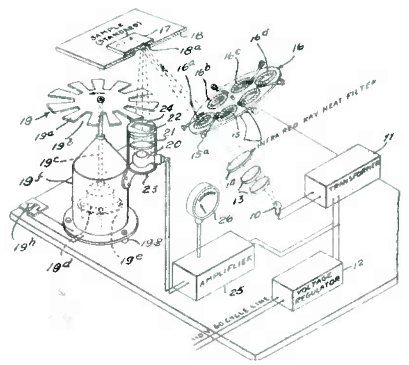
Rejection System. Apparatus for rejecting defective sheets made from joined metallic strips by forming holes on either side of the joints, detecting the holes while the strips are in motion, and means for conveying each sheet to one of several discharge points. E. R. Muddiman, Wilkinsburg, Pa. No. 2,286,686.

Gas Analysis. Phototube apparatus for determining the concentration of a constituent of a gas mixture. V. F. Hanson, du Pont & Co. No. 2,286,985.

Welding. Use of tubes in welding control. No. 2,294,388, to J. W. Dawson, Raytheon; Nos. 2,287,540, 2,287,543 and 2,287,544 to Alfred Vang, Clayton Mark & Co. See also No. 2,287,542 to Vang on electric induction heating.

Vibration Control. No. 2,287,223 to C. W. Baird, Traylor Vibrator Co.; and No. 287,880 to H. H. Hittson, The Jeffrey Mfg. Co., both for control of vibration apparatus.

Color Testing. Apparatus for measuring the reflection characteristics of a

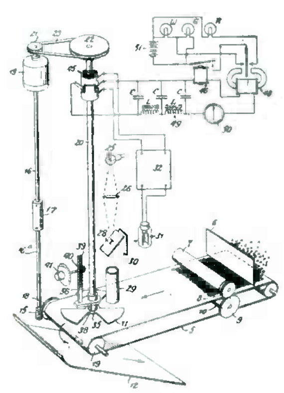


surface. O. E. Nelson, West Virginia Pulp and Paper Co. No. 2,287,322.

Cycle Timer. Apparatus for traffic signal control. W. M. Jeffers, Crouse-Hinds Co. No. 2,288,458.

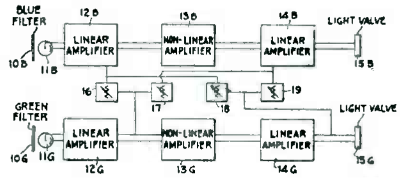
Radio Sonde. An automatic weather station using a radio transmitter with several keying circuits responsive to certain meterological factors to be transmitted, step-by-step apparatus for putting transmitter into operation, transmitting the desired information in sequence. Harry Diamond and W. S. Hinman, Jr. assigned to the United States government. No. 2,287,786.

Color Apparatus. Machine for detecting a definite color phase during the processing of a material using



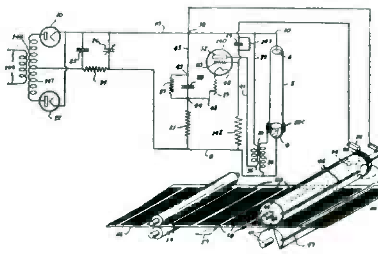
phototubes, rotating sector disk, etc. Henry Lehde, Brooklyn, No. 2,287,808.

Color Correction. An electro-optical system for reproducing multicolored originals comprising separate channels in which are established energies corresponding to the color components of



each point in the original in scanning succession, channels containing nonlinear amplifiers so that the output can be controlled logarithmically etc. V. C. Hall, Eastman Kodak Co. No. 2,286,730.

Cutting Machine. Stroboscopic means for having a knife make its cut at



predetermined points along a moving material. H. E. Edgerton, Belmont, Mass. Reissue. No. 22,123.

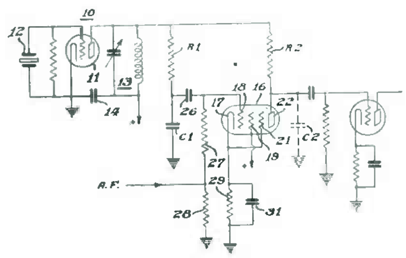
Frequency Modulation

Tuning Indicator. Two patents to E. W. Herold, RCA. No. 2,286,412 involving a detector having a direct current output whose polarity and magnitude depend upon frequency departure of center frequency of applied input; a shadow tube whose angle of indication depends upon frequency departure. No. 2,286,413 utilizes two diodes with a common input circuit, a direct current developed in a load circuit with a voltage which varies in magnitude and polarity in response to variation in extent and direction respectively of frequency departure of modulated carrier placed upon input. See also No. 2,286,410 to W. A. Harris, RCA, on a FM indicator.

