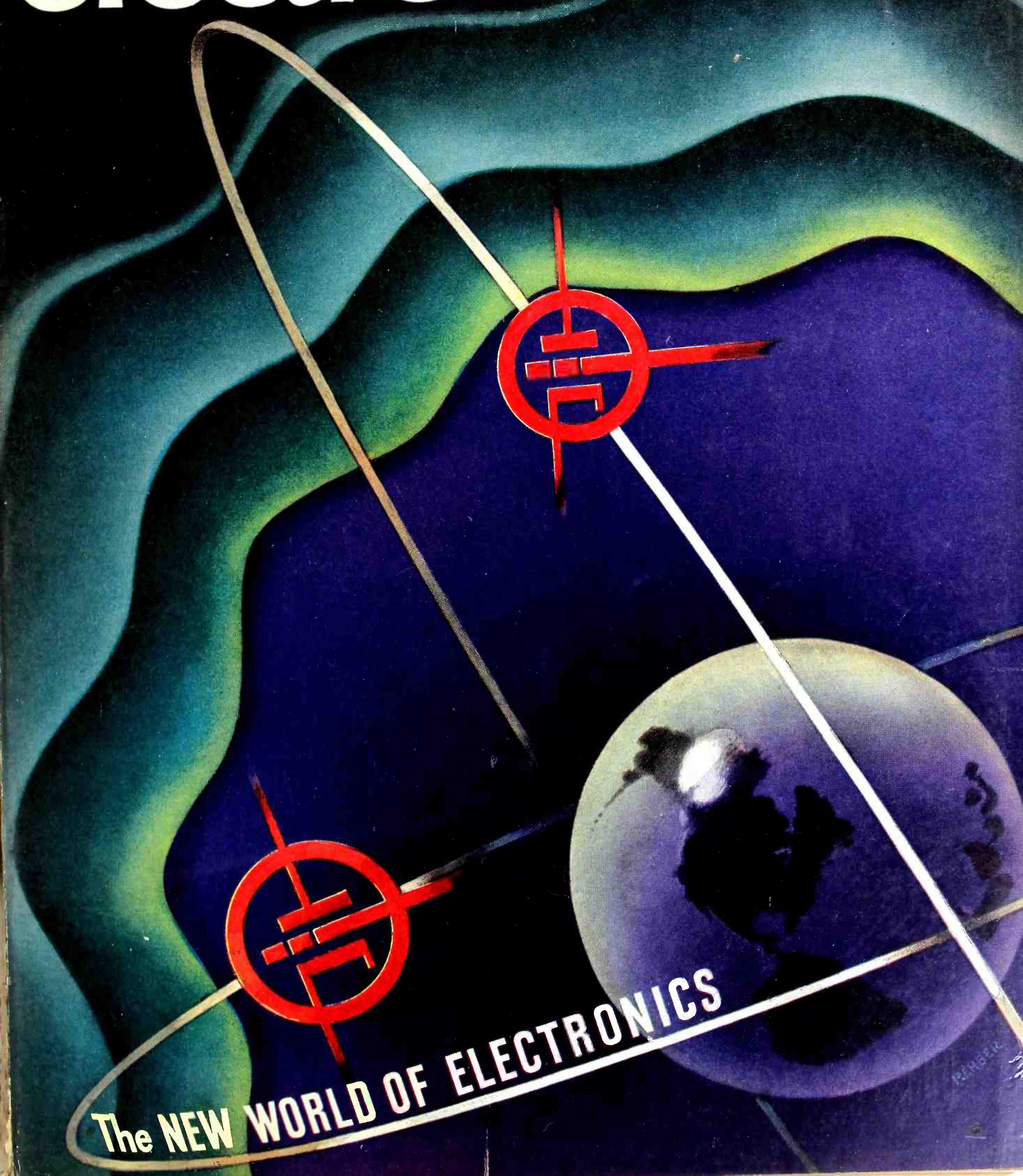
MARCH • 1943

electronics



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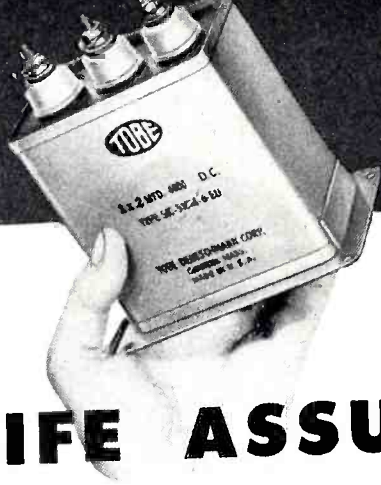


LONG LIFE ASSURED!

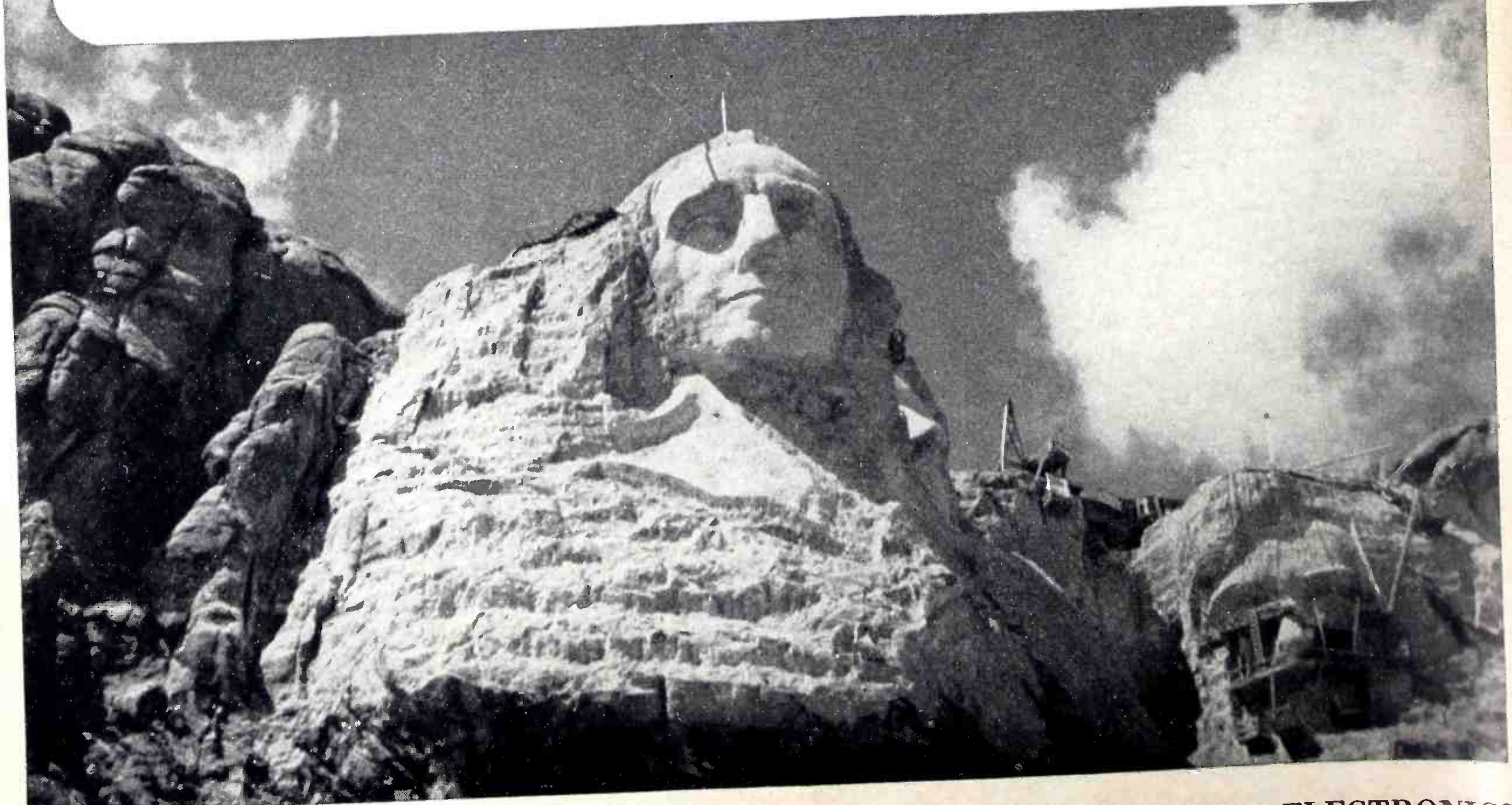
The single most important quality you seek in any condenser is...*a guarantee of long life.* And this guarantee is built into Tobe Capacitors—built in by persistence in research, soundness in engineering, excellence in production, *plus* 20 years of condenser experience.

One of the Tobe Capacitors is Type SIC-510M-6 illustrated above. It is doing a vital war job as a filter condenser in secret equipment. Impregnated and filled with mineral oil, it is typical of the careful manufacture and conservative rating which characterize Tobe Capacitors. Ask us about *your* condenser problems.

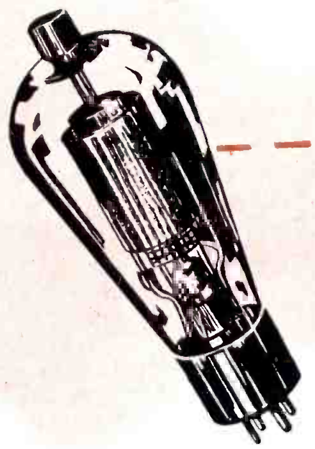
TOBE CAPACITOR—TYPE SIC-510M-6-EU

CAPACITY . . . 3 x .2 mfd.
TEST VOLTAGE . . . 8,000 volts DC
WORKING VOLTAGE . . . 4,000 volts DC
SHUNT RESISTANCE . . . 15,000 megohms or greater
POWER FACTOR . . . At 1,000 cycles—less than .004
MINERAL OIL IMPREGNATED—MINERAL OIL FILLED

A SMALL PART IN VICTORY TODAY • TOBE DEUTSCHMANN CORP. TOBE CANTON · MASSACHUSETTS • A BIG PART IN INDUSTRY TOMORROW



Two ways of PUTTING THE



THE TUBING WITHIN THE TUBE . . .

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SEAMLESS– Nickel of electronic quality in Random lengths, or Nickel Cathode Sleeves to exact lengths. Plain or Beaded (embossed), and also to *Shaped* specifications.

LOCKSEAM*– Nickel Cathode Sleeves, Round or Special Shapes, to specified lengths. Plain, or Beaded as specified.

LAPSEAM– Nickel Sleeves produced mechanically for special purposes.

ANODES– Stainless Steel—Nickel of electronic quality — Monel — Inconel. For Cathode Ray Tubes and Power Tubes. In random lengths or to exact specifications.

ANTENNAS– Brawn Monel.** For transmitting and receiving purposes. Especially adapted to Marine use.

EXHAUST TUBES– Coppered Steel. To exact specifications.

TUBING IN STEEL and IRON can be produced on short notice in sizes from ⅝" OD down to .010" OD and smaller.

TUBING with special magnetic and sealing properties can be handled.

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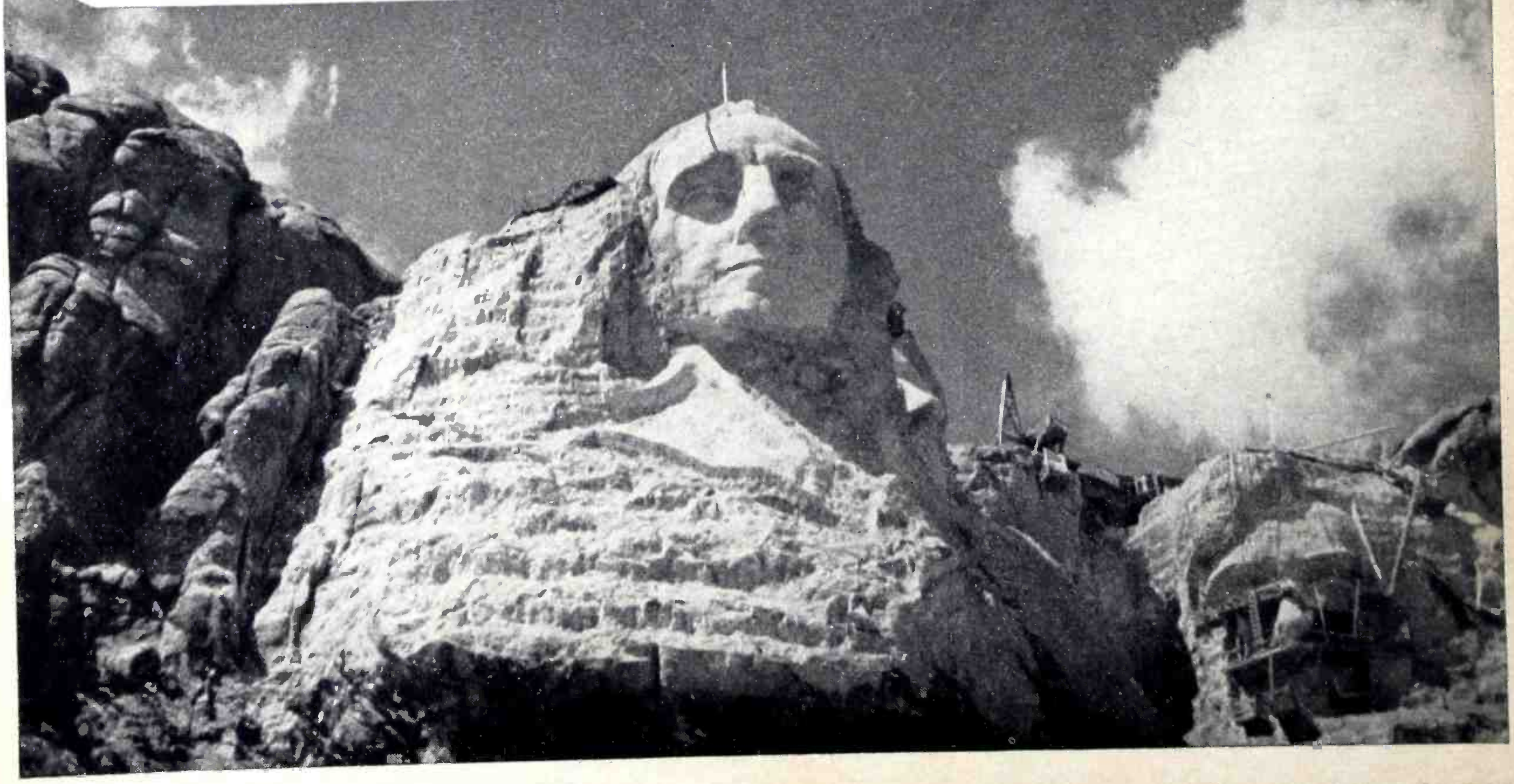
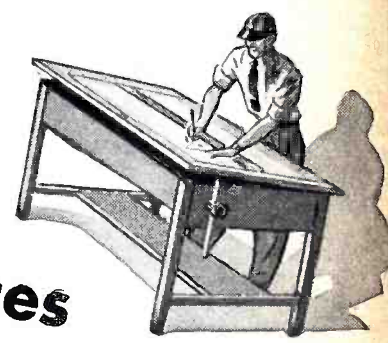


USERS TELL US . . .

ALBANITE produces a Better Tracing Paper



No wonder this remarkable new tracing paper has found its way into the best drafting rooms in America. It gives you every possible drawing advantage, *and a permanence that protects your tracings against the ravages of time!*

For ALBANENE is made of 100% long fiber pure white rags—treated with *ALBANITE*—a new crystal clear synthetic solid developed in the K & E laboratories. It is free from oil and wax, physically and chemically inert. ALBANENE will not oxidize, become brittle or lose transparency with age.

Even more to the point, ALBANENE has an improved drawing surface that takes ink or pencil fluently and erases with ease . . . A high degree of transparency that makes tracing simple, produces strong, sharp blueprints . . . Extra strength to stand up under constant corrections, filing and rough handling. ALBANENE has *all* the working qualities you have always wanted *and it will retain all these characteristics indefinitely.*

Let ALBANENE prove its merits on your own drawing board, under actual drafting conditions. Ask your K & E dealer, or write us for an illustrated brochure and a generous working sample . . .

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NEW YORK—HOBOKEN, N. J.
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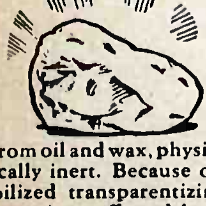
SAN FRANCISCO · LOS ANGELES · DETROIT · MONTREAL

MINERAL OIL. Most tracing papers are treated with some kind of oil. Mineral oil is physically unstable, tends to "drift", never dries completely. Papers treated with mineral oil pick up dust, lose transparency with age.

VEGETABLE OIL, chemically unstable, oxidizes easily. Papers treated with vegetable oil become rancid and brittle, turn yellow and opaque with age.

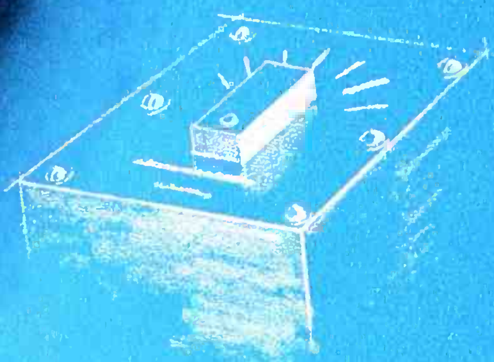


ALBANITE is a crystal-clear synthetic solid, free from oil and wax, physically and chemically inert. Because of this new stabilized transparentizing agent Albanene is unaffected by harsh climates—will not oxidize with age, become brittle or lose transparency.

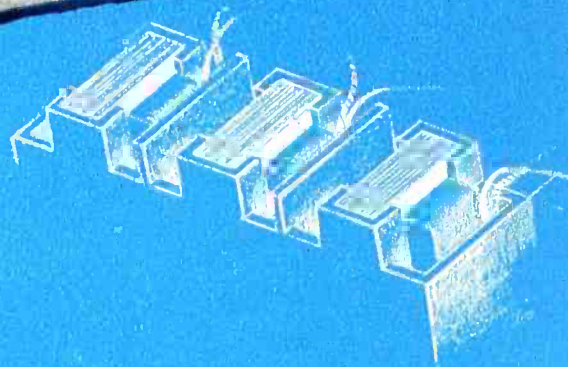
K&E Albanene
REG. U. S. PAT. OFF.
THE STABILIZED TRACING PAPER

Combinations for Victory

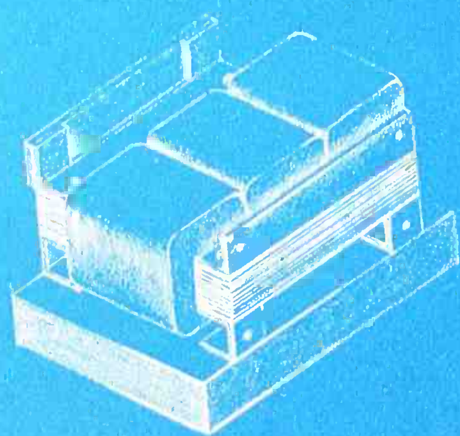
Savings in materials and machine time are vital to victory. Substantial savings can frequently be effected by combining elements. Typical UTC design refinements of this type are illustrated.



The design of this unit combines switch plate, name plate, and cover.



This unit employs a special die cast housing which combines the mounting of six units, eliminating twelve sets of brackets, twenty-four screws, and a special outer case.



UTC three phase to single phase transformers combine the mounting facilities of the transformer and condenser. This and electrical design reduced the volume and weight of the UTC design forty per cent compared to contemporary design.

Two reactors, four condensers, and two shielded transformers are combined in this hermetically sealed container. Separately cased, the volume and weight would be doubled.

May we design a Victory Unit to your application?

UNITED TRANSFORMER CO.

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EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

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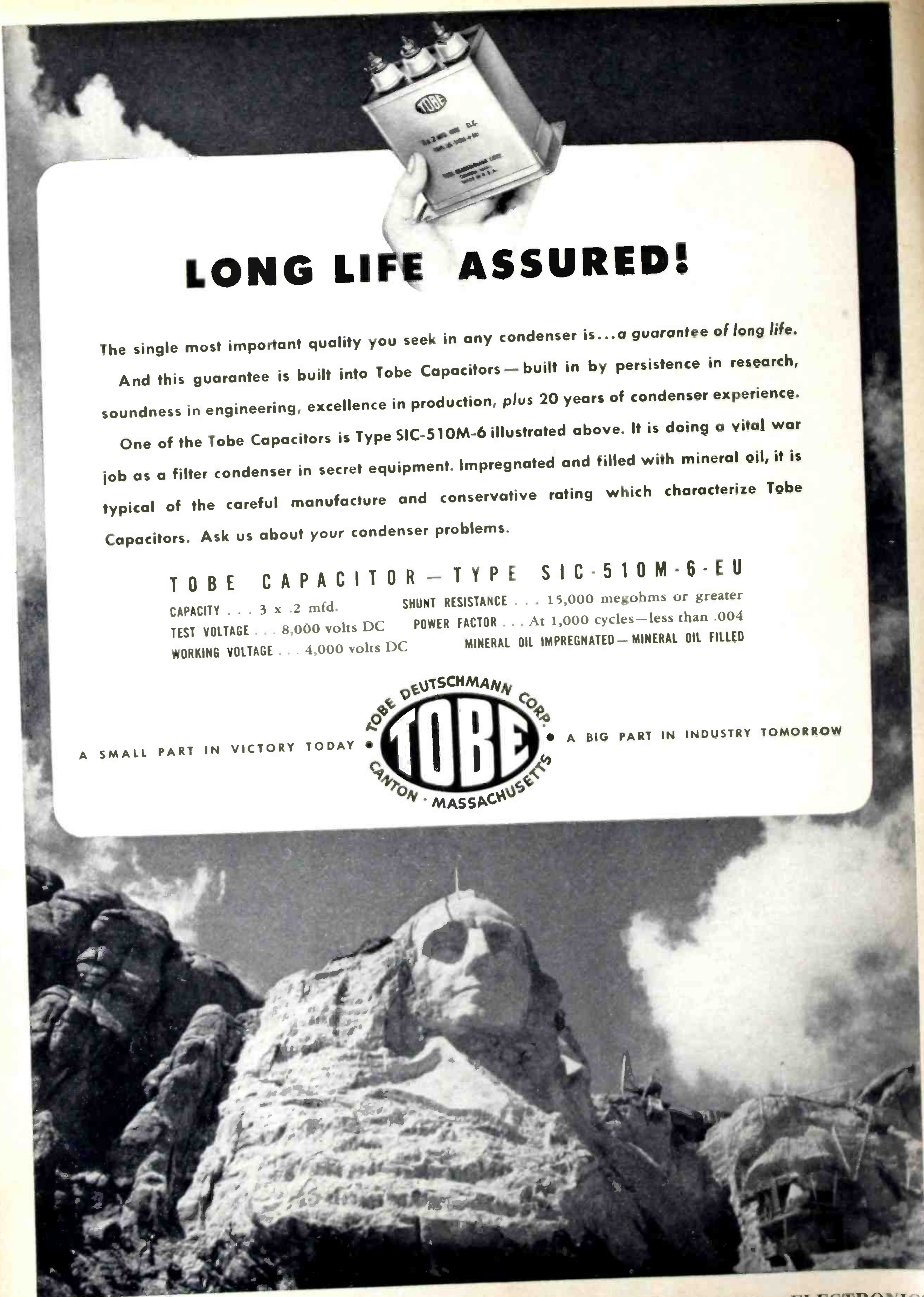
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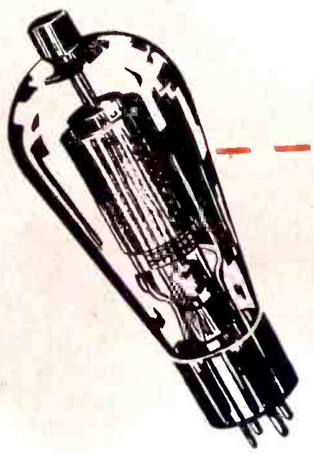

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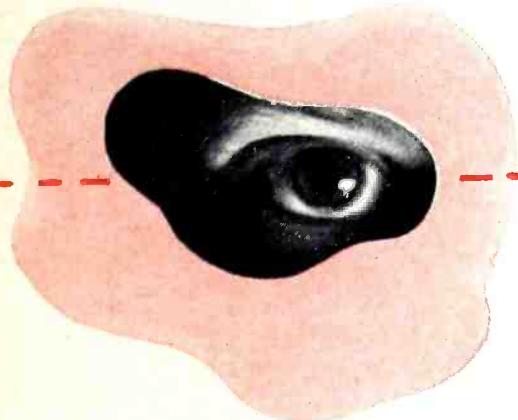
SUPERIO

GLEAM IN YOUR EYE *to work*



SUPERIOR TUBING WITHIN THE TUBES TO BE...

That "gleam in your eye" may be a new electronic tube for facsimile, electronic motor control, FM, a Signal Corps development, or for an entirely new principle of high frequency location.

What of the *Anode* or *Cathode Sleeve* to make that "gleam in your eye" a reality — first as a successful development project, and then as a design adaptable to economical production in quantity?

When you come to the "tubing within the tube" in your experimental planning, take advantage of the highly specialized facilities centered at Superior Tube Company. Here your blue prints will be transformed into a metal sleeve — perhaps Seamless, perhaps Lockseam, or perhaps Lapseam — a sleeve that is the metallurgical and physical counterpart of your electronic expectations.

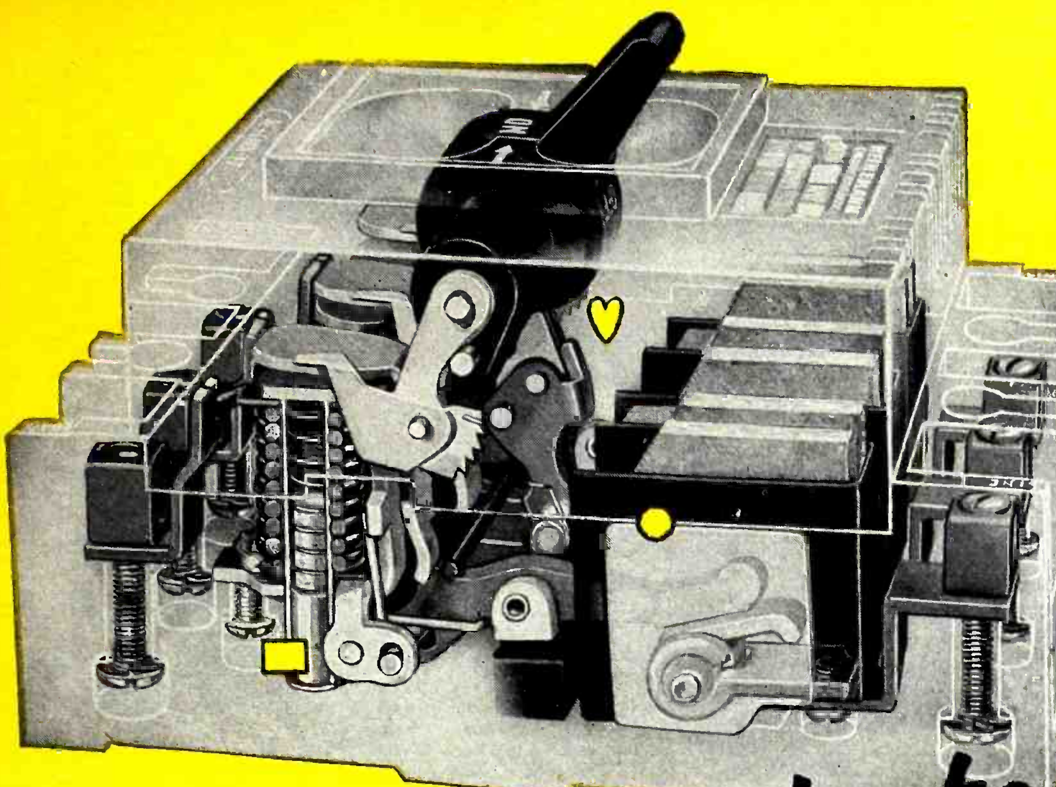
Superior is keenly aware of the needs of an Electronic Industry which is already looking to tomorrow's horizon. Even as these words are being written, the walls of a new, enlarged Engineering and Research Laboratory are taking shape here at Superior. This Laboratory will be the crossroads where the electronic engineer will find assembled for his convenience a staff of experienced research men, and Superior's production line — with special equipment, mostly designed and built by our own engineers, making low costs possible.

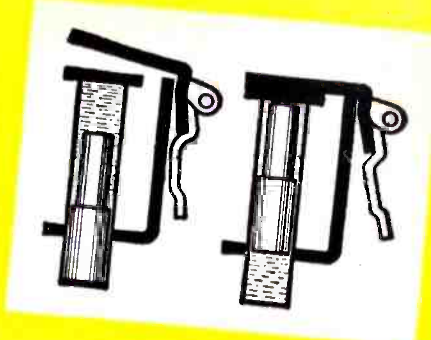
So, when you are ready to put that "gleam in your eye" to work, come to Superior for the *Anode* or *Cathode Sleeve* to do your particular job. If it hasn't been made, Superior is the place to start; if it is a standard sleeve, we are probably making it.

The big name in SMALL TUBING *for Uncle Sam!*

R TUBE CO.

NORRISTOWN, PENNSYLVANIA





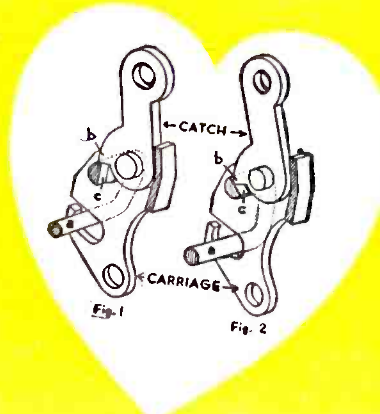
TIME DELAY ON OVERLOADS

The magnet coil surrounds a hermetically sealed liquid filled cylinder containing an iron plunger which, while normally out of the magnetic field, moves into it on overloads, the liquid controlling the speed. As the plunger rises to the top of the cylinder the magnetic flux increases to its maximum. At this point the armature is attracted to the pole piece.

All 3 contribute to the High Efficiency of

HEINEMANN

MAGNETIC CIRCUIT BREAKERS



HIGH SPEED LATCH

The armature, on engaging the lower leg of the lock (a) rotates it so that the tooth of the catch (b) passes through the cut portion of the lock (c) and opens the contacts. Of all known latches this one acts with the least amount of friction and mechanical delay. The Latch collapses only on short circuit or overload conditions even if the handle is purposely held in the "on" position.

They employ an overload trip unit that is FULLY ELECTROMAGNETIC and have a definite and instantaneous trip point independent of their time delay characteristics. The current carrying capacity as well as the minimum and instantaneous trip points are not affected by ambient temperatures. A true inverse time delay in the hermetically sealed unit allows the passage of inrush current. However, continued overload opens the breaker in time inverse to the ratio of the current.

HIGH SPEED BLOWOUT

The stationary contact is coiled around an insulated iron core connecting steel plates to form a U-shaped magnet. On overloads and short circuits, the current flowing through the contact creates magnetic lines which force the arc into the chamber and blow it out. As the value of the current to be interrupted increases, the quenching effect becomes greater due to intensified magnetic blowout field.

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary of Heinemann Electric Co. Est. 1888

97 PLUM STREET TRENTON, N. J.

ENGINEERS!

CHECK THESE SIX OUTSTANDING FEATURES OF NEW

1 MINIMUM FREQUENCY DRIFT

Absence of hot flow and cold flow, maximum dimensional stability and minimum expansion combine to provide a minimum of frequency drift. Often it is not necessary to use crystals or other compensating devices.

2 NEGLIGIBLE WATER ABSORPTION

Multiform glasses show a water absorption of less than 0.01 per cent (24 hours). Impregnants or added glazes are unnecessary, assuring better dimensional tolerances. Loss of efficiency due to improper impregnation or cracked glaze is eliminated.

3 LOW LOSS FACTOR

Insulators, made from Multiform glasses, offer you definitely greater efficiency. Multiform glass #707, for example, has a loss factor of only 0.40 at 20°C,—1 Meg.

4 UNIFORM ACCURACY

Threads, grooves and holes are accurate from piece to piece because they are molded in the piece. All sizes can be made with tolerances of ±2.0%, not less than ±0.010″.

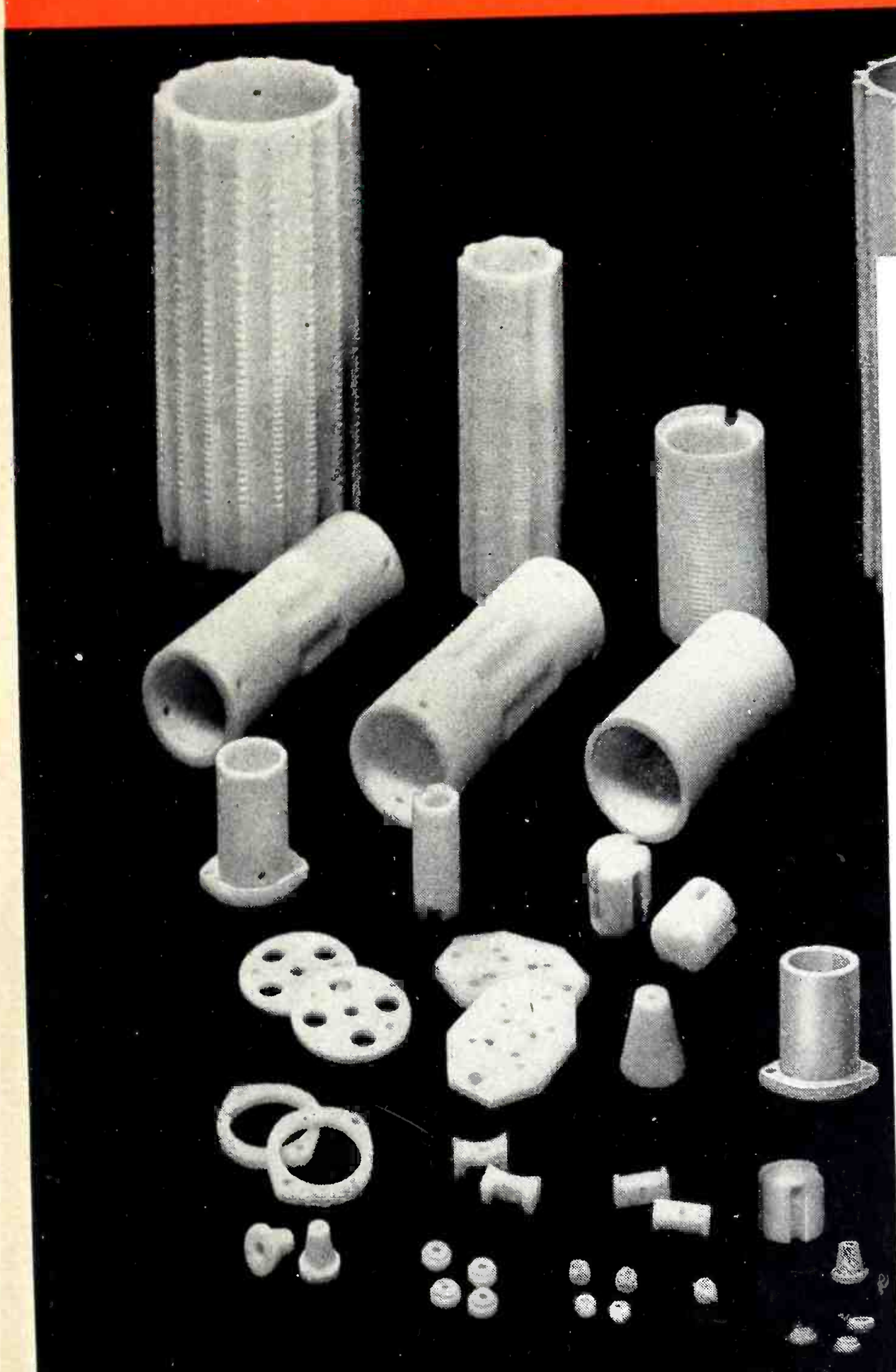
5 EXTREMELY WIDE RANGE OF SIZES AND SHAPES

There's almost no limit on shapes, cylindrical or flat. In size, pieces range from tiny beads, several thousand to the pound, to 25-lb. pieces 15″ or more across.

6 HIGH DIELECTRIC STRENGTH

Multiform glasses have a dielectric strength of 500 volts per mil or more—approximately twice the dielectric strength of porcelains and steatites.

CORNING MULTIFORM GLASS INSULATION



NO SHORTAGE OF GLASS TO REPLACE STEATITE, PORCELAIN AND OTHER ELECTRICAL INSULATION MATERIALS

DELIVERIES slow on electrical insulators? Here's good news! New-type insulators developed by Corning Glass Research—Pyrex brand Multiform Glassware—are available now! Check the six outstanding features on the opposite page. See why all Multiform glasses not only comply with the proposed A.S.A. American War Standard on Radio Insulation Materials of Low Dielectric Constant, but actually offer you more in efficiency and long life!

The characteristics of these glasses plus Corning's new fabrication methods make possible an extremely wide range of shapes and sizes. General dimensional tolerances are: large or heavy pieces, intricate shapes, hollow cylindrical sections— ± 2.0% or 0.010″; flat plates, solid rods, discs, beads, bushings— ± 1.0% or 0.005″, except thickness which should be ± 4% or 0.005″.

If you have an insulator problem, do this today: Fill in and mail the coupon now for a free sample of Pyrex brand Multiform Glass and complete, descriptive booklet.

MAIL COUPON TODAY FOR FREE SAMPLE AND DATA!

Corning Glass Works, Corning, N. Y.
Insulation Division, Dept. E-32

Please send me immediately, without charge, sample and descriptive booklet on new Pyrex brand Multiform Insulators.

Name..

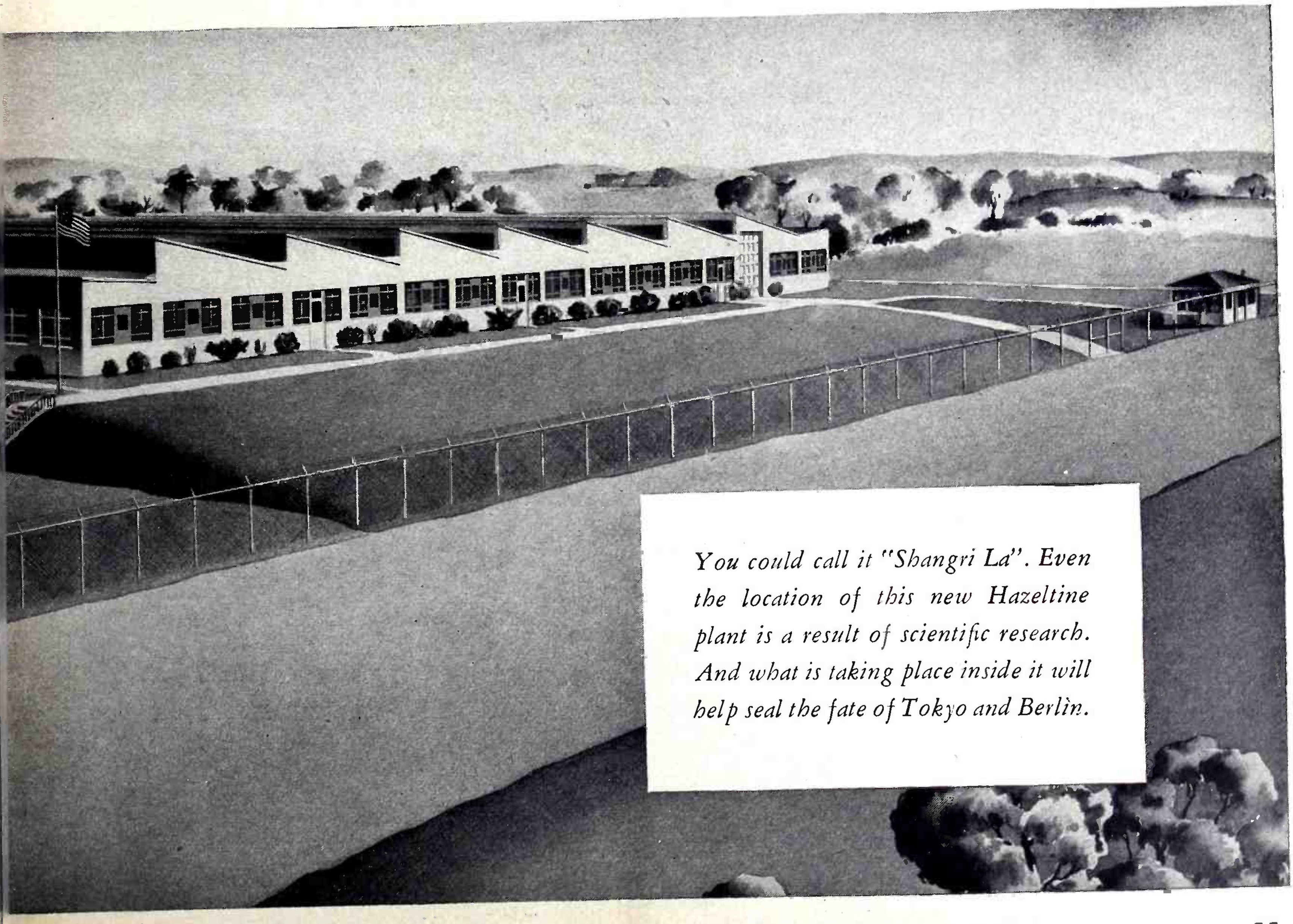
Company.......................................

Street Address................................

City....................State..................