Signalling System. Producing a wave modulated as to its timing, in one path multiplying the modulated wave's frequency to a value higher than that to be transmitted, in another path beating the modulated frequency to a lower frequency, filtering the beat-down frequency, heterodyning the filtered wave to a higher frequency, combining the two sets of waves and using the combination for transmission. W. van B. Roberts, RCA, No. 2,89,041. See also Nos. 2,286,377 and 2,286,378 to Roberts on a FM dectector and limiter circuit.

Converter. Combining modulated FM signals of given center frequency with a constant frequency of different value to produce waves lower in frequency, and at the same time beating the constant frequency waves with another FM wave of same center frequency but in phase quadrature so that amplitude modulated waves result. S. Hunt, RCA, No. 2,286,997.

Phase Modulation. Tube having an output terminal with capacity to ground and a resistance connecting terminal to anode; a phase shifting network connected to input so that a phase shift



at anode is produced opposite to phase shift caused by condenser-resistance thereat; and varying the g_m of the tube in accordance with a modulating signal. L. E. Barton, RCA, No. 2,294,372.

Wavelength Modulation. Phase is modulated in accordance with modulating potentials by subjecting the phase modulated energy to a frequency demodulation, modulating the frequency of a carrier in accordance with the demodulated energy and translating the carrier so modulated. M. G. Crosby, RCA, No. 2,292,868.

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WEATHER MAN

Constant contact is maintained by radio between the RAF ferry command airport and airplanes flying the North Atlantic. This is the transmitting room of the ferry command. C. M. Brant, shown in uniform, is in charge of the communications system

Electronics

H-f Tube. An electron tube including a source of electrons, means for directing electrons in a flat spiral path and applying a retarding field thereto, means including a pair of aligned magnetic pole pieces arranged in spaced relation, the opposed spaced ends of pole pieces having generally circular surfaces and serving as opposed electrodes, pole pieces having longitudinally and diametrically extending gaps formed as by cutting pole pieces longitudinally along a given diameter thus providing diametrically extending uniform gaps in the electrode surfaces of pole pieces, the longitudinal lengths of pole-piece gaps being substantially equal to an integer multiple of one quarter the wave length of the desired operating frequency, whereby electrode structures may simultaneously serve to direct electrons between circular surfaces in a flat spiral path and also resonate of themselves as transmission lines. A. G. Clavier and E. Rostas, Int. Standard Elect. Corp. No. 2,289,756.

Image Dissector. A television signal generating tube comprising a photoelectric cathode adapted to have an optical image focused thereon, an electron gun for developing a beam of electrons, an elongated electrode having an insulating surface adapted to receive photoelectrons from cathode and adapted to be scanned by beam of electrons, means transparent to light but non-permeable to electrons, having an elongated aperture for permitting only photoelectrons emitted from a linear portion of photoelectric cathode from reaching insulating surface at any given instant, an electrode adjacent insulating surface, and means for collecting electrons emitted by insulating surface. P. T. Farnsworth, Farnsworth Tele. & Radio Corp. No. 2,292,111.

Image Amplifier. The method of producing an electron image which comprises the steps of utilizing light of a first spectral range to create a uniform stream of relatively low velocity electrons, utilizing light of a second different spectral range to create a non-uniform stream of relatively high velocity electrons, the non-uniformity representing electron density values in image relation, and modulating said uniform stream by charges produced in spatial relation with and by non-uniform stream. P. T. Farnsworth, Farnsworth Tele. & Radio Corp. No. 2,292,437.

Dissector Tube. Image dissector having photoelectric cathode and an anode having a scanning aperture of dimensions permitting the electron picture signal current emitted by an elemental area of cathode corresponding to a single picture element to pass through, electron multiplier, electrode having solid portion and an opening for passing signal current, and deflecting means to deflect electron current upon solid portion. W. Dillenburger, Fernseh. No. 2,287,298.

X-Ray Tube. In combination, an X-ray tube having a stationary cathode adapted to serve as the source of a cathode ray beam, a stationary target with at least two materially displaced areas capable of generating X-rays under the impact of the cathode ray beam, and means for deflecting the cathode ray beam relative to the target to cause it to be fixed alternatively upon one or the other of the areas, whereby X-radiations may be projected from the tube in different directions depending upon the particular one of said target areas at which radiations are generated. T. E. Allibone, G.E.Co. No. 2,292,859.

Electron Multiplier. Secondary emission tube in which the position of the beam of electrons on first and succeeding electrodes is varied with an output voltage corresponding to the position variations. J. A. Rajchman, RCA. No. 2,292,847.

Emission Device. Vacuum tube with triode in one section including an emitter, anode and modulating grid and an anti-cathode in another portion of the tube with a tubular electrode having a narrow opening maintained at a potential intermediate between anti-cathode and anode, said electrode forming an electrostatic shield and preventing formation of an intense field in first portion of tube. David Applebaum, Los Angeles. No. 2,294,533.

Velocity Modulated Beam Tube. Electrons are caused to pass as a beam toward a collector, velocities of electrons in the beam are modulated and electrons are deflected laterally in amounts depending upon their velocities and a wave guide across path of deflected electrons having such a configuration that the beam sweeps the guide along its length with a velocity approximating the wave propagation velocity along the guide. T. C. Fry, BTL, Inc. No. 2,288,694.