Pyrex Insulators
BRAND

"PYREX" is a registered trade-mark and indicates manufacture by Corning Glass Works



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RESIST

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SALT SPRAY ATMOSPHERE
HUMIDITY
CRACKING OR FLAKING
ACIDS AND ALKALIS

HAVE

EXCELLENT FLEXIBILITY
ADHESIVE QUALITIES
HIGH COLD FLOW
GOOD THERMAL CONDUCTIVITY

M-R WAXES

PENETRATE

FIBRE, FLOSS, BAKELITE,
PAPER AND CLOTH

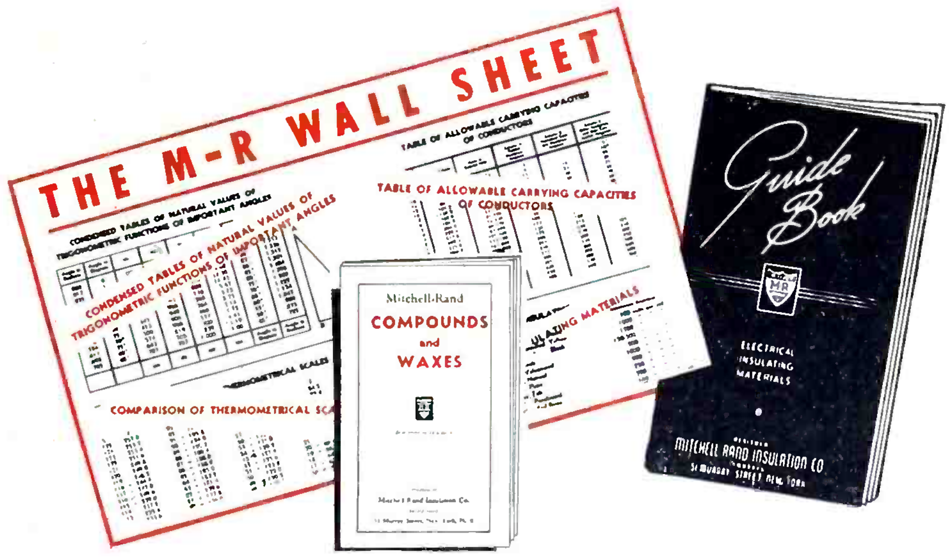
HAVE

LOW VISCOSITY
HIGH SURFACE TENSION
GOOD ELECTRICAL
CHARACTERISTICS

There is a Mitchell-Rand Insulating and Impregnating Compound or Wax to meet every known condition and requirement of the electronic and electrical industry.

53 years of serving the needs of the electronic and electrical industry, during which time upwards of 3500 Compound and Wax formulas were developed, now places Mitchell-Rand in the position of Headquarters for Waxes and Compounds.

M-R will gladly assist in the selection of the best suited Wax or Compound for your particular purpose.



M-R Waxes and Compounds have everything necessary for their purposes . . . write today for your copy of the M-R Wax and Compound Guide Book . . . other valuable aids, free for your asking, are the M-R Guide Book of Electrical Insulation; — The Wall Chart of reference tables, electrical, symbols, allowable capacities of conductors, dielectric averages and thicknesses of insulating materials, tap drill sizes, standards of varnished tubing sizes, etc.; . . . all are FREE and Full of Valuable Information . . . write for them on your letterhead.

INSULATION M-R COMPANY EST. 1889

MITCHELL-RAND INSULATION COMPANY, INC.

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A PARTIAL LIST OF M-R PRODUCTS

Fiberglas Varnished Tape and Cloth
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Fiberglas Braided Sleeving
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Impregnated Varnish Tubing
Insulating Varnishes of all types
Fiberglas Saturated Sleeving and Varnished Tubing
Asbestos Sleeving and Tape
Extruded Plastic Tubing
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth and Tubing

Aluminum just naturally belongs in the Electronics picture

Electronics at work frequently involves aluminum in some form or other; in the device itself or the apparatus working with it. Designers and manufacturers will find in the following tabulation the properties which make versatile aluminum so highly desirable for such equipment.

LIGHTNESS with HIGH STRENGTH — The light weight of aluminum is its most striking quality; lightness with high strength. It weighs only one-third as much as the heavy metals.

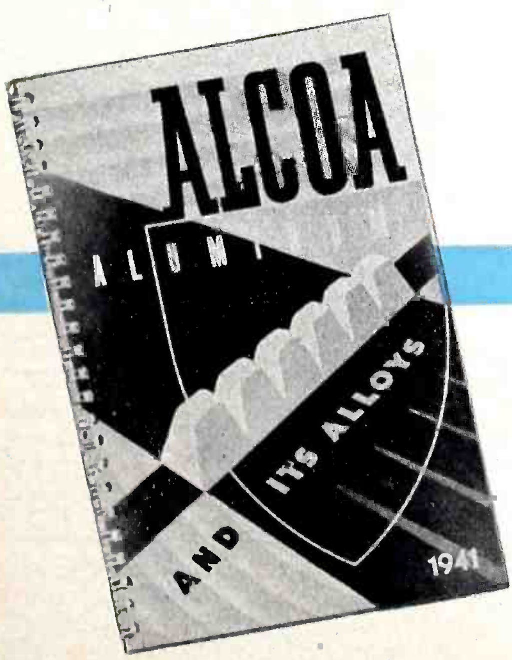
RESISTANCE TO CORROSION — Aluminum is able to resist the corrosive action of the atmosphere and a great variety of chemical compounds.

HIGH THERMAL and ELECTRICAL CONDUCTIVITY — Heat is distributed rapidly throughout its mass, usually permitting higher ratings. And aluminum is also an excellent conductor of electricity.

NONMAGNETIC NONSPARKING — Being nonmagnetic and nonsparking, aluminum is especially desirable for many electronic and associated devices.

EASY TO FABRICATE — Alcoa Aluminum Alloys are available in every commercial form, and are easily fabricated by all common methods. They can be economically finished in a wide range of durable, attractive surface finishes.

The booklet, "Alcoa Aluminum and Its Alloys," presents in concise form much fundamental information of value to designers and manufacturers. If you are wondering about including aluminum in your military or postwar products, you should have a copy. Mail the coupon today.



ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA
2136 Gulf Building, Pittsburgh, Pa.
Send me a copy of the booklet, "Alcoa Aluminum and Its Alloys."

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ADDRESS________________

. . . Awarded the Maritime M "for Outstanding Development and Production of Radio Equipment"

The new Liberty Ship radio
Developed for The Maritime Commission
By I. T. & T.'s manufacturing associate
Federal Telephone and Radio Corporation
Is helping save the manpower hours
That build our bridge of ships.

Not eight or ten separate parts
But *one*
Compact, all-in-one
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Takes care of
Both sending and receiving.

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Normally required—
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In recognition of
"Outstanding performance
In the development and production
Of radio equipment"
The Maritime Commission has awarded
Federal Telephone and Radio Corporation
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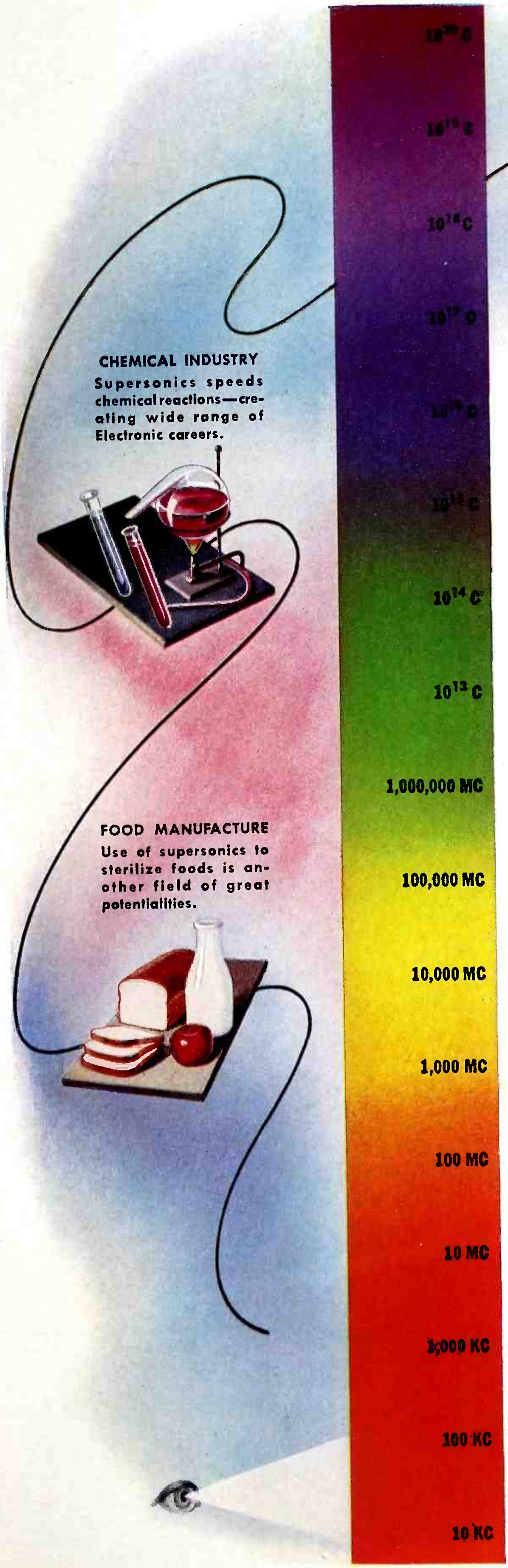
The Victory Fleet Flag
And Maritime Merit Badges.

Federal Telephone and Radio Corporation

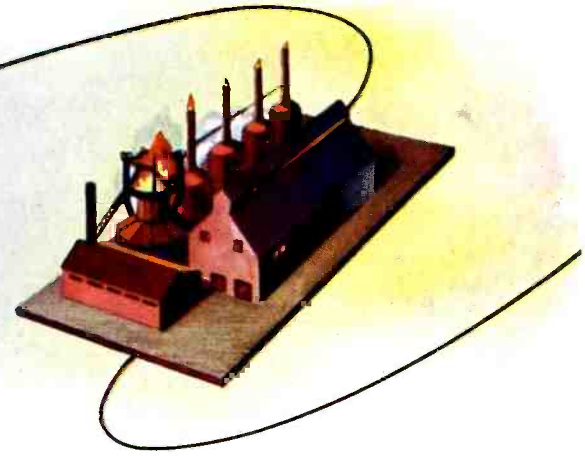
General Offices: 200 Mt. Pleasant Avenue, Newark, N. J.

AN I T&T ASSOCIATE



CHEMICAL INDUSTRY
Supersonics speeds chemical reactions—creating wide range of Electronic careers.

FOOD MANUFACTURE
Use of supersonics to sterilize foods is another field of great potentialities.



STEEL MAKING
Faster hardening of steel by supersonics opens whole new fields to men of Electronics.

SOMETHING'S HAPPENED TO ELECTRONICS!

Electronics isn't just broadcasting any more, or even communications. It's the sound of a blade of grass *growing* . . . a transport plane landing safely *pilotless* . . . it's busy smokestacks *and no smoke!*

Tomorrow belongs to the men of electronics . . . the scientists in university laboratories, the engineers in war industries, the youths everywhere who ponder the marvels of this amazing science. From these will come the brilliant achievements of the electronic future.

Already the uses of electronics have turned the frequency spectrum of the electronic industries into a many-runged ladder of commercial applications.

Industry is only beginning to realize, for example, the vast potentialities in supersonics for commercial and industrial application: solidifying melts of tin and aluminum more rapidly, accelerating the hardening of steel, sterilizing foods and other products, speeding chemical reactions.

With Victory, electronics will invade every industry . . . introducing new devices and machines . . . creating new fields of endeavor for men electronically trained.

Isolantite, too, has been exploring the possibilities of electronics with an eye to eventual broad-scale development. The architects of the new industrial era—America's electronic engineers—will find Isolantite ready with the needed insulating materials when the electronic world of the future finally emerges out of the wastes of war.

ISOLANTITE

CERAMIC INSULATORS

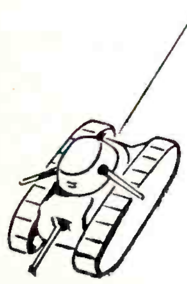
ISOLANTITE INC., BELLEVILLE, N. J.

The Heart of the Transmitter
CRYSTAL UNIT
DC-43
FREQ-KC
8183.520
CRYSTAL K.C.
PRODUCTS MO.
Producers of Approved Precision Crystals for Radio Frequency Control
Crystal
PRODUCTS COMPANY
1519 McGEE STREET • KANSAS CITY, MISSOURI

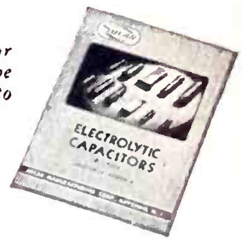
FREEZE 'EM OR FRY 'EM

• Global war means airplanes in the Arctic. It means tanks in the tropics. For fighting machines of all kinds, combat conditions call for freezing or frying — and sometimes both!

Solar is building capacitors which meet these extreme conditions. If "freezing or frying" is part of your capacitor problems — call on Solar's "temperature-engineering" services.



Facts and more facts. Complete capacitor data describing and illustrating the entire Solar line is now available to design engineers on request.



Solar

SOLAR

SOLAR MANUFACTURING CORP. BAYONNE, N.

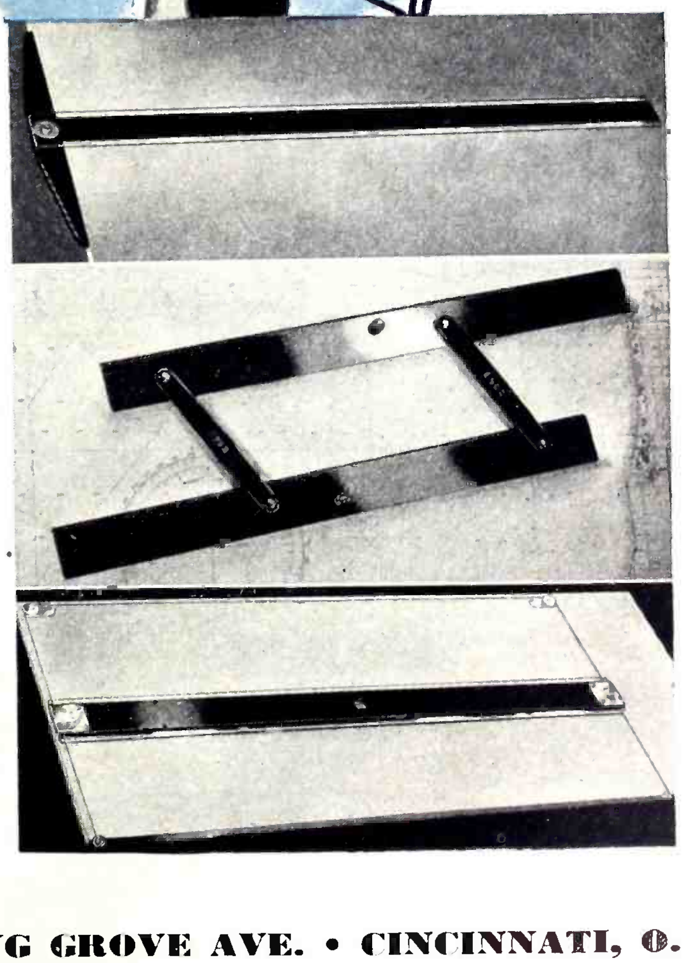
CAPACITORS

MAKERS OF CAPACITORS: ELECTROLYTIC • MICA • PAPER • TRIMMER • TRANSMITTING

A FRIENDLY HAND *to the Engineer*

HERE'S some friendly help to the engineer in his own personal work. By using Formica for numerous purposes in the machines they design engineers have often found the going easier, the product better. Now this same modern, laminated plastic material is offered in the form of T squares and other drawing instruments for use in the draughtsman's work—instruments that wear like iron, hold together and endure for years, never change in dimensions or appearance. They are beautiful instruments when you get them and they remain that way.

They are manufactured from Formica materials by the Engineering Sales Company, Sheboygan, Wisc.



ARMY E NAVY

FORMICA

Formica has received the Army-Navy "E" Award for Excellence in Production.

THE FORMICA INSULATION CO. • 4661 SPRING GROVE AVE. • CINCINNATI, O.

MYKROY

CERAMIC INSULATING MATERIAL

A special bonded mica product now serving widely in Army and Navy equipment

COMPARE!

These are some of the outstanding features and characteristics of MYKROY

INSULATING PROPERTIES—A low loss material that will not pass high frequencies nor dissipate h.f. energy. Will not carbonize under heat or arc, and therefore cannot create a path for leakage or short circuits.

MOISTURE RESISTANT — Absorption is negligible because it is non-porous, impervious to moisture, water, vapor, etc., thereby preventing failures otherwise due to improper insulation.

MECHANICAL STRENGTH—Nearly as strong in rupture as cast iron. Because it is not fragile it will withstand severe shock and vibration.

BONDING—Binds or seals perfectly to certain metals, thereby permitting its use in applications where bond or seal is critical.

MACHINABILITY—Machinable to high precision, either in simple surfaces or intricate parts.

NON-WARPING—No strain . . . no impairment of electrical contacts . . . no change in relation to associated parts . . . no change in form factor.

FROM REPORTS OF INDEPENDENT TESTING LABORATORIES

No. 4			No. 8
6.68	Dielectric Constant	(Dry)	6.75
6.73	Dielectric Constant	(Wet)	6.70
.00240	Power Factor	(Dry)	.00164
.00241	Power Factor	(Wet)	.00231
1.60	Loss Factor	(Dry)	1.11
1.62	Loss Factor	(Wet)	1.54
630 Volts per Mil	Dielectric Strength		660 Volts Per Mil.
22,000 lbs. per sq. in. rupture	Mechanical Strength		16,000 lbs. per sq. in. rupture

If you are confronted with an insulating problem, our engineers will welcome the opportunity to acquaint you with the performance of MYKROY. It is available in ample quantities and can be supplied for war and essential production requirements. For further information, please write to us or telephone today . . . PAssaic 3-4108.

MYKROY IS SUPPLIED IN SHEETS . . . MACHINED WITH PRECISION . . . MOULDED TO SPECIFICATION . . . MADE EXCLUSIVELY BY

ELECTRONIC MECHANICS INC.

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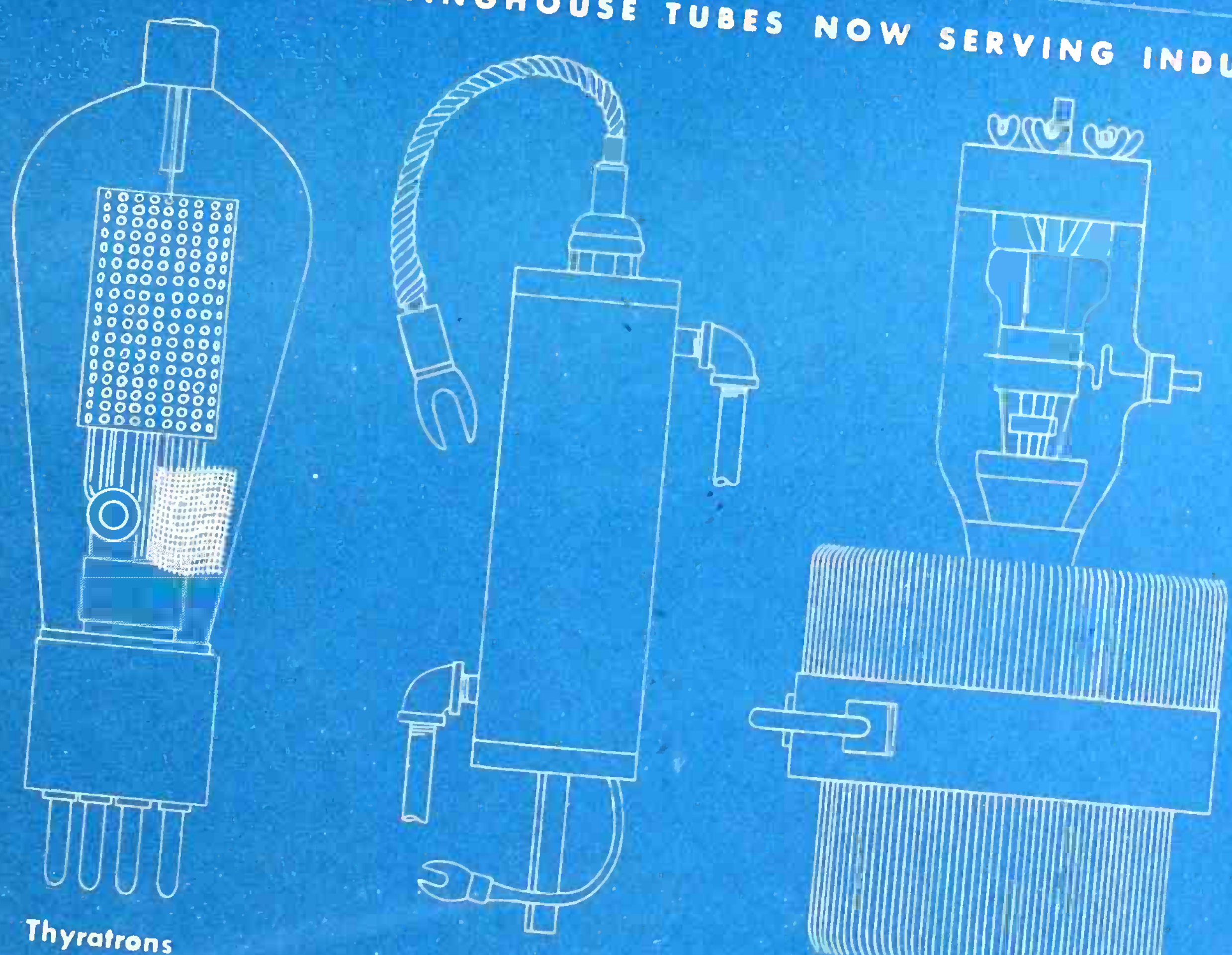
S 27

Electronic Tubes for Today's Jobs

A FEW OF THE WESTINGHOUSE TUBES NOW SERVING INDUSTRY



Thyratrons

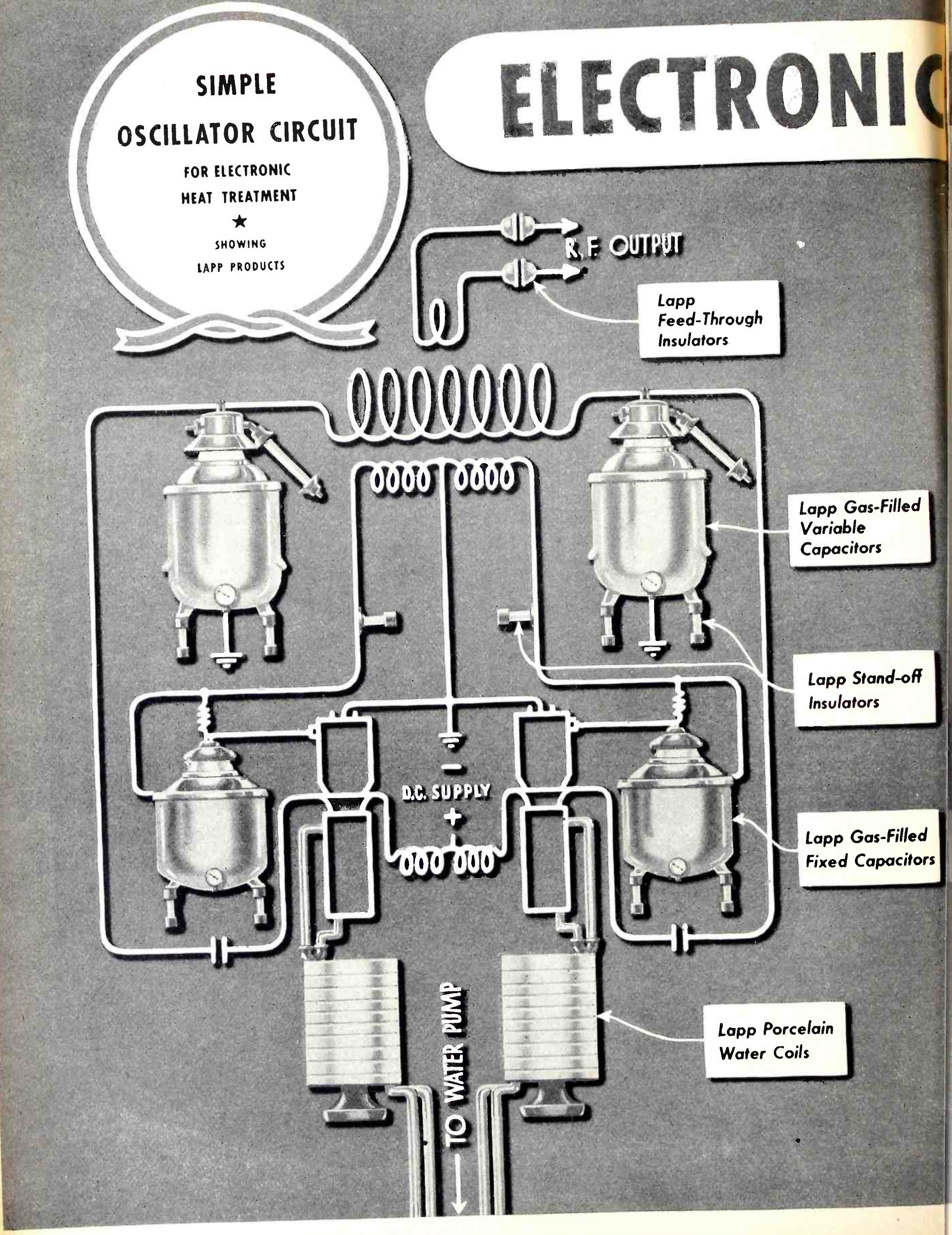
Used for high speed sensitive relays, and controlled rectifiers for such purposes as welding control and motor speed control. Made in both mercury vapor and gas filled types. Ask for bulletins TD-81; TD-79.

Ignitrons

An outstanding Westinghouse development, used for resistance welding control, high power rectification or in any application where large amounts of power must be accurately controlled. Ask for Bulletins: TD-80, TD-91, B-3102.

Transmitting Tubes

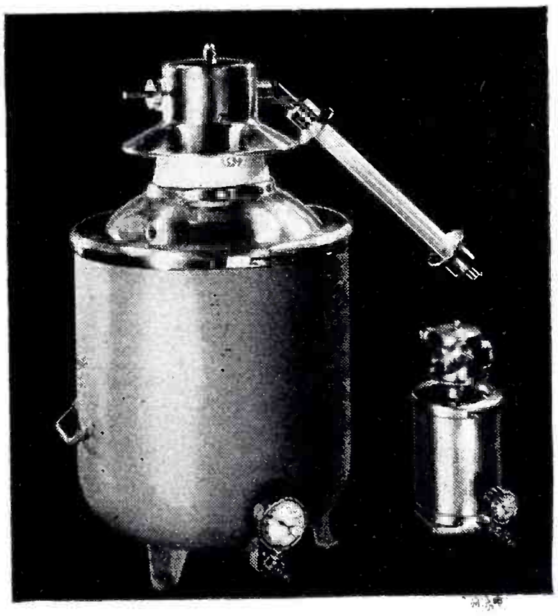
Westinghouse provides a complete line of transmitting tubes for military and civilian radio purposes.


SIMPLE
OSCILLATOR CIRCUIT
FOR ELECTRONIC
HEAT TREATMENT
SHOWING
LAPP PRODUCTS
ELECTRONIC
R. F. OUTPUT
Lapp Feed-Through Insulators
Lapp Gas-Filled Variable Capacitors
Lapp Stand-off Insulators
D.C. SUPPLY
Lapp Gas-Filled Fixed Capacitors
Lapp Porcelain Water Coils
TO WATER PUMP

HEAT TREATING

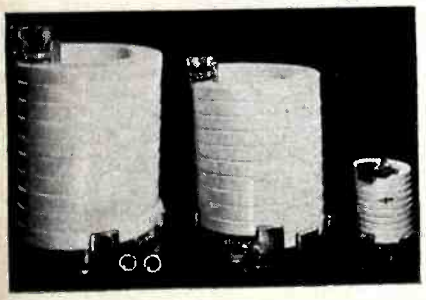
These Lapp products reduce operating costs, improve performance, increase security

Electron-tube oscillators turn electrical "losses" into industry's gain by providing quick, efficient, localized heat. For surface hardening, for localized hardening or annealing without warping or distortion, for brazing, for bonding plywood, for certain drying applications, for softening thermoplastics—for almost countless specialized industrial heating problems, the high-frequency oscillator offers the modern efficient method. Use of these Lapp products will save power, save time, and save trouble.



LAPP GAS-FILLED CONDENSERS

For lump capacitance in any high-power circuit, Lapp Gas-filled Condensers are the industry's best bet. In quick summary, their features include: **GAS-FILLED**—No mica is required. Use of Lapp condensers releases this critical material for more pressing needs. **PUNCTURE-PROOF**—There is no fixed dielectric to puncture; an external gap prevents internal flashover—"fail-proof" is a reasonable and honest term. **ZERO LOSS**—Loss can be measured only as zero; in comparison with solid-dielectric capacitors, a single large Lapp unit in continuous operation will effect a substantial saving on power consumption. **CONSTANT CAPACITANCE**—No warm-up period required. Lapp condensers do not heat up, and their capacitance is constant under any temperature variation. **FIXED, ADJUSTABLE AND VARIABLE STYLES**—Variable Lapp units permit precise circuit tuning as easy as tuning your home radio. Without adjusting the inductance coil you can bring your circuit to exact frequency for most efficient performance on any heating job.



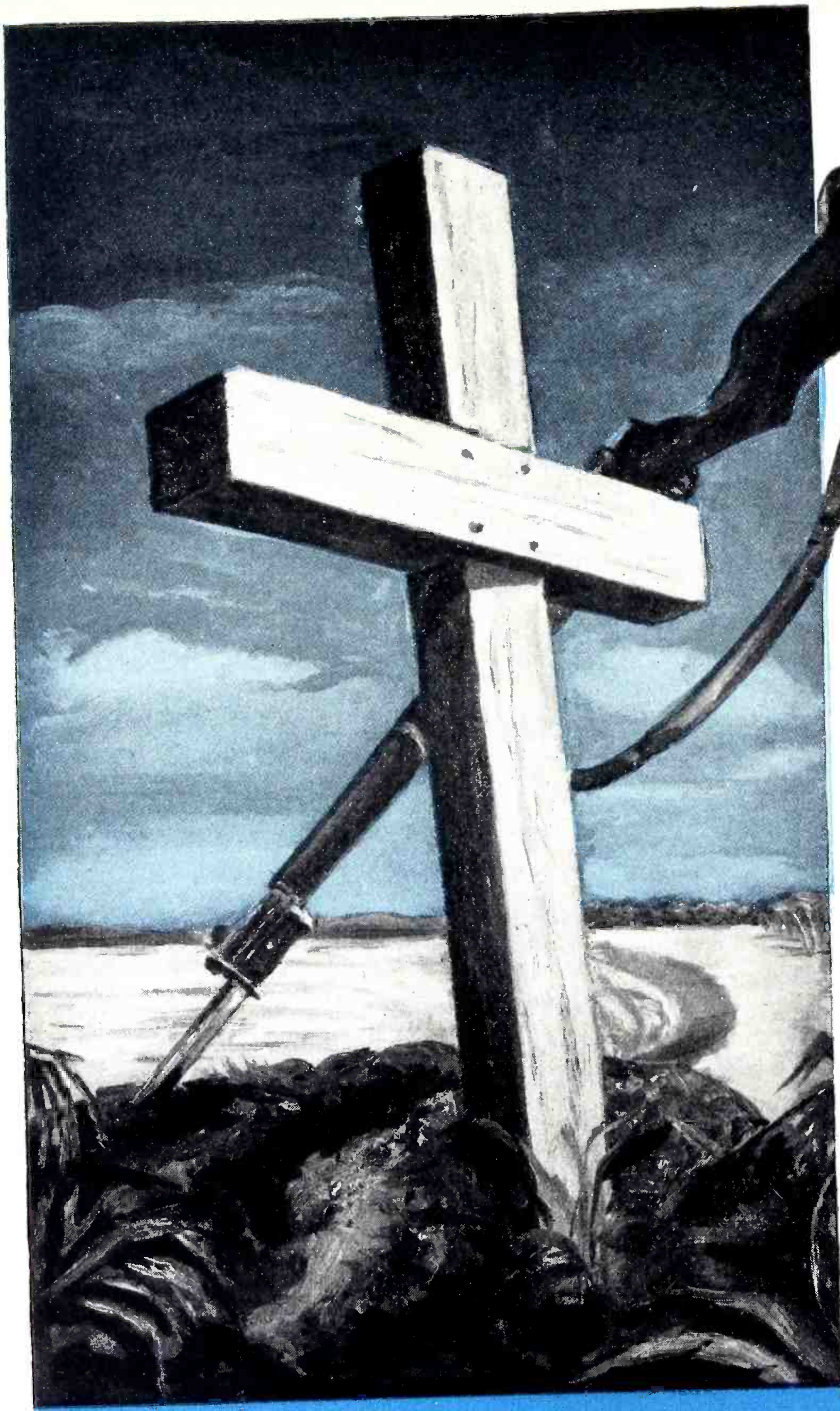
LAPP WATER COILS

The water-cooled tubes customarily used in high-power circuits can most efficiently be cooled with a system utilizing Lapp Porcelain Coils, porcelain pipe and fittings. No rubber need be used; sludging is eliminated, and with it need for periodic water changing and cleaning of the cooling system.

LAPP STAND-OFF, BOWL, ENTRANCE INSULATORS

Insulators for bus support, mounting of equipment, entrance, or any other application are available from Lapp in any wanted style and rating. Lapp is also equipped for production of many special assemblies, incorporating porcelain, steatite or special-characteristic ceramic, and associated metal parts.

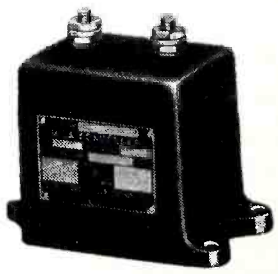
Lapp ARMY E NAVY **INSULATOR CO., INC., LE ROY, N.Y.**



THROUGH NO FAULT OF YOURS?

America cannot afford *dead heroes* through failure of fighting tools. Only maximum reliability is "good enough" for vital war equipment. You can give your product that degree of reliability by using C-Ds when the design calls for capacitors.

Cornell-Dubilier has *specialized* in the manufacture of capacitors exclusively for more than 33 years. The extra measure of stamina this unique experience has built into C-Ds—a competitive advantage in peacetime—is a priceless assurance of reliability in time of war. Cornell Dubilier Electric Corporation, South Plainfield, New Jersey.



Medium Power Transmitter Capacitors
TYPE 30

The type 30 Mica Capacitors in moulded cases are designed for a wide variety of radio frequency applications where size and weight are at a premium. They are being used in aircraft, portable, low and high power transmitters as grid, plate, coupling tank and by-pass capacitors. These units employ the patented series mica stack construction, eliminating corona losses and permitting their use on higher r.f. voltages. Described in detail in catalog No. 160T on request.

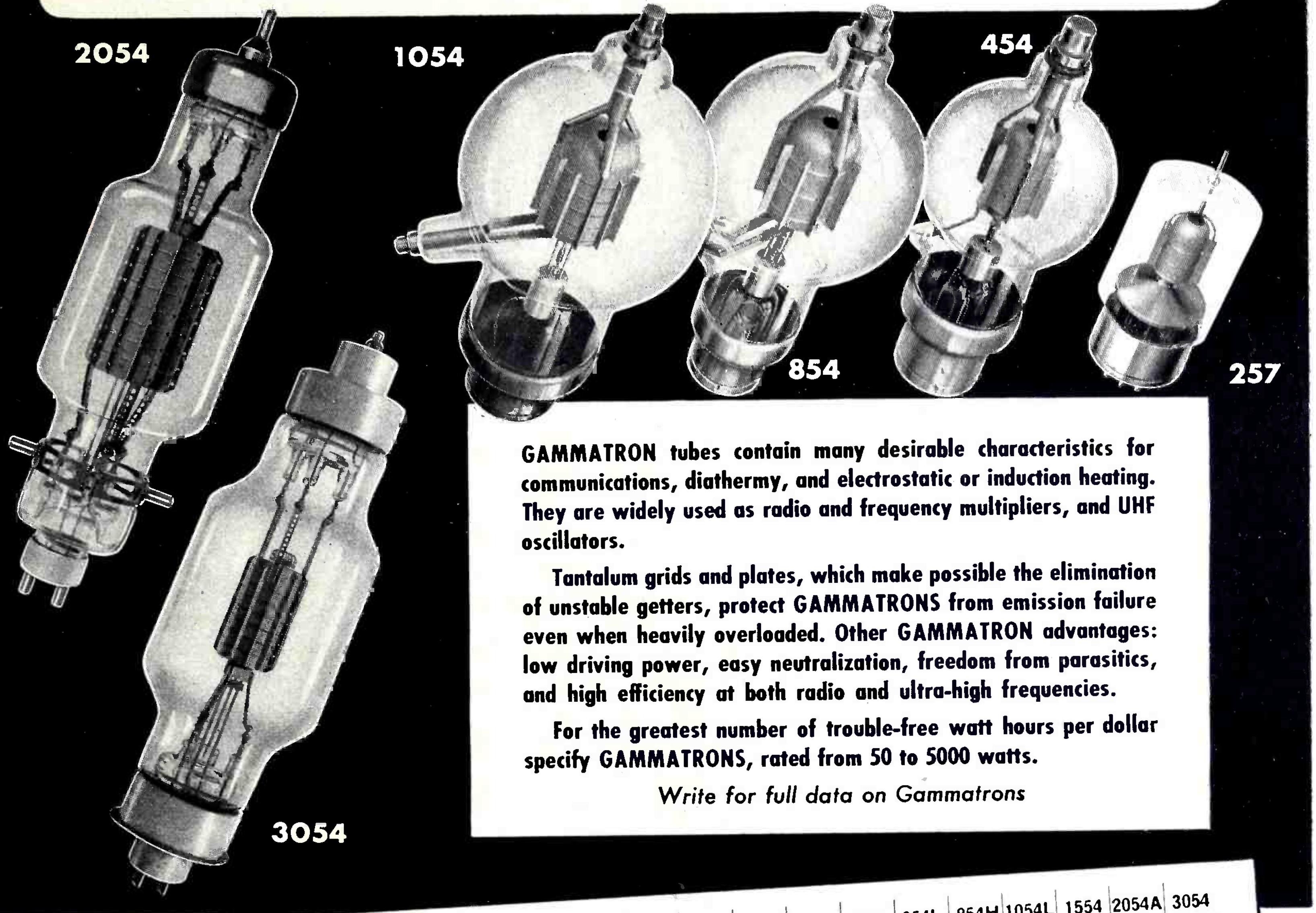
Cornell-Dubilier capacitors

MICA DYKANOL PAPER
WET AND DRY ELECTROLYTICS

CORNELL-DUBILIER CAPACITORS CD

MORE IN USE TODAY THAN ANY OTHER MAKE

GAMMATRON *Tantalum Tubes*



GAMMATRON tubes contain many desirable characteristics for communications, diathermy, and electrostatic or induction heating. They are widely used as radio and frequency multipliers, and UHF oscillators.

Tantalum grids and plates, which make possible the elimination of unstable getters, protect GAMMATRONS from emission failure even when heavily overloaded. Other GAMMATRON advantages: low driving power, easy neutralization, freedom from parasitics, and high efficiency at both radio and ultra-high frequencies.

For the greatest number of trouble-free watt hours per dollar specify GAMMATRONS, rated from 50 to 5000 watts.

Write for full data on Gammatrons

TYPE NO.	24	54	152L	158	254	257*	304L	354C	354E	454L
MAX. POWER OUTPUT: Class 'C' R.F.	90	250	610	200	500	238	1220	615	615	900
PLATE DISSIPATION: Watts	25	50	150	50	100	75	300	150	150	250
AVERAGE AMPLIFICATION FACTOR	25	27	10	25	25		10	14	35	14
MAX. RATINGS: Plate Volts Plate M.A. Grid M.A.	2000 75 25	3000 150 30	3000 500 75	2000 200 40	4000 225 40	4000 150 25	3000 1000 150	4000 300 60	4000 300 70	5000 375 60
MAX. FREQUENCY, Mc.: Power Amplifier	200	200	175	100	175	150	175	50	50	150
INTERELECTRODE CAP: C g—p u.u.f. C g—f u.u.f. C p—f u.u.f.	1.7 2.5 0.4	1.8 2.1 0.5	5 7 0.4	4.6 4.7 1.0	3.6 3.3 1.0	0.04 13.8 In. 6.7 Out.	9 12 0.8	3.8 4.5 1.1	3.8 4.5 1.1	3.4 4.6 1.4
FILAMENT: Volts Amperes	6.3 3	5.0 5	5-10 13-6.5	12.6 2.5	5.0 7.5	5.0 7.5	5-10 13-26	5 10	5 10	5 11
PHYSICAL: Length, Inches Diameter, Inches Weight, Oz. Base	4 1/4 1 3/8 1 1/2 Small UX	5 7/16 2 2 1/2 Std. UX	7 3/4 2 1/2 8 Johnson #213	4 3/4 2 4 Std. UX	7 2 5/8 6 1/2 Std. 50 Watt	6 3/4 2 5/8 6 Giant 7 Pin	7 3/4 3 1/2 9 Johnson #213	9 3 3/8 6 1/2 Std. 50 Watt	9 3 3/8 6 1/2 Std. 50 Watt	10 3 3/4 7 Std. 50 Watt
NET PRICE	4.75	8.00	30.00	18.50	13.50	27.50	65.00	24.50	24.50	27.50

TYPE NO.	454H	654	854L	854H	1054L	1554	2054A	3054
MAX. POWER OUTPUT: Class 'C' R.F.	900	1400	1800	1820	3000	3600	2000	5300
PLATE DISSIPATION: Watts	250	300	450	450	750	1000	1200	1500
AVERAGE AMPLIFICATION FACTOR	30	22	14	30	13.5	14.5	10	20
MAX. RATINGS: Plate Volts Plate M.A. Grid M.A.	5000 375 85	4000 600 100	6000 600 80	6000 600 110	6000 1000 125	5000 1000 250	3000 800 200	5000 2000 500
MAX. FREQUENCY, Mc.: Power Amplifier	150	50	125	125	100	30	20	30
INTERELECTRODE CAP: C g—p u.u.f. C g—f u.u.f. C p—f u.u.f.	3.4 4.6 1.4	5.5 6.2 1.5	5 6 0.5	4 8 0.5	5 8 0.8	11 15.5 1.2	18 15 7	15 25 2.5
FILAMENT: Volts Amperes	5 11	7.5 15	7.5 12	7.5 12	7.5 21	11 17.5	10 22	14 45
PHYSICAL: Length, Inches Diameter, Inches Weight, Oz. Base	10 3 3/4 7 Std. 50 Watt	10 3/8 3 3/4 14 Std. 50 Watt	12 1/2 5 14 Std. 50 Watt	12 1/2 5 14 Std. 50 Watt	16 1/2 7 42 Johnson #214	18 6 56 HK 255	21 1/4 6 66 W.E. Co.	30 3/4 9 200 HK 255
NET PRICE	27.50	75.00	75.00	75.00	175.00	225.00	300.00	395.00

*Beam Pentode.