Amplification, Modulation etc.

Multiplier. System for obtaining odd harmonics comprising a third-harmonic producer composed of a non-linear 4-terminal network constituting a bridge, having such a characteristic that the output and input potential are related by

$$u_2 = \frac{3}{4} k u_1 - k u_1^3$$

where k is a constant, u_1 is the input potential, and u_2 is the output potential, and a second similarly arranged third harmonic frequency producer four-terminal network, and means for connecting two four-terminal networks in series, whereby there is obtained a harmonic which is an odd multiple of said third harmonic. Werner Benz, G. E. Co. No. 2,291,366.

Limiter. In a FM system, means for reducing amplitude modulation. R. E. Schock, RCA. No. 2,286,442.

Magnetron Modulator. Method of modulating a double-anode magnetron comprising a common source of direct current for the anodes and two inductance branches with resistance in one branch to keep voltage in that branch lower than the voltage applied to the other anode. C. W. Hansell, RCA. No. 2,292,073.

Volume Control. Push-pull amplifier with rectifiers across a portion of the input transformer arranged to control the bias of the tubes so that the rate of change of the grid potential varies with respect to the input volume. B. M. Hadfield, Associated Electric Labs. Inc. No. 2,294,862.

Low Frequency Amplifier. A generator producing waves of the order of one or two cps and an amplifier for the same with a gain control such that the amplification varies as a root of the input voltage whereby the output voltage variations occur exponentially but to a smaller extent than input voltages for signals of varying amplitudes. D. H. Nelson and W. D. Buckingham, WU Tel Co. No. 2,287,942.

Magnetic Amplifier. Application of feedback to a magnetizable core amplifier, the core having two windings connected in series opposition, a.c. energizing the windings, rectifier for the output current and a d-c winding on the core so that during current flow in the third winding the reactance and output current of the pair of windings are varied; feedback additionally varying the winding reactance. Gustav Barth, Siemens. No. 2,287,755.

Phase Inverter. Two similar tubes, signal applied to grid of first tube, second tube grid grounded, resistance common to both cathodes, load in second tube plate circuit, and a resistance load in the plate circuit of the first tube approximately equal to the amplification constant of tubes times the resistance of cathode resistor times the resistance of the plate load of second tube divided by the sum of the plate resistance of tubes plus second tube plate resistor plus cathode resistance minus the product of amplification constant and cathode resistance. A. W. Barber. No. 2,289,301.

Amplifier Circuits. Other recent patents relating to tube amplifiers are as follows. No. 2,292,136, D. G. Lindsay and R. F. J. Flood, Amalgamated Wireless, on a push-pull resistance coupled amplifier using pentode drivers and tetrode output tubes. No. 2,289,822, Heinz Boucke, Telefunken, on a means for automatically varying bandwidth of audio amplifier. No. 2,289,752 to L. Bruck and Otto Tuxen, Telefunken, on a feedback wideband amplifier. Also No. 2,289,821 to Boucke, Telefunken, on wideband amplifier design.

Tube Applications

Registration. Apparatus for indicating when a moving web is out of register utilizing light sensitive apparatus. Morris Sorkin, Interchemical Corp. No. 2,289,737.

Detonating Device. System for detecting detonation in an internal combustion engine. J. H. Lancor, Sperry Gyroscope. No. 2,291,045.

Generator Control. Application of phototube to a vapor generator for control purposes. P. S. Dickey, Bailey Meter Co. No. 2,292,023.

Design Making. System for producing geometric or artistic designs on the viewing screen of cathode-ray tube by proper use of sub-harmonic voltages with fundamental frequency so that the intensity and rates of horizontal and vertical deflection are controlled solely by frequencies harmonically related to the master oscillator of the system. C. E. Burnett, RCA. No. 2,292,045.

Odor Elimination. Method of treating aqueous material to eliminate undesired offensive odor-producing characteristics comprising in combination, detecting the electrode potential of the treated material with respect to a standard reference potential, and adding a halogen to the material when and as required to maintain the detected potential of the treated material below the minimum potential which would be detected if free chlorine were present in the material but above the maximum potential detected in the material when the undesired characteristic is present. R. Pomeroy, Wallace & Tiernan. No. 2,289,589.

Speed Measurement. Phototube method of measuring high speed shafts and spindles. H. J. Burnett. No. 2,290,606.

Statistical Machine. Means of sorting data on records by electron tubes. J. W. Bryce, IBM. No. 2,294,734. Other IBM patents are Nos. 2,294,751, 2,294,681.

Phase Measurement. No. 2,287,174, R. A. Heising, BTL Inc. on measuring relative phase; and No. 2,293,022, M. G. Crosby, RCA, on measurement of deviation of frequency or phase.