HEINTZ AND KAUFMAN LTD.

HK

SOUTH SAN FRANCISCO
CALIFORNIA U·S·A·

HEAT TREATING

These Lapp products reduce operating costs, improve performance, increase security

Electron-tube oscillators turn electrical "losses" into industry's gain by providing quick, efficient, localized heat. For surface hardening, for localized hardening or annealing without warping or distortion, for brazing, for bonding plywood, for certain drying applications, for softening thermoplastics—for almost countless specialized industrial heating problems, the high-frequency oscillator offers the modern efficient method. Use of these Lapp products will save power, save time, and save trouble.

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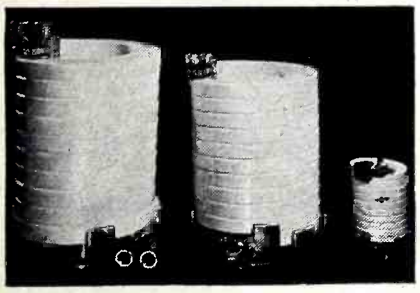

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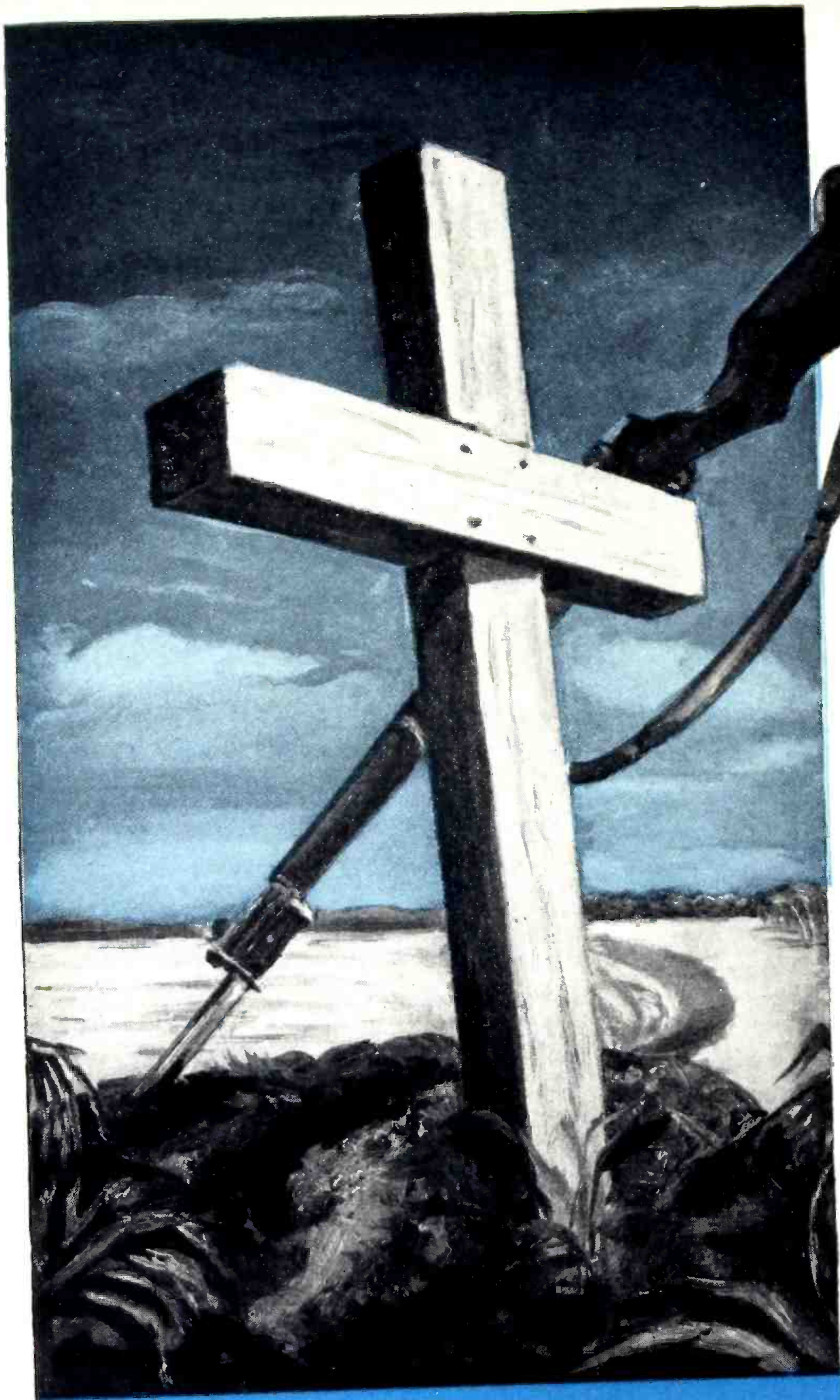

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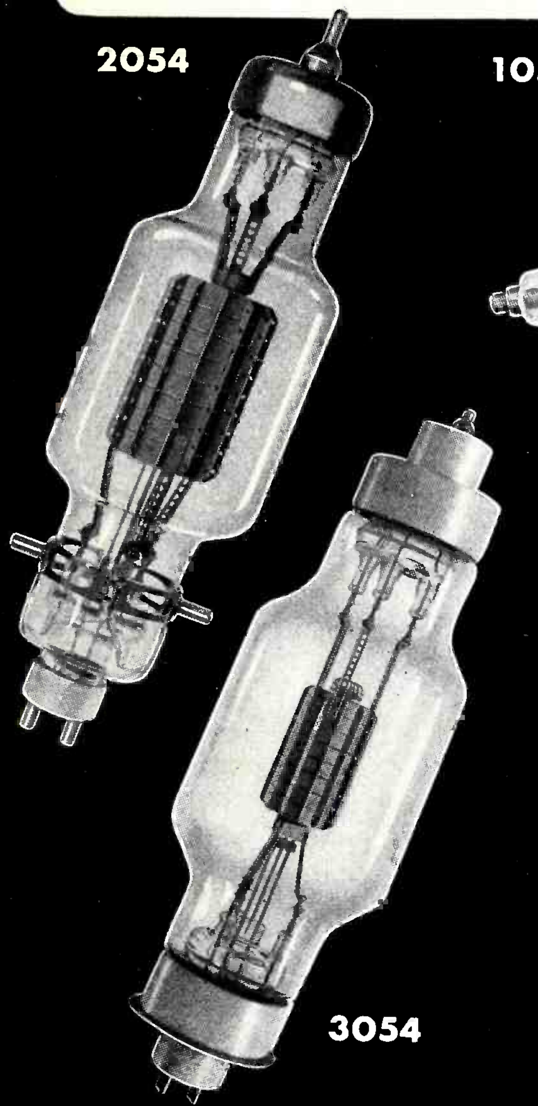

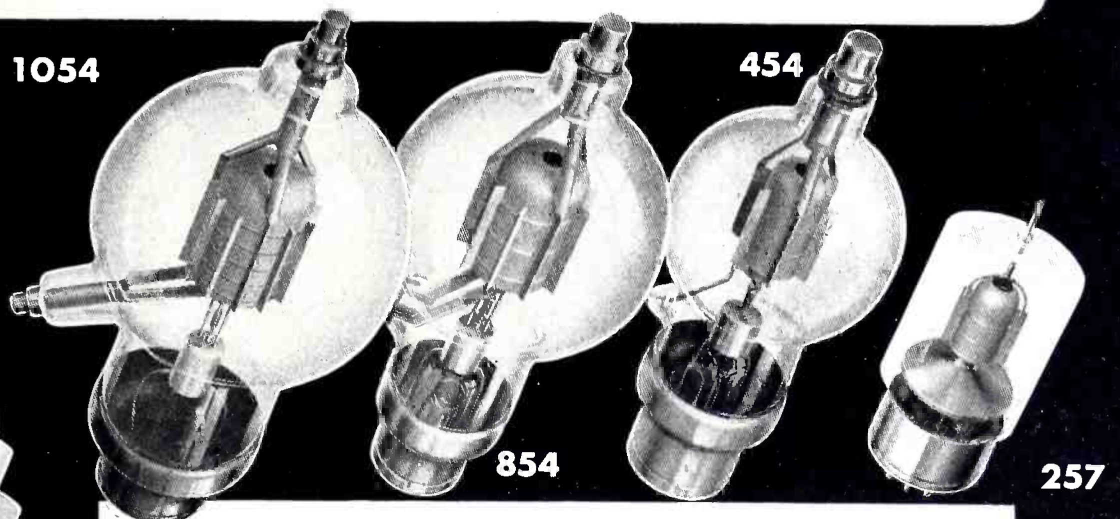

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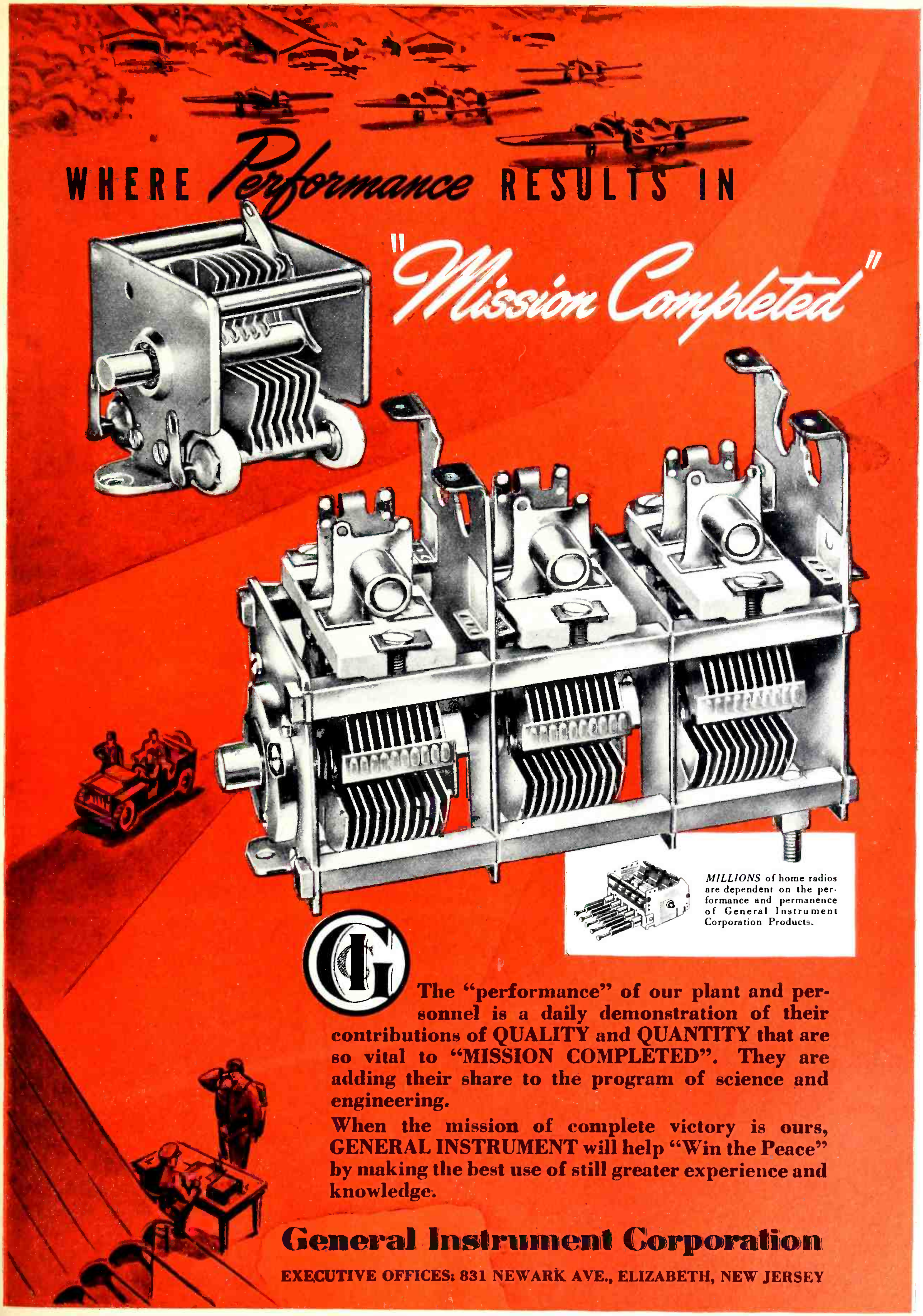
MAX. RATINGS: Plate Volts Plate M.A. Grid M.A.	2000 75 25	3000 150 30	3000 500 75	2000 200 40	4000 225 40	4000 150 25	3000 1000 150	4000 300 60	4000 300 70	5000 375 60
MAX. FREQUENCY, Mc.: Power Amplifier	200	200	175	100	175	150	175	50	50	150
INTERELECTRODE CAP: C g—p u.u.f. C g—f u.u.f. C p—f u.u.f.	1.7 2.5 0.4	1.8 2.1 0.5	5 7 0.4	4.6 4.7 1.0	3.6 3.3 1.0	0.04 13.8 In. 6.7 Out.	9 12 0.8	3.8 4.5 1.1	3.8 4.5 1.1	3.4 4.6 1.4
FILAMENT: Volts Amperes	6.3 3	5.0 5	5-10 13-6.5	12.6 2.5	5.0 7.5	5.0 7.5	5-10 13-26	5 10	5 10	5 11
PHYSICAL: Length, Inches Diameter, Inches Weight, Oz. Base	4¼ 1⅜ 1½ Small UX	5 7/16 2 2½ Std. UX	7¾ 2½ 8 Johnson #213	4¾ 2 4 Std. UX	7 2⅝ 6½ Std. 50 Watt	6¾ 2⅝ 6 Giant 7 Pin	7¾ 3½ 9 Johnson #213	9 3⅜ 6½ Std. 50 Watt	9 3⅜ 6½ Std. 50 Watt	10 3¾ 7 Std. 50 Watt
NET PRICE	4.75	8.00	30.00	18.50	13.50	27.50	65.00	24.50	24.50	27.50

TYPE NO.	454H	654	854L	854H	1054L	1554	2054A	3054
MAX. POWER OUTPUT: Class 'C' R.F.	900	1400	1800	1820	3000	3600	2000	5300
PLATE DISSIPATION: Watts	250	300	450	450	750	1000	1200	1500
AVERAGE AMPLIFICATION FACTOR	30	22	14	30	13.5	14.5	10	20
MAX. RATINGS: Plate Volts Plate M.A. Grid M.A.	5000 375 85	4000 600 100	6000 600 80	6000 600 110	6000 1000 125	5000 1000 250	3000 800 200	5000 2000 500
MAX. FREQUENCY, Mc.: Power Amplifier	150	50	125	125	100	30	20	30
INTERELECTRODE CAP: C g—p u.u.f. C g—f u.u.f. C p—f u.u.f.	3.4 4.6 1.4	5.5 6.2 1.5	5 6 0.5	4 8 0.5	5 8 0.8	11 15.5 1.2	18 15 7	15 25 2.5
FILAMENT: Volts Amperes	5 11	7.5 15	7.5 12	7.5 12	7.5 21	11 17.5	10 22	14 45
PHYSICAL: Length, Inches Diameter, Inches Weight, Oz. Base	10 3¾ 7 Std. 50 Watt	10⅜ 3¾ 14 Std. 50 Watt	12½ 5 14 Std. 50 Watt	12½ 5 14 Std. 50 Watt	16½ 7 42 Johnson #214	18 6 56 HK 255	21¼ 6 66 W.E. Co.	30¾ 9 200 HK 255
NET PRICE	27.50	75.00	75.00	75.00	175.00	225.00	300.00	395.00

*Beam Pentode.

HEINTZ AND KAUFMAN LTD. — SOUTH SAN FRANCISCO CALIFORNIA U·S·A·


WHERE Performance RESULTS IN
"Mission Completed"
MILLIONS of home radios are dependent on the performance and permanence of General Instrument Corporation Products.
The "performance" of our plant and personnel is a daily demonstration of their contributions of QUALITY and QUANTITY that are so vital to "MISSION COMPLETED". They are adding their share to the program of science and engineering.
When the mission of complete victory is ours, GENERAL INSTRUMENT will help "Win the Peace" by making the best use of still greater experience and knowledge.
General Instrument Corporation
EXECUTIVE OFFICES: 831 NEWARK AVE., ELIZABETH, NEW JERSEY

THROUGH NO FAULT OF YOURS?

America cannot afford *dead heroes* through failure of fighting tools. Only maximum reliability is "good enough" for vital war equipment. You can give your product that degree of reliability by using C-Ds when the design calls for capacitors.

Cornell-Dubilier has *specialized* in the manufacture of capacitors exclusively for more than 33 years. The extra measure of stamina this unique experience has built into C-Ds—a competitive advantage in peacetime—is a priceless assurance of reliability in time of war. Cornell Dubilier Electric Corporation, South Plainfield, New Jersey.

Medium Power Transmitter Capacitors
TYPE 30

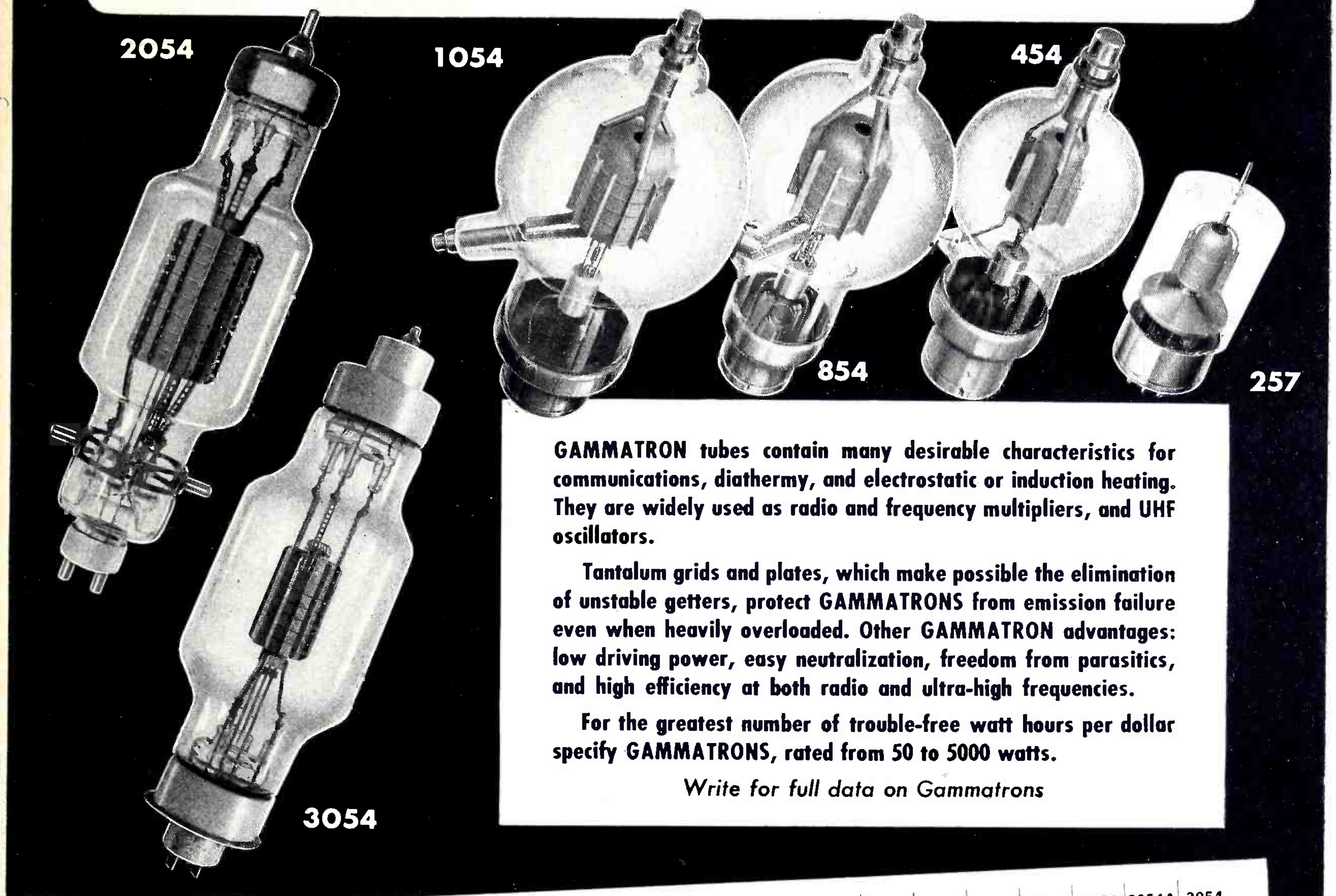
The type 30 Mica Capacitors in moulded cases are designed for a wide variety of radio frequency applications where size and weight are at a premium. They are being used in aircraft, portable, low and high power transmitters as grid, plate, coupling tank and by-pass capacitors. These units employ the patented series mica stack construction, eliminating corona losses and permitting their use on higher r.f. voltages. Described in detail in catalog No. 160T on request.

Cornell-Dubilier capacitors

MICA DYKANOL PAPER
WET AND DRY ELECTROLYTICS

MORE IN USE TODAY THAN ANY OTHER MAKE

GAMMATRON *Tantalum Tubes*



GAMMATRON tubes contain many desirable characteristics for communications, diathermy, and electrostatic or induction heating. They are widely used as radio and frequency multipliers, and UHF oscillators.

Tantalum grids and plates, which make possible the elimination of unstable getters, protect GAMMATRONS from emission failure even when heavily overloaded. Other GAMMATRON advantages: low driving power, easy neutralization, freedom from parasitics, and high efficiency at both radio and ultra-high frequencies.

For the greatest number of trouble-free watt hours per dollar specify GAMMATRONS, rated from 50 to 5000 watts.

Write for full data on Gammatrons

TYPE NO.	24	54	152L	158	254	257*	304L	354C	354E	454L	454H	654	854L	854H	1054L	1554	2054A	3054
MAX. POWER OUTPUT: Class 'C' R.F.	90	250	610	200	500	238	1220	615	615	900	900	1400	1800	1820	3000	3600	2000	5300
PLATE DISSIPATION: Watts	25	50	150	50	100	75	300	150	150	250	250	300	450	450	750	1000	1200	1500
AVERAGE AMPLIFICATION FACTOR	25	27	10	25	25		10	14	35	14	30	22	14	30	13.5	14.5	10	20
MAX. RATINGS: Plate Volts Plate M.A. Grid M.A.	2000 75 25	3000 150 30	3000 500 75	2000 200 40	4000 225 40	4000 150 25	3000 1000 150	4000 300 60	4000 300 70	5000 375 60	5000 375 85	4000 600 100	6000 600 80	6000 600 110	6000 1000 125	5000 1000 250	3000 800 200	5000 2000 500
MAX. FREQUENCY, Mc.: Power Amplifier	200	200	175	100	175	150	175	50	50	150	150	50	125	125	100	30	20	30
INTERELECTRODE CAP: C g—p u.u.f. C g—f u.u.f. C p—f u.u.f.	1.7 2.5 0.4	1.8 2.1 0.5	5 7 0.4	4.6 4.7 1.0	3.6 3.3 1.0	0.04 13.8 In. 6.7 Out.	9 12 0.8	3.8 4.5 1.1	3.8 4.5 1.1	3.4 4.6 1.4	3.4 4.6 1.4	5.5 6.2 1.5	5 6 0.5	4 8 0.5	5 8 0.8	11 15.5 1.2	18 15 7	15 25 2.5
FILAMENT: Volts Amperes	6.3 3	5.0 5	5-10 13-6.5	12.6 2.5	5.0 7.5	5.0 7.5	5-10 13-26	5 10	5 10	5 11	5 11	7.5 15	7.5 12	7.5 12	7.5 21	11 17.5	10 22	14 45
PHYSICAL: Length, Inches Diameter, Inches Weight, Oz. Base	4¼ 1⅜ 1½ Small UX	5 7/16 2 2½ Std. UX	7¾ 2½ 8 Johnson #213	4¾ 2 4 Std. UX	7 2⅝ 6½ Std. 50 Watt	6¾ 2⅝ 6 Giant 7 Pin	7¾ 3½ 9 Johnson #213	9 3⅜ 6½ Std. 50 Watt	9 3⅜ 6½ Std. 50 Watt	10 3¾ 7 Std. 50 Watt	10 3¾ 7 Std. 50 Watt	10⅜ 3¾ 14 Std. 50 Watt	12½ 5 14 Std. 50 Watt	12½ 5 14 Std. 50 Watt	16½ 7 42 Johnson #214	18 6 56 HK 255	21¼ 6 66 W.E. Co.	30¾ 9 200 HK 255
NET PRICE	4.75	8.00	30.00	18.50	13.50	27.50	65.00	24.50	24.50	27.50	27.50	75.00	75.00	75.00	175.00	225.00	300.00	395.00

*Beam Pentode.

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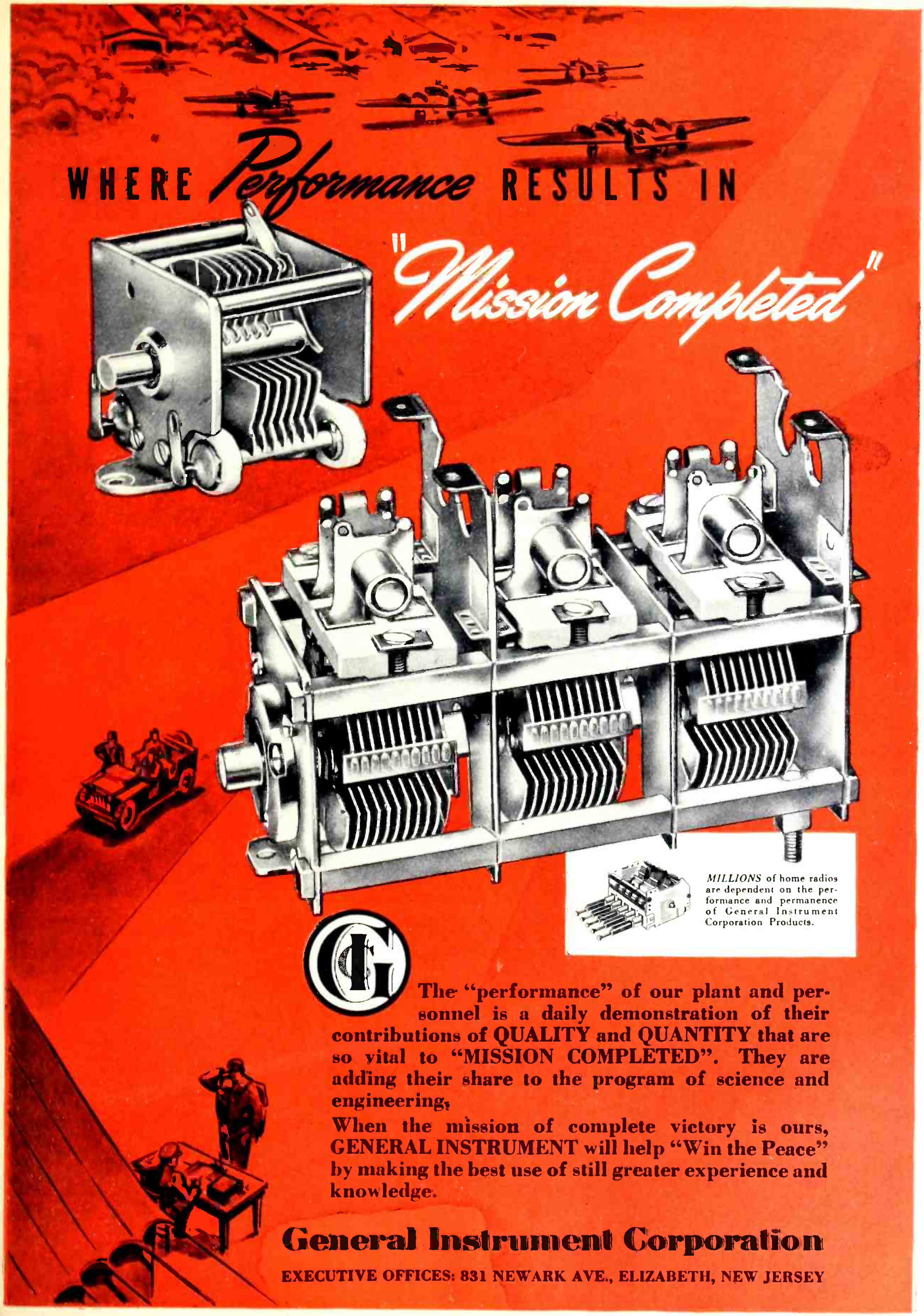

WHERE Performance RESULTS IN
"Mission Completed"
MILLIONS of home radios are dependent on the performance and permanence of General Instrument Corporation Products.
The "performance" of our plant and personnel is a daily demonstration of their contributions of QUALITY and QUANTITY that are so vital to "MISSION COMPLETED". They are adding their share to the program of science and engineering.
When the mission of complete victory is ours, GENERAL INSTRUMENT will help "Win the Peace" by making the best use of still greater experience and knowledge.
General Instrument Corporation
EXECUTIVE OFFICES: 831 NEWARK AVE., ELIZABETH, NEW JERSEY


Ceramics by Centralab

Serving the Electronic Industry Since 1922!

FOR more than two decades CENTRALAB has been indelibly connected with the radio industry. Since the first "battery" and "loud speaker" sets, practically every radio of importance to this day contains CENTRALAB parts.

NOW . . . more than ever before . . . CENTRALAB is a definite part of the radio and electronic picture. While to a very limited extent we are still taking care of the civilian needs, we are putting our main effort into supplying the armed forces with vitally needed equipment.

We are proud to be able to contribute our pioneer experience as well as our extensive facilities at this crucial time.

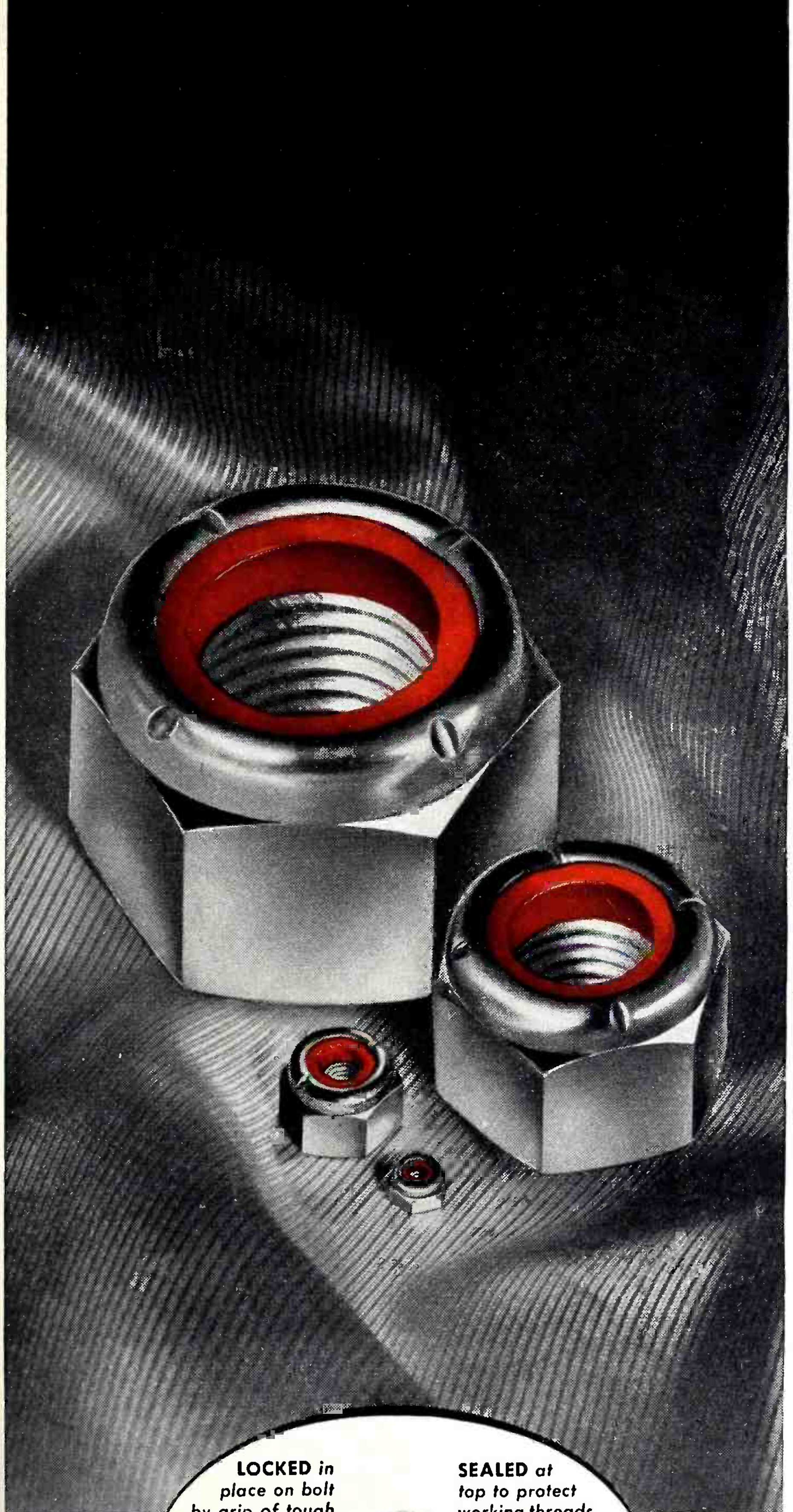
CENTRALAB PARTS INCLUDE:

- Steatite Insulators
- Ceramic Trimmers
- High Frequency Circuit Switches
- Volume Controls
- Ceramic Capacitors
- Wire Wound Controls
- Sound Projection Controls

Centralab

DIV. OF GLOBE-UNION INC., MILWAUKEE, WIS.

TOUGH NUTS TO CRACK



We've made billions of Elastic Stop Nuts.

And to our knowledge not one has failed to do its job.

But the tough nuts we refer to now are the fastening problems which looked hopeless until Elastic Stop Nuts were used.

We've met lots of these in our day – and licked them.

There have been plenty of them in war production.

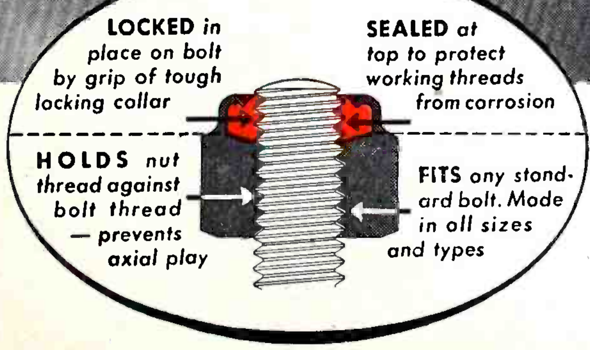
And how well these fastenings have filled the bill can best be told this way:

Every nut we can possibly produce is going into war goods. Yet even doubling our round-the-clock plant capacity hasn't let us gain on the demand.

In the days to come there will be many peacetime needs for these nuts.

Some will be simple. Others will look like "tough nuts to crack."

Our engineers like to meet both kinds. They stand ready to share their experience with you, work on your fastening problem and recommend the proper Elastic Stop Nut application for the job.



ELASTIC STOP NUTS

Lock fast to make things last

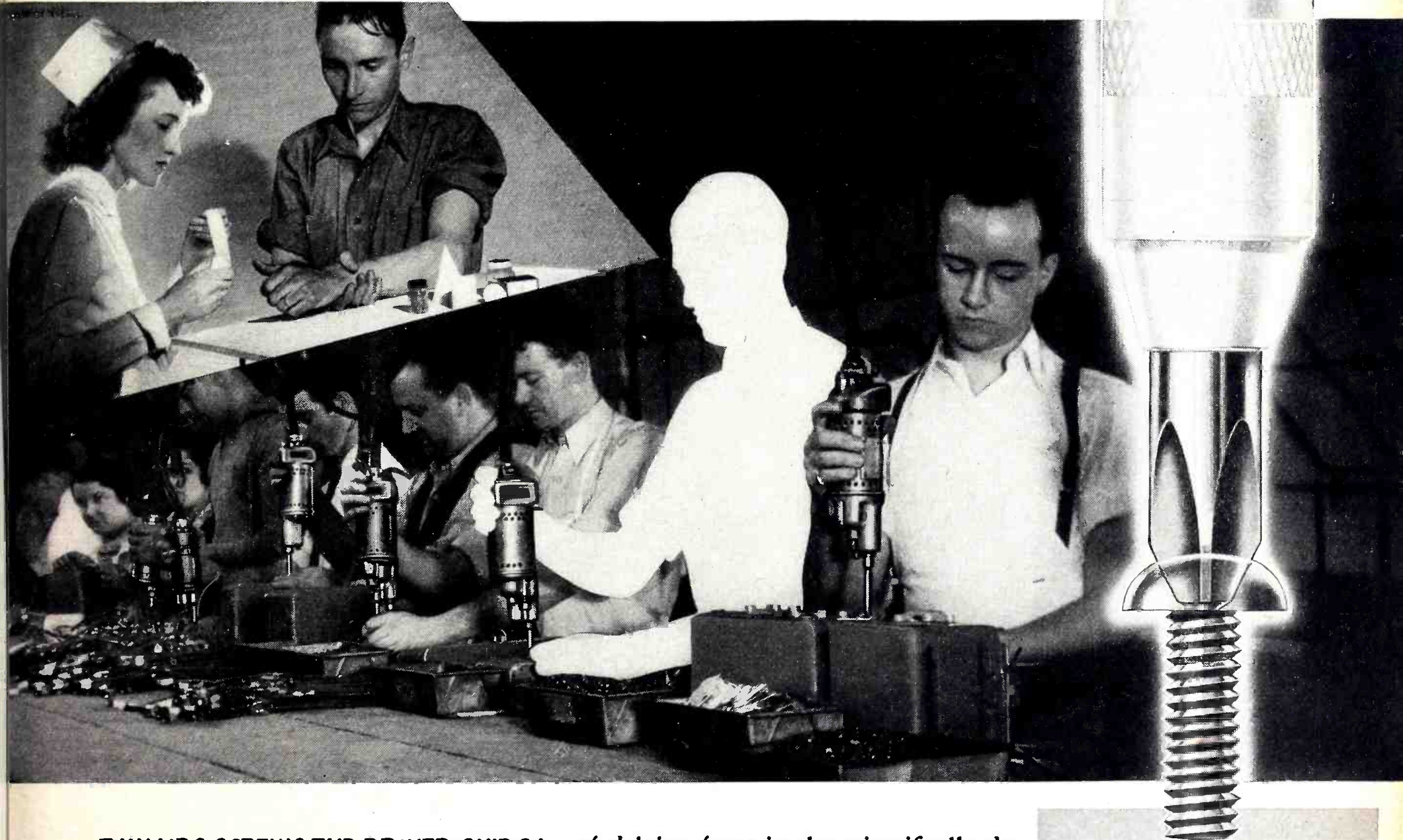
ESNA TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA
UNION, NEW JERSEY

The cornerstone in Eimac's existence has been their advanced electronic engineering. The development of the gas-free tube, pioneering in the use of new materials, radical changes in existing tube design... all these things are the results of their research. During today's accelerated business situation Eimac engineers have developed and put to work many outstanding innovations. Number one on this list is the actual achievement of mass production of a product that heretofore was hand-made in a scientific laboratory. Today the most interesting of the other developments must be kept secret but the heads-up engineering is going forward apace. The services of this organization are available only for war problems now but will be offered to industry at large when peace comes. If you have a problem, the solution to which might involve vacuum tubes, write direct to factory.

EITEL - McCULLOUGH, INC. • SAN BRUNO, CALIFORNIA

PREVENT CASUALTIES in Your Screw Driving Army



PHILLIPS SCREWS END DRIVER-SKIDS!

"Speed up, and do it safely!" That's 1943's war production challenge. This year we can't afford another sacrifice of 500 million worker days to preventable shop accidents . . . like injuries from skidding screw drivers.

Safety measure No. 1 for screw driving operations is accomplished when you specify screws with the Phillips Recessed Head. The driver *can't* slip out of the recess to slash a worker, or damage the work!

Relieved of fear, workers naturally step up speed. And, the *automatic centering of driving force* in the scientifically designed Phillips Recess eliminates many other handicaps to speed: the fumbling, wobbly starts . . . re-driving of slant-driven screws . . . removal of broken-head screws . . . reclaiming of marred parts. Fast, faultless, *safe* driving becomes automatic, even for "green hands." Power driving becomes practical.

They cost less to use! Compare the cost of driving Phillips and slotted head screws. You'll find that the price of screws is a minor item in your total fastening expense . . . that it actually costs less to have the many advantages of the Phillips Recess!

KEY TO FASTENING SPEED AND ECONOMY

The Phillips Recessed Head was scientifically engineered to afford:

Fast Starting – Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.