Aircraft Radio Applications

Speed Indicator. An aircraft ground speed indicator including an optical screen, said screen including rows of opaque markers and transparent spacers, means for focusing an image of the ground on said screen, means for interrupting said image at a constant frequency to form a row of stroboscopic images on said spacers, an altimeter, and means for indicating the ground speed of said craft as functions of its altitude and said interrupted image. H. F. Olson, RCA No. 2,292,153.

Glide Path. Method for vertical guidance of aircraft with respect to terrain by propagating a radiated field and varying the field intensity corresponding with the obstructional characteristics of the terrain. Re. No. 22,157. Gomer L. Davies, Washington Institute of Technology.

Speed Indicator. Translating image of object on ground into electrical impulses, translating these impulses into light signals moving with a speed proportional to the relative motion of the object on the ground, and translating the light signals into alternating currents of a frequency proportional to the speed of the object. H. E. Jones, Kansas City Testing Laboratory, No. 2,292,641.

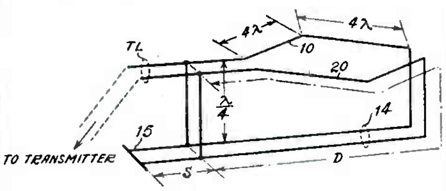
Antennas

Elliptical Pattern. Quarter-wave elements arranged above one another, each element having a bend intermediate, its ends forming parallel portions, with the free ends of the elements pointing in the same direction; also means of attaching transmission line to elements. G. H. Brown, RCA. No. 2,290,800.

Broadcast Array. Two-element array, individual elements producing toroidal pattern having uniform value in horizontal plane, units spaced from each other in the order of 200 to 400 electrical degrees at the operating frequency. A. Alford, IT&T Co. No. 2,289,856.

Linear Array. Three elements, quarter-wavelength spacing, translation device, lines carrying current connecting elements to device, adjustable amplitude and phase controls in each line. Currents bear a 1,1.41,1 amplitude distribution and 0, 135 and 90 degree phase distribution. S. A. Schelkunoff, BTL Inc. No. 2,286,839.

Antenna Feedback System. A rhombic antenna comprising a pair of conductors having their ends adjacent and the midpoints separated, a transmission line, means for coupling line to antenna at one pair of adjacent ends whereby traveling waves are set up in antennas, a second transmission line having a pair of conductors connected



at one end to the other pair of adjacent ends, the electrical length of antenna and second transmission line being an integral multiple of 360 degrees, second transmission line being short-circuited at its other end, and means for coupling second line to first mentioned means at a predetermined distance from short-circuited end. P. S. Carter, RCA. No. 2.290.314.

Loop Antenna. Input tuning system for radio receiver using permeability tuning whereby the response at the low frequency end is boosted. V. D. Landon, RCA, No. 2,290,825.

Input System. Means for increasing directivity of a radio receiver by increasing response from a given direction and simultaneously decreasing response to an undesired direction by using a portion of the input system as an interference shield. N. P. Case. Hazeltine Corp. No. 2,291,450.

Piezoelectric Crystals

Crystal Cuts. Two patents to W. P. Mason, Bell Laboratories. No. 2,292,885: A face mode piezoelectric Rochelle salt type crystal element having its substantially rectangular major surfaces substantially parallel to the plane of a Y axis and the Z axis, the major axis length dimension of said major surfaces being inclined at an angle of substantially 49° 56′ with respect to said Y axis, the dimensional ratio of the width dimension of said major surfaces with respect to said length dimension thereof being one of the values between substantially 0.20 and 1.0.

No. 2,292,388: A piezoelectric Rochelle salt type crystal element having its substantially rectangular major surfaces substantially parallel to the plane of two of the three mutually perpendicular X, Y and Z axes thereof, the major axis length dimension of said major surfaces being in said plane and inclined at an angle of substantially 22.5 degrees with respect to one of said two of said three X, Y and Z axes, the dimensional ratio of the width dimension of said major surfaces with respect to said length dimension thereof being one of the values between substantially 0.576 and 0.822, and means including a plurality of sets of functionally independent electrodes adjacent said major surfaces for operating said element simultaneously at a plurality of independently controlled frequencies dependent upon different sets of said major surface dimensions, one of said frequencies being dependent upon the fundamental of the longitudinal or extensional mode vibration along said width dimension.

Temperature Compensation. Method of compensating the effects of temperature-induced variations in the sensitivity of a piezoelectric generator using an attenuator with an auxiliary piezoelectric crystal and subject to same temperature variations as the frequency controlling crystal. M. P. Odell, Brush Development Co. No. 2,286,437.

Cathode-Ray Tubes

(*Continued from page* 52)

sweeps, and consequently the frequency and waveform of the voltage producing the known deflection are relatively unimportant.

Applications in which no time base is required include the measurement of voltage, current, power, dielectric characteristics, magnetic measurements, dynamic voltage-current characteristics of rectifiers, electron tubes, arcs, and discharge tubes, corona, modulation and detection studies, and measurement of electromagnetic field intensities.

In those applications for which no time base is required, the traces on the screen of the cathode-ray tubes are usually lines or closed loops.

(2) Phenomena which have a fixed periodicity of recurrence require a fixed time base whose waveform determines the shape of the pattern which can be obtained. The type of pattern also depends upon the manner in which the voltages are applied to the electrodes of the cathode-ray tube. The two deflecting voltages are frequently synchronized.

Applications in which a time base of fixed periodicity is required include measurements of phase, power factor, frequency and frequency comparison, mechanical measurements of impact, pressure, linear oscillation, torsional oscillation, and so on, studies of atmospherics and sparks, acoustic measurements, illumination measurements, ionosphere studies, and electrocardiographic applications in medicine.

In these applications, a wide variety of traces are encountered. The more common types of traces include lines and closed loops, Lissajous figures, Lissajous figures in "perspective" with trace and retrace sweeps spacially separated, traces in Cartesian coordinates, traces in polar coordinates, gear shaped figures, roulette or star shaped figures, and spiral and circular traces.

(3) Phenomena which vary with frequency, or whose characteristics are to be studied throughout a frequency band or spectrum, require an independent scanning sweep of variable frequency.

Applications requiring an independent time base of variable frequency include measurements in which the dependent variable is a function of a frequency band. The more common applications include audio frequency and radio frequency response measurements and curves, and sound and film television recording.

In these applications, the trace frequently takes the form of a frequency-amplitude spectrum.

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NEW BOOKS

The Radio Code Manual

By Arthur R. Nilson, *McGraw-Hill Book Company, 1942. 170 pages, semi-looseleaf bound.*

This little book comprises 20 lessons on how to learn the radio code, how to send it and how to receive it; how to build simple code machines, lists of international signals; lists of words and code material for practice, sample radio messages, questions and answers leading to a license for restricted radiophone operation and other information of interest to one wishing to become a radio operator.

The lessons leading to knowledge of the code progress from the simplest letters to the more complex, and by planned steps the student is taught the coordination necessary between hearing a signal and interpreting it into a readable written letter.

It should be a most helpful book. The format is small and type matter is easy to read and to understand.—K.H.

Short-Wave Manual

By F. J. Camm, *First American Edition, 211 pages. Price $2.50.*

The Superhet Manual

By F. J. Camm, *First American Edition, 131 pages. Price $2.50.*

Wireless Coils, Chokes and Transformers

By F. J. Camm, *First American Edition, 176 pages. Price $2.50.*

The Mathematics of Wireless

By Ralph Stranger, *First American Edition, 210 pages. Price $3.00.*

All published by Chemical Publishing Co., Brooklyn, N. Y., 1942.

These books were written by English engineers and therefore give the British practice, which, except for details, is much the same as American practice. The Short-Wave Manual deals with the special problems underlying the design of short-wave apparatus. Constructional data for several receivers of varying complexity are given. Mechanical details such as chassis layout and location of holes and component layouts are given.

The Superhet Manual discusses the design, operation and servicing of superheterodyne receivers. Fundamental principles of radio are also discussed to fill the need for elementary information for many readers Wireless Coils, Chokes, and Transformers contains much practical data for the making of many different kinds of coils used in radio. Simple coil winders are described for making coils in small quantities.

The Mathematics of Wireless explains in simple language some of the mathematics necessary to the understanding of radio principles. It is written in elementary fashion; will be useful to those who want to have some knowledge of this necessary subject. It covers arithmetic, algebra, geometry, powers and roots, trigonometry, mathematics of wavelengths and frequencies, differential calculus, integral calculus, logarithms, curves and graphs, the slide rule, and many problems of radio circuits.—C.W.

Handbook of Technical Instruction for Wireless Telegraphists

BY H. M. DOWSETT and L. E. Q. WALKER, *660 pages, 7th edition, 1942, price 25 shillings or by mail, 25 shilling 9 pence, Iliffe & Sons, Ltd. Dorset-House, Stamford Street, London.*

THIS IS THE 7TH EDITION of this popular book of practical data for radio operators. It pursues a conventional course starting with the charge in a condenser, through Ohm's law, a-c circuits, batteries, magnetism, dynamo electric machines, measuring instruments, receiving and transmitting gear, etc.

Although this is an English book, the information in it is international in character. It could be used by American radio men as well as by British, the slight differences in terminology causing no trouble. Material not found in American books on depth sounding, lifeboat and emergency apparatus and trawler equipment is contained in this volume.—K.H.