Faster Driving – Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)

Easier Driving – Turning power is fully utilized by automatic centering of driver in screw head. Workers maintain speed without tiring.

Better Fastenings – Screws are set-up uniformly tight, without burring or breaking heads. A stronger, neater job results.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

21 SOURCES

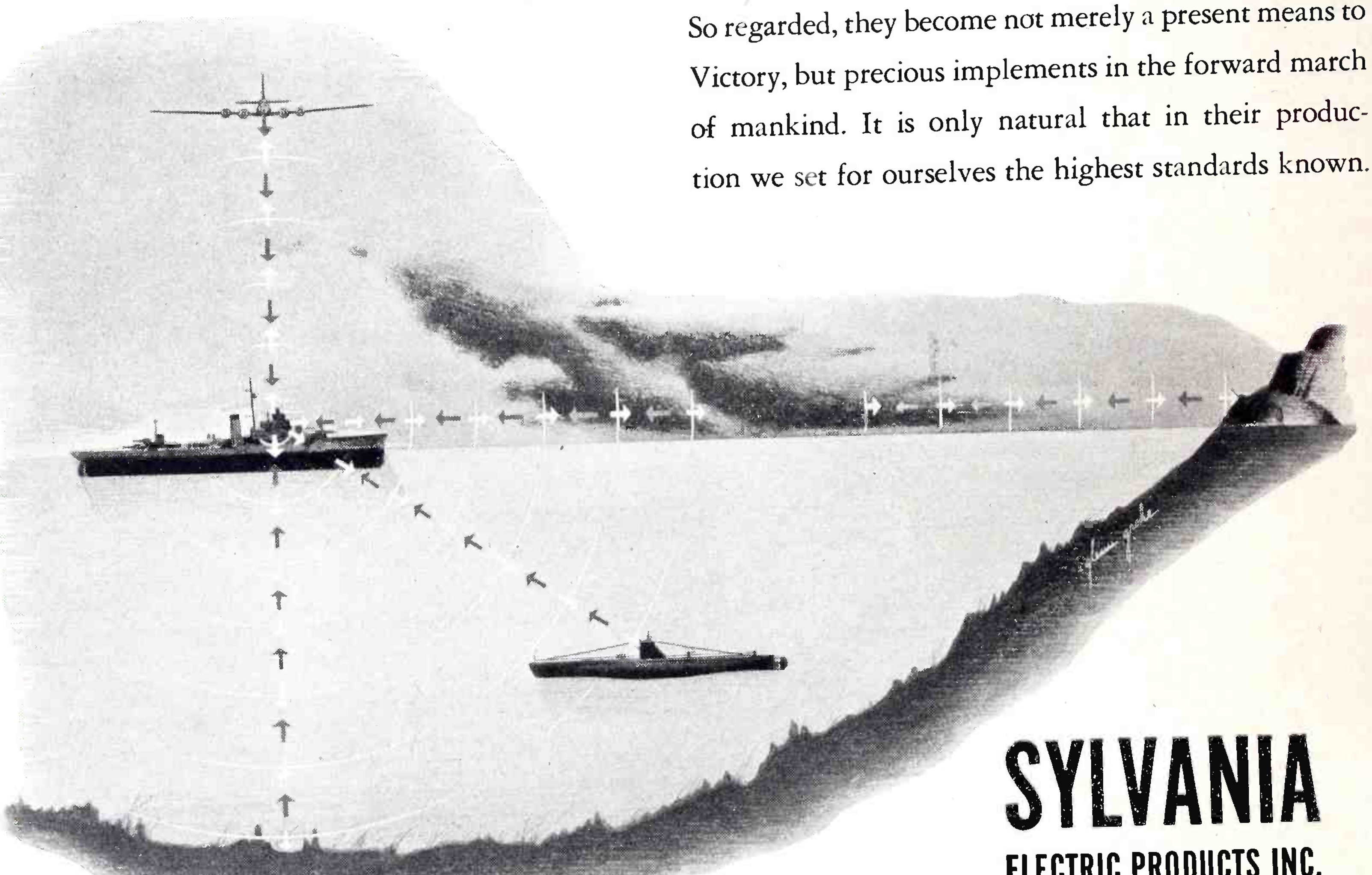
American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
The H. M. Harper Co., Chicago, Ill.

International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.

Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Reading Screw Co., Norristown, Pa.
Pheoll Manufacturing Co., Chicago, Ill.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

Beyond Sight and Transcending Hearing

● Two of the simplest words in the English language make up the phrase, "I see." Yet in that phrase is wrapped up most of the progress man has made. It spells understanding – which, whether gained through eye or ear, is the key to all things good. It is the beginning of knowledge, the source of progress, the interpreter of beauty, the keystone of civilization. That is why the everyday things we build – radio and electronic tubes, incandescent lamps, fluorescent lamps and equipment – are to our mind more than they physically seem. They might be called the Means to the Future, since they enter areas beyond sight and transcending hearing. So regarded, they become not merely a present means to Victory, but precious implements in the forward march of mankind. It is only natural that in their production we set for ourselves the highest standards known.



SYLVANIA

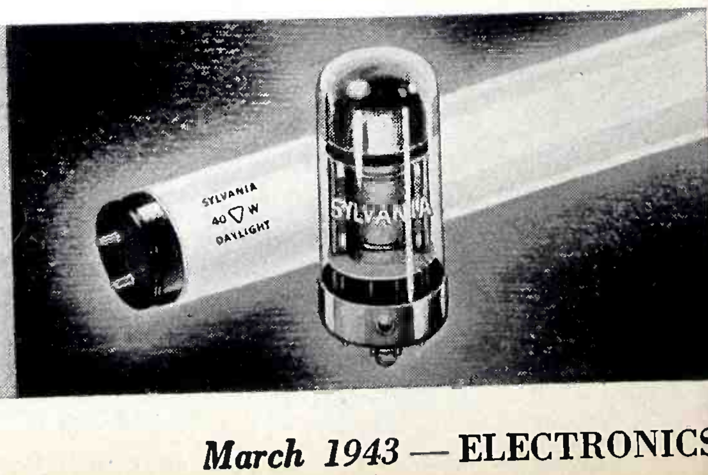
ELECTRIC PRODUCTS INC.

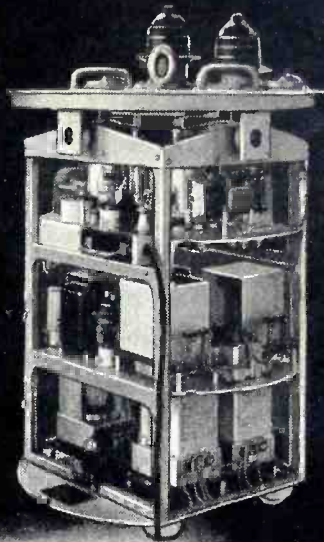
formerly Hygrade Sylvania Corporation

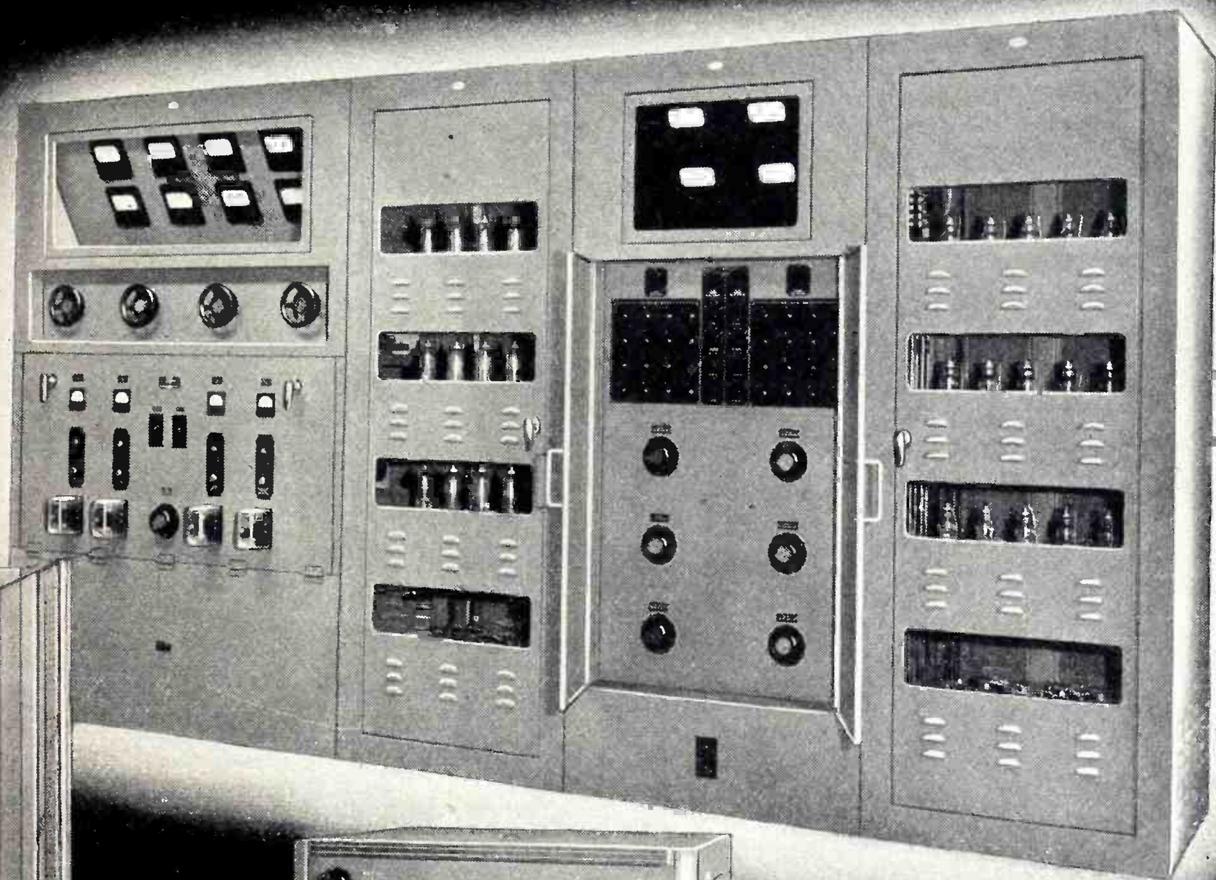
Emporium, Pa.

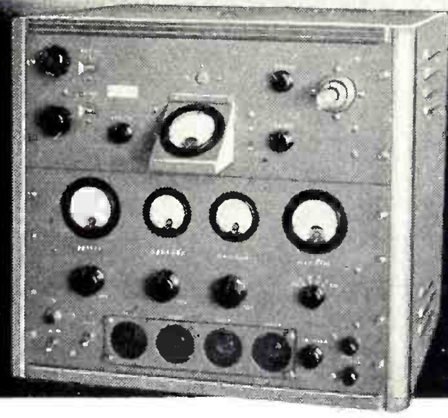
Established 1901 . . . Makers of Incandescent Lamps, Fluorescent Lamps, Fixtures and Accessories, Radio Tubes and Electronic Devices

GOOD WARES DESERVE GOOD CARE. Sylvania Radio Tubes, Sylvania Incandescent Lamps and Sylvania Fluorescent Lamps and Equipment are all made to serve you well. But the first need of wartime is to save and conserve, both to free men and material for necessary wartime purposes and because of inescapable shortages. So take good care of your Sylvania products, not because they need coddling, but because they are good tubes and lamps, and deserve good handling. And also because you may find it less easy to lay hands on these top-quality products when replacement finally does become necessary.

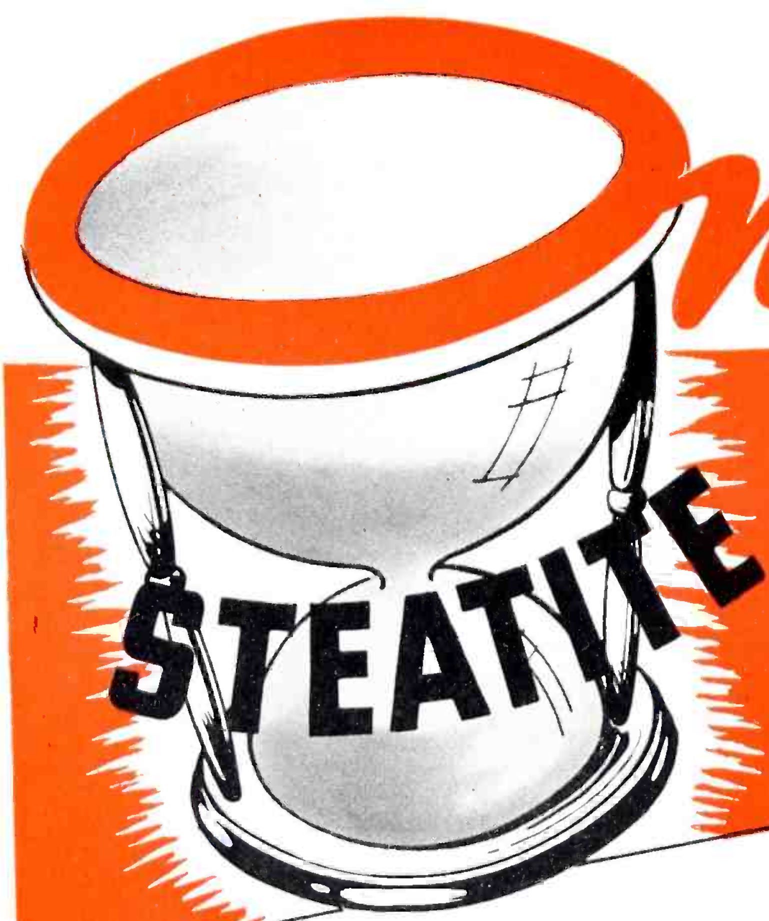








On Time!



Not so long ago, an order for Steatite Insulators brought a sympathetic shrug of the shoulders and a "Sorry, five to six months delivery." We did not like to tell our customers that. We did not like it because we knew how badly Steatite was needed for the war effort.

This is what we did to quicken deliveries of Steatite Insulators.

- Expanded our plant facilities.
- Enlarged our staff of engineers and technicians.
- Devised improved methods of production.

As a result, there roll from our kilns every month increasing quantities of insulators. Gradually, but surely the backlog of orders was reduced. Now we promise our customers deliveries on standard parts from stock in a reasonably short time.

If you have any insulator problem—whether specialized or standard—we would like a shot at it. You can rest assured that your requirements will receive prompt, individual attention.

TABLE OF CHARACTERISTIC PROPERTIES OF GENERAL CERAMICS STEATITE INSULATORS

ABSORPTION	
Dye Penetration	None
Water Absorption %	.05 to .00
SPECIFIC GRAVITY	2.7
COLOR	Cream Grey
HEAT RESISTANCE	
Softening Temperature	2100F. 1148C.
Resistance to Heat (sage limit)	1700F. 978C.
HARDNESS	7.5
COEFFICIENT OF THERMAL EXP.	
0 to 150° C.	9.05 x 10-6
150 to 900° C.	9.22 x 10-6
TENSILE STRENGTH (lbs./sq. in.) ASTM-D116-39	9,500
COMPRESSIVE STRENGTH (lbs./sq. in.) ASTM-D116-39	81,420
MODULUS OF RUPTURE (lbs./sq. in.) ASTM-D116-39	22,600
IMPACT RESISTANCE (ft. lbs./sq. in.) Simples Beam ASTM-D116-39	2.37
DIELECTRIC STRENGTH (volts/mill. thick) ASTM-D116-39	385
DIELECTRIC LOSS 1000 KILOCYCLES	
Dielectric Constant	5.87
Power Factor %	.127
Dielectric Loss Factor	.750

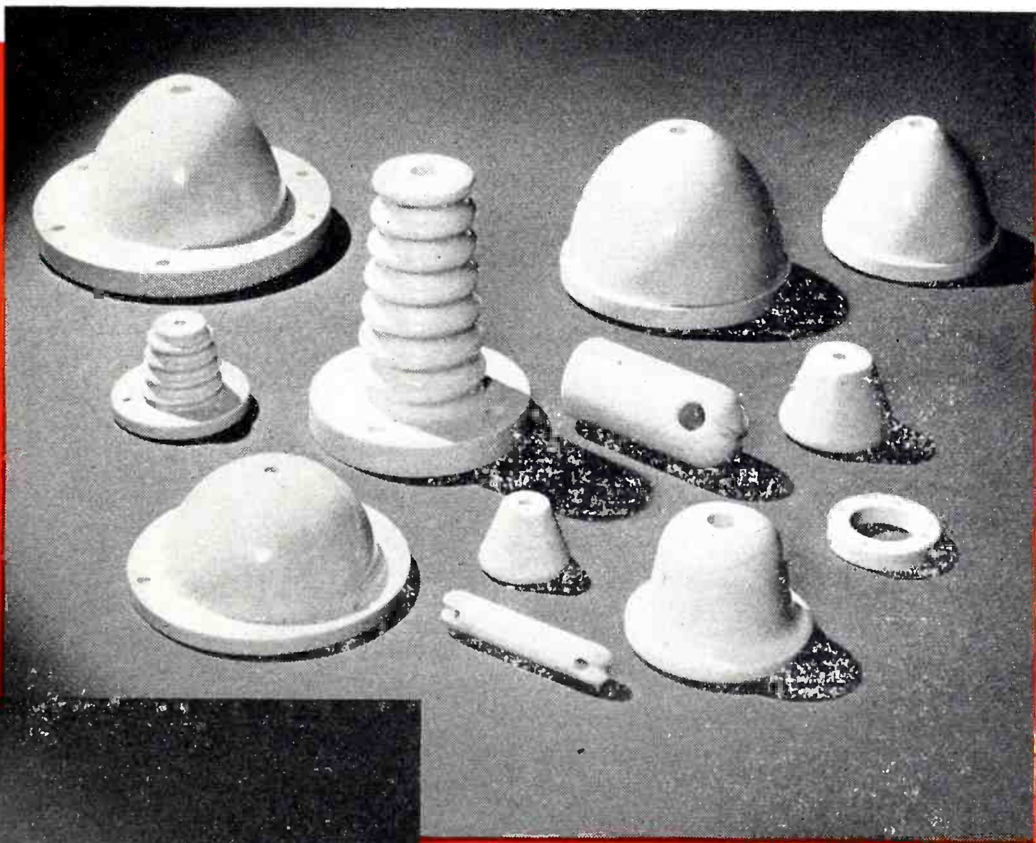
General

GENERAL CERAMICS AND STEATITE CORPORATION

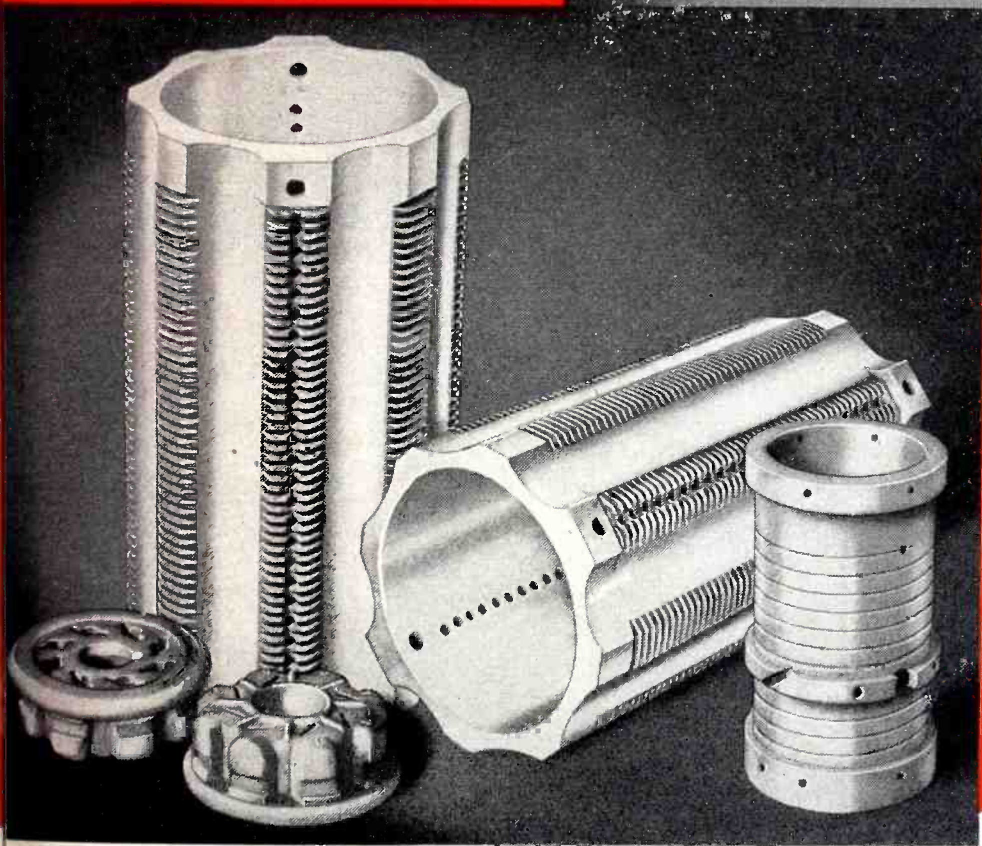
STEATITE INSULATORS

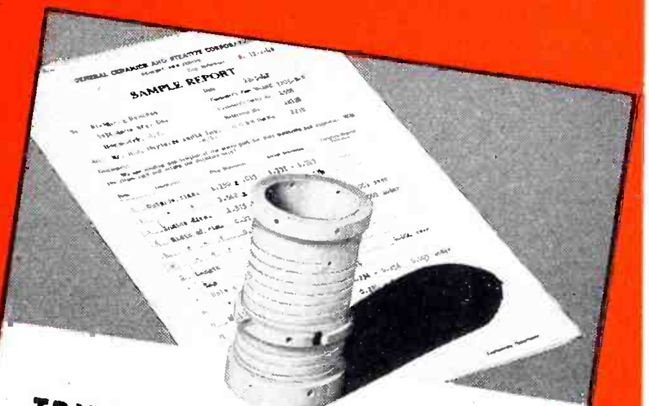
QUICKER DELIVERY FOR STEATITE INSULATORS

Stock insulators such as these are now available in quantity for prompt delivery. Write for data concerning the many different types of Steatite insulators.