• • •

FIELD RADIO WITH THE AEF

American Troops are shown receiving instruction somewhere in Northern Ireland in preparation for their big job

Acoustic Design Charts

BY FRANK MASSA, *In charge of the Acoustic Division, The Brush Development Co., The Blakiston Co., Philadelphia, Pa., 1942, 228 pages. Price, $4.00.*

THIS COLLECTION OF acoustical engineering data is bound to be of great usefulness to any engineer in speeding up his work in designing or constructing electro-acoustic equipment. There are 107 charts illustrating quantitively the numerous relationships of acoustical engineering. Many of the charts contain families of curves and indicate the effect of changing certain parameters without the necessity of involved calculations. The scope of the collection is indicated by the headings of the ten sections of the books. They are: Fundamental Relations in Plane and Spherical Sound Waves, Mechanical Vibrating Systems, Acoustical Elements and Vibrating Systems, Radiation of Sound from Pistons (Direct Radiator Loud Speakers), Directional Radiation Characteristics, Reverberation and Sound Reproduction, Exponential Horn Loudspeakers, and Electro-Magnetic Design Data. A tenth section is reserved for miscellaneous charts which don't fit elsewhere.

While these charts were primarily intended to aid in the design of acoustical equipment, many of the charts are of general interest and some apply to specific fields such as those charts covering electro-magnetic design data and mechanical vibrating systems. The author is to be congratulated on the very good job he has done in the collection and presentation of this vast amount of information.—C.W.

• • •

STILL INVENTING

Dr. Lee De Forest, the inventor of the three element tube has recently patented a new television-camera tube, applied for a patent on a dirigible bomb and is at work on an automatic blackout device in his laboratory as pictured here

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published

Attenuator Design

IN MY ARTICLE ON attenuator design published in *Electronics* in November 1941, several errors occurred which can be corrected as follows:

Diagram Corrections:

1. Balanced U—One of the series resistors is called R_2 and should be R_1.
2. Balanced H—Lower, left hand resistor should be R_1 instead of R_2.

Formula Corrections: (Unsymmetrical).

1. Balanced H: $R_2 = \frac{Z_2}{Z}\left(\frac{K^2+1}{K^2-1}\right) - \sqrt{Z_1 Z_2}\left(\frac{K}{K^2-1}\right)$

$$R_3 = \sqrt{Z_1 Z_2}\left(\frac{K}{K^2-1}\right)$$

2 π: $R_2 = \sqrt{Z_1 Z_2}\,\sinh\theta$

$$R_3 = \frac{Z_1 Z_2 \sinh\theta}{Z_1\cosh\theta - \sqrt{Z_1 Z_2}}$$

3. O: $R_3 = \left[\frac{K^2-1}{K^2 - 2\frac{K}{S} + 1}\right] Z_2$

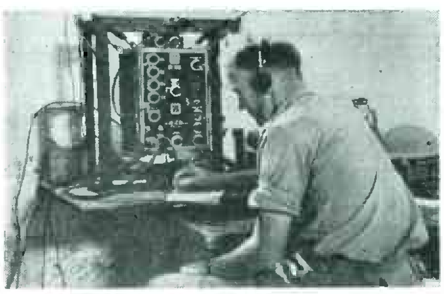
4. Balanced O:

$$R_3 = \frac{1}{2}\left[\frac{Z_1 Z_2 \sinh\theta}{Z_1\cosh\theta - \sqrt{Z_1 Z_2}}\right]$$

DAWKINS ESPY,
Waterford, Conn.

• • •

ON THE BATTLEFRONT



This Collins 18-meter transmitter receiver is set up in the battle front area of South Africa. Corp. B. McAlister is shown receiving a message

"T" to "Pi" Transformation

(Continued from page 73)

the amplifying tube as a constant current generator. (Y_p and Y_g represent the stray, as well as reflected, admittances.)

Solution: From the T network *abc*, shown in Fig. 4B, we obtain the π network $a'b'c'$, shown in Fig. 4C. Following the transformation rule, written in admittance form, Eq. (4), we obtain directly:

$$Y_1 = \frac{-j FG}{-jB + G_1 + G_2}$$

$$Y_2 = \frac{G_1 G_2}{-jB + G_1 + G_2}$$

$$1/Y_3 = Z_3 = \frac{jB + G_1 + G_2}{-jBG_2}$$

Here $jB = 1/jX_c = j\omega C$.

$$\text{Writing } Y' = K_p + Y_p + Y_L + Y_1 = \frac{1}{Z'}$$

$$Y'' = Y_o + Y_c = \frac{1}{Z''}$$

we obtain a π network, which is easily transformed into the final T network. The left-right formula gives

$$Z_{s1} = \frac{Z' Z_3}{Z' + Z'' + Z_3}$$

$$Z_{s2} = \frac{Z'' Z_3}{Z' + Z'' + Z_3}$$

$$Z_p = \frac{Z' Z''}{Z' + Z'' + Z_3}$$

The problems above may be simplified if suitable approximation are introduced.

• • •

College Courses in Electronics

SUPPLEMENTARY INFORMATION to the article "Electronics and Communication Courses in American Colleges" in the Electron Art Department of ELECTRONICS for September, is a recent communication from Prof. W. H. Pickering of the Department of Electrical Engineering, California Institute of Technology. Prof. Pickering advises that all electrical engineering seniors are required to take courses in vacuum tubes and electronics. The u-h-f course which was offered last year will be repeated and additional undergraduate instruction in electronics is offered. E.S.M.W.T. courses at various levels are offered on radio. This summer a 12-weeks course was given for Army and Navy officers on various branches of communication engineering.

CONTACTS

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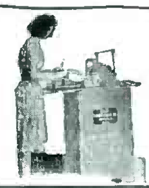

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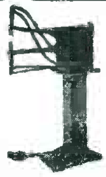

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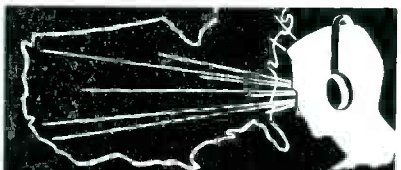

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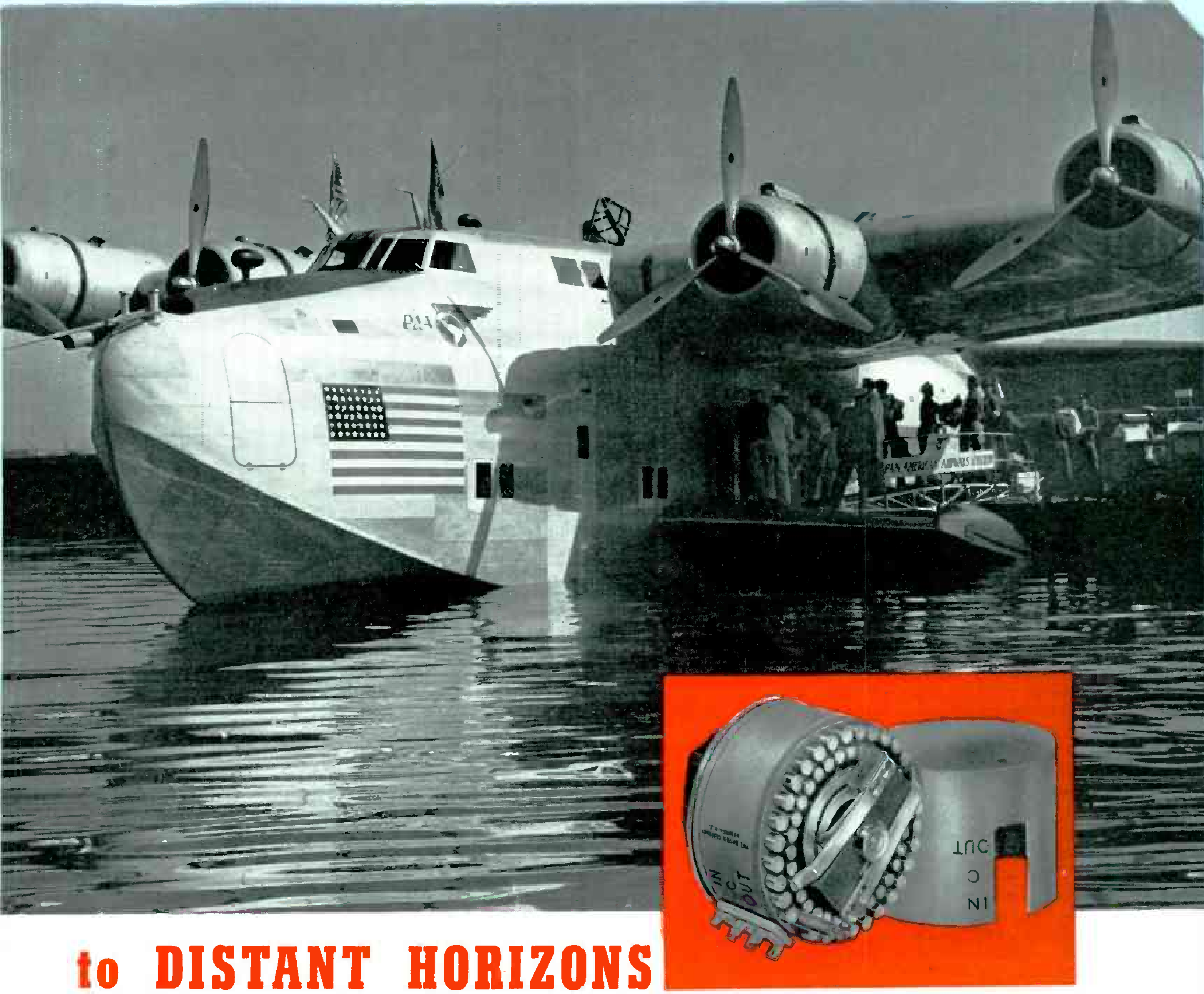

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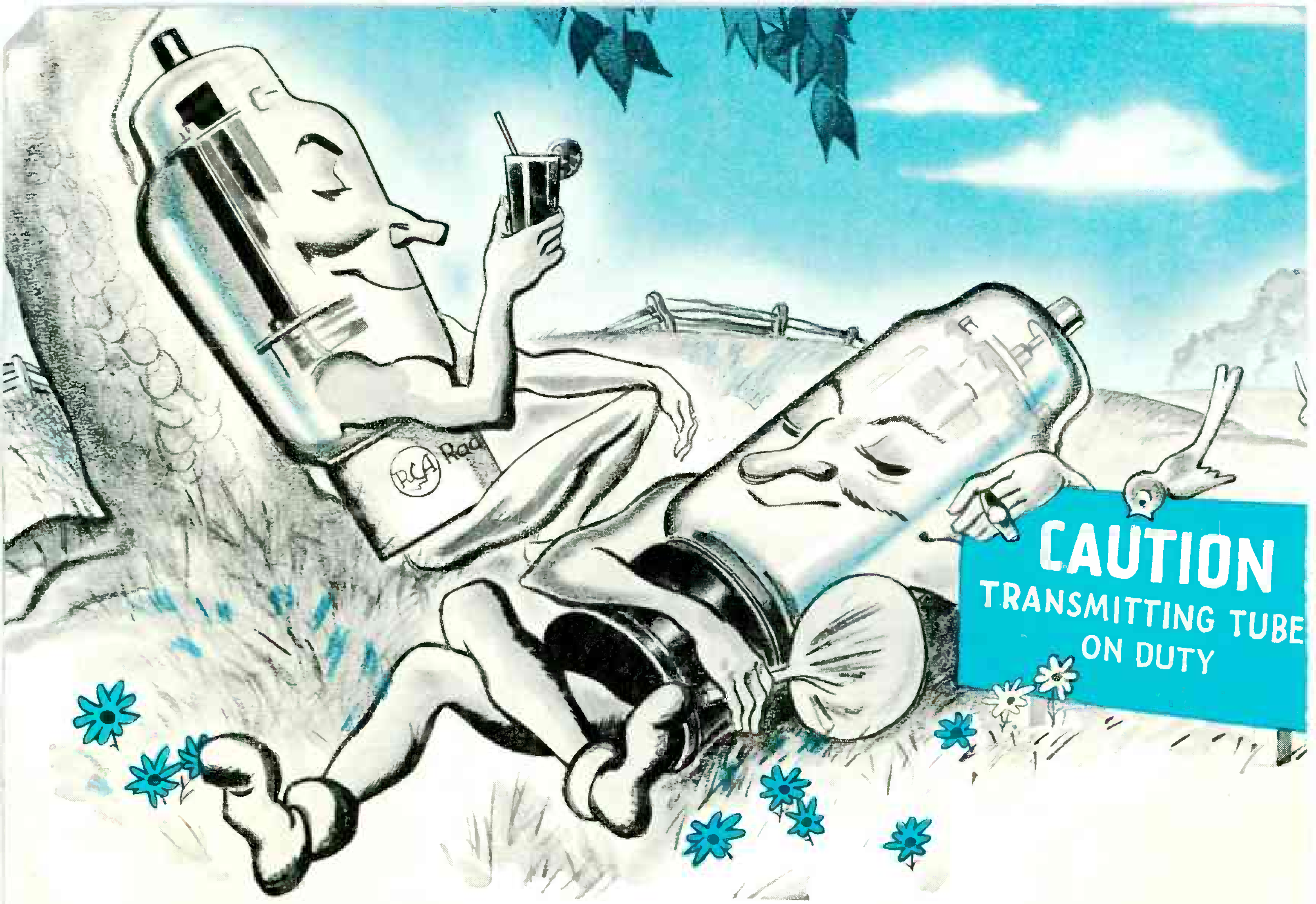

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TUNGSTEN AND THORIATED-TUNGSTEN-FILAMENT TYPE TUBES—Every time a filament is turned on or off, it passes through a temperature range in which it has reduced strength. This repeated action may cause warping and, eventually, grid-filament shorts. Rather than turning off the filament during short standbys, reduction of filament voltage to 80% of normal will prevent warping, will enable the filament to come up to operating temperature quickly, and will avoid evaporation of emissive material.

During standby periods, tubes using thoriated-tungsten filaments should have their filament voltage decreased to 80% of normal provided the periods are of less than 15 minutes' duration. For longer standby periods, the filament voltage should be turned off.

Tubes using tungsten filaments should have their filament voltage decreased to 80% of normal for standby periods of less than two hours. For longer periods, the tubes should be shut down. At reduced voltage, a tungsten-filament tube will last about ten times as long as at normal voltage. Its hot filament also acts as a "getter" to maintain a high vacuum within the tube.

Care should always be taken in starting up tungsten filaments, and never should the filament current exceed, even momentarily, a value of more than 150% of normal. Wherever possible, it is wise to operate the filaments of all types of tubes on the low side—perhaps 5% down when only light loads are involved. As previously explained, even this small reduction may actually double tube life—a mark well worth shooting at these days, even at the possible cost of some slight decrease in station efficiency.

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