These coil forms and insulators were designed and pressed for special applications where stock insulators would not serve. They are working examples of the engineering skill available for your special insulator problems.





TRIPLE CHECKED ACCURACY ON SPECIAL JOBS

Your special steatite insulator order receives a triple checking for absolute accuracy in compliance with your blueprint and specifications.

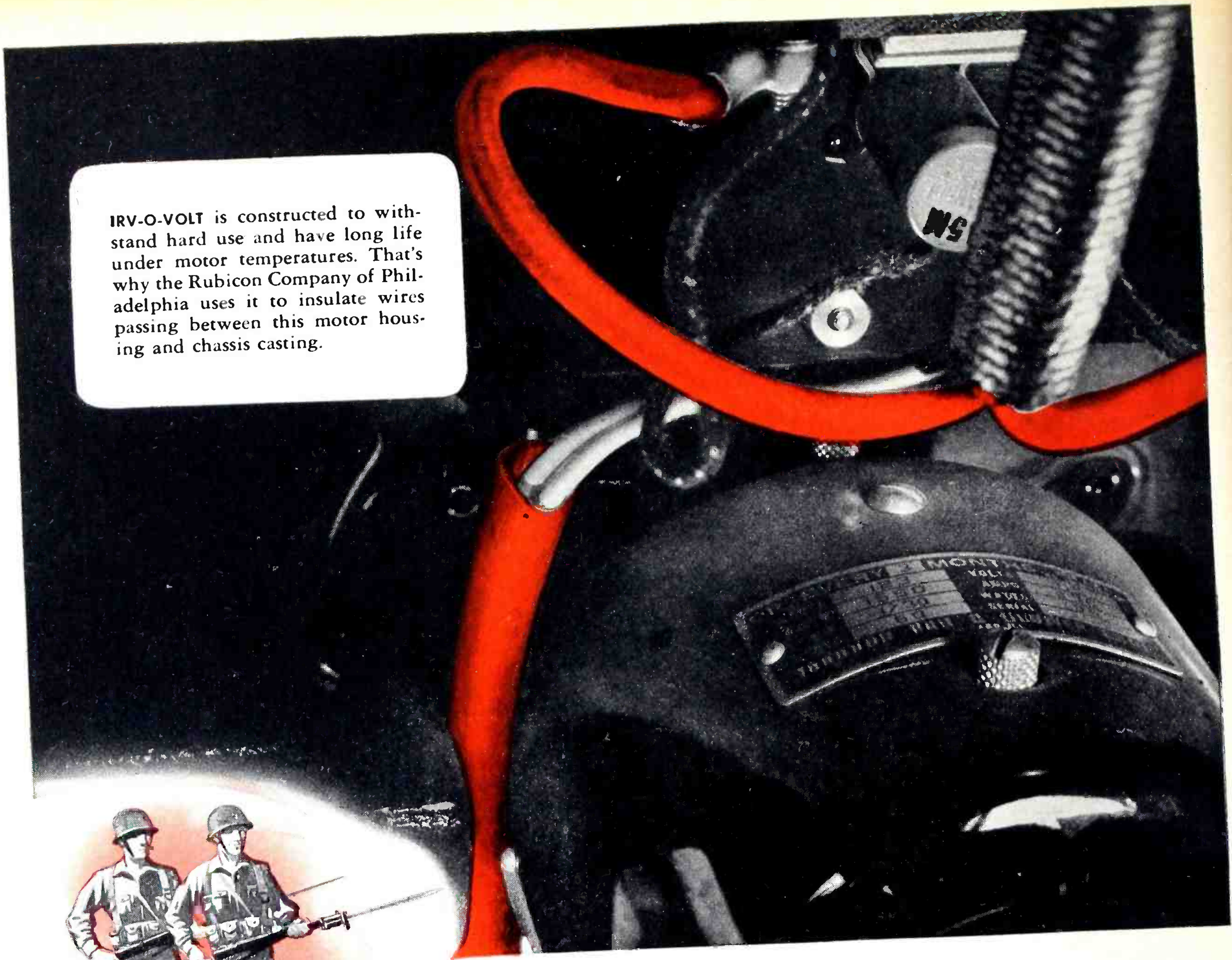
Check Number One: We make and check the tools for fabricating your order. *Check Number Two:* Samples are produced and receive a complete inspection of every detail. *Check Number Three is Yours:* Inspectors make a report which you receive with samples. This report states drawing dimensions, actual dimensions and the variations beyond tolerance, if any.

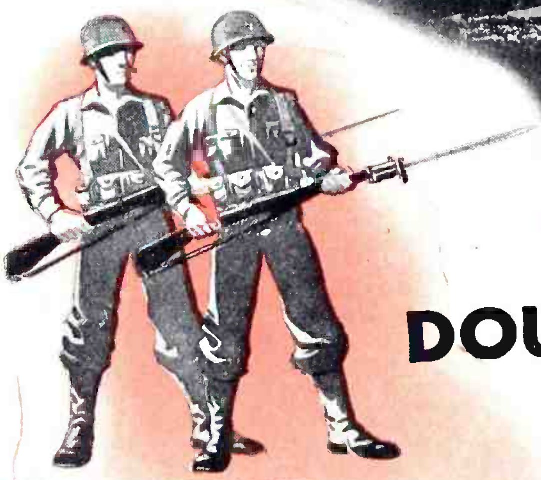
After your approval, you can be sure that the rest of the order will conform to your specifications.

Ceramics AND STEATITE CORP.

KEASBEY NEW JERSEY

3573





DOUBLE *INSULATION* PROTECTION
WITH
IRV-O-VOLT

BECAUSE it is varnished inside as well as out, Irv-O-Volt tubing gives double insulation protection. If for some reason, the outer surface becomes chafed, the inside coating of varnish will still give a large measure of protection.

The varnish used for coating is highly resistant to oil, acid vapors, weak alkalies and moisture—the double coat reduces moisture absorption of the tubing to a minimum because only the edges of the braid at the end of the tubing are exposed. The varnish is formulated so that it will properly flow and cure, thereby producing uniform coatings with no blisters or wrinkles.

In addition, Irv-O-Volt is flexible, mechanically strong and cuts clean. Ends will not fray. Moreover, because of its varnished inside surface, Irv-O-Volt allows quick assembly, even on stranded wire. Continuous operating temperatures as high as 175 deg. F. have no effect on the insulating qualities of this tubing. Also, the tubing will stand up to 450 deg. F. for 15 minutes without softening, blistering or flowing.

Irv-O-Volt is manufactured in three types, each designed to meet a definite need. Types A-1, B-1 and C correspond to these grades in A.S.T.M. Specification D 372-40T and meet the specified requirements.

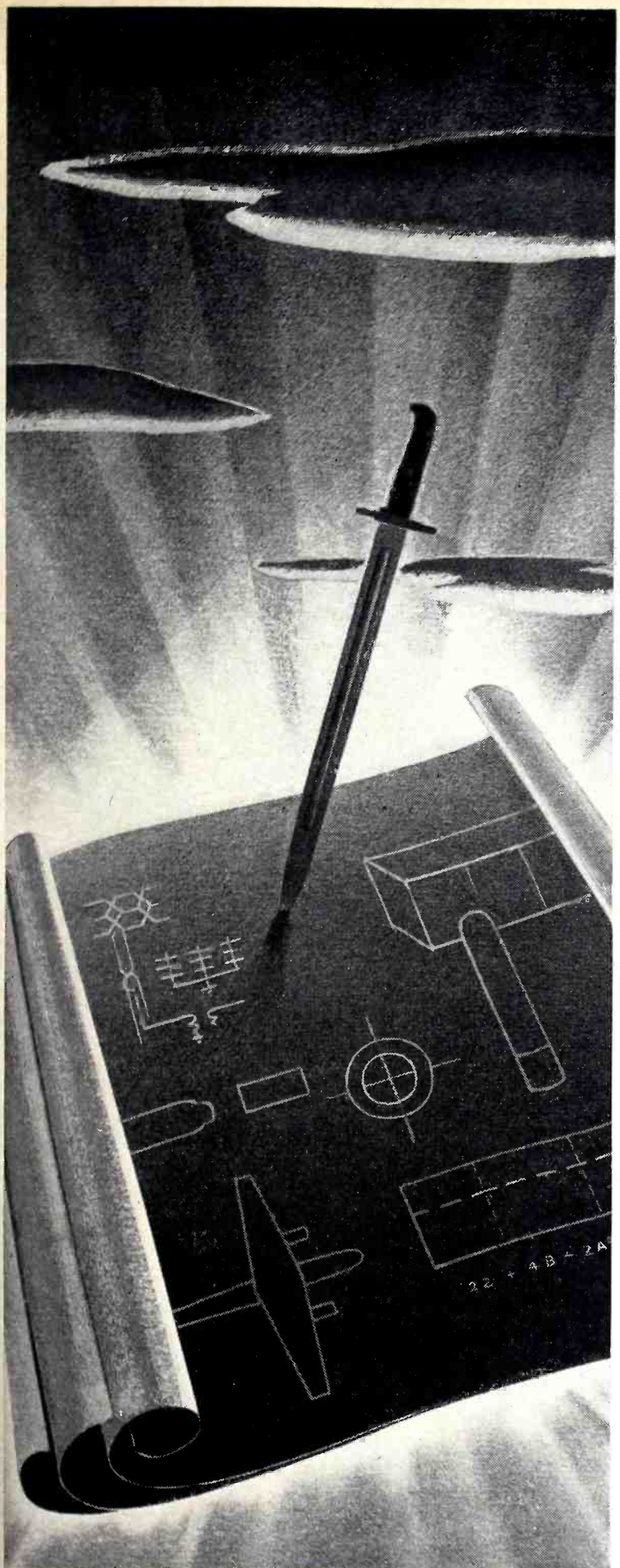
- **TYPE A-1** is especially suitable for use where exposure to high temperatures cannot be avoided. It has an average dielectric strength of 7000 volts, 5000 volts minimum.
- **TYPE B-1** is similar to Type A-1 except that it has an average dielectric strength of 4000 volts, 2500 volts minimum.
- **TYPE C** finds use as insulation for armature leads and on field coils which are subsequently dipped in varnish. Average dielectric strength is 1200 volts, 800 volts minimum.

Another tubing, Type CT Saturated Sleeving is a special heavy-walled insulation, constructed of tough, coarse fibres which give it the extra mechanical strength to resist extreme physical abuse. Its applications are similar to Type C. There is no A.S.T.M. specification for this tubing.

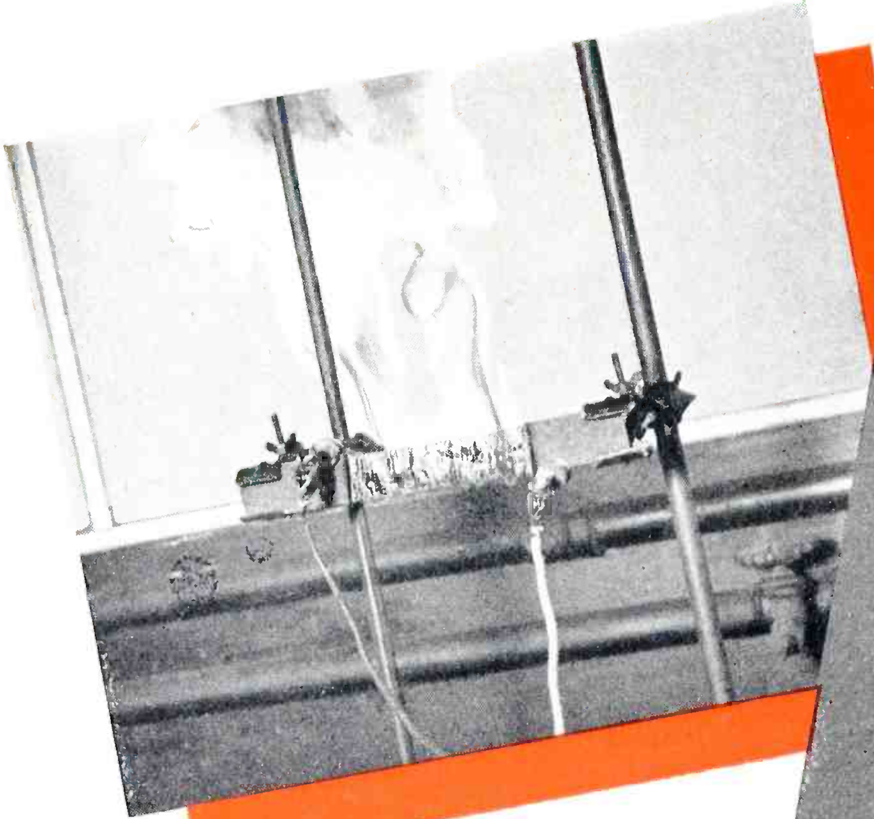
Write today for prices, samples and more complete information
Dept.-106

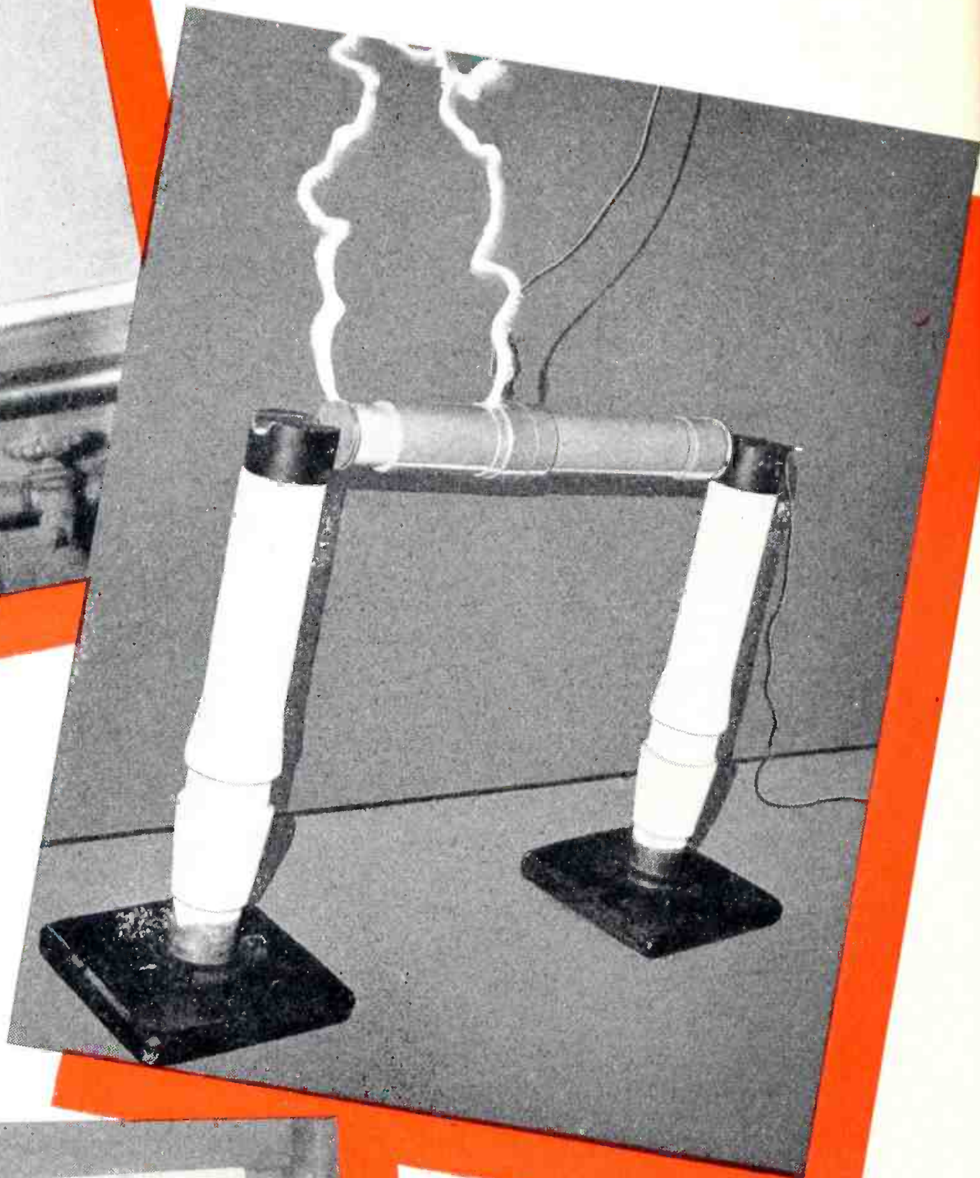
Irvington

STANDARD OF THE WORLD **VARNISH & INSULATOR COMPANY**
IRVINGTON INSULATION TRADE MARK REG. U.S. PAT. OFF.
IRVINGTON, N. J., U. S. A. • PLANTS AT: IRVINGTON, N. J. & HAMILTON, ONT., CAN.
Representatives in 20 Principal Cities

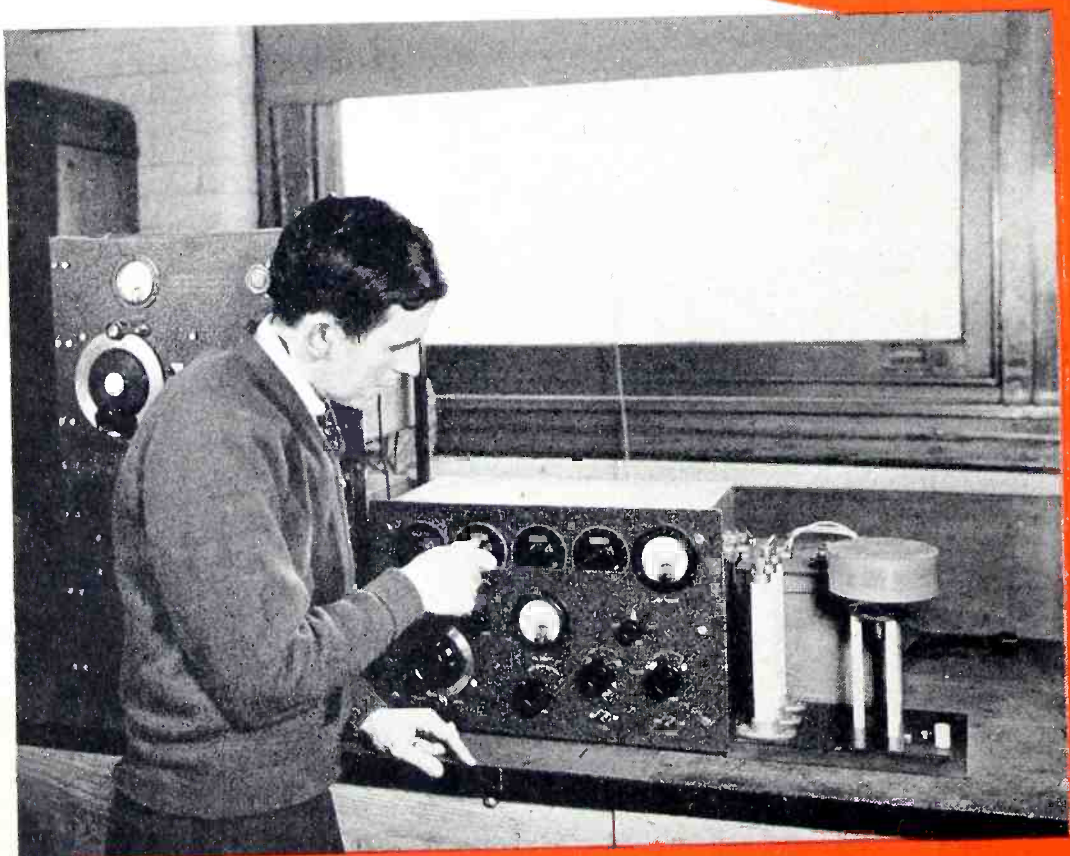


. . . C-D's CUSTOMERS





YES, DILECTO like most organic materials will BURN, BUT our Research Engineers can give you the exact time in seconds required to ignite this versatile insulating material. Complete details also may be found in the ASTM Standards.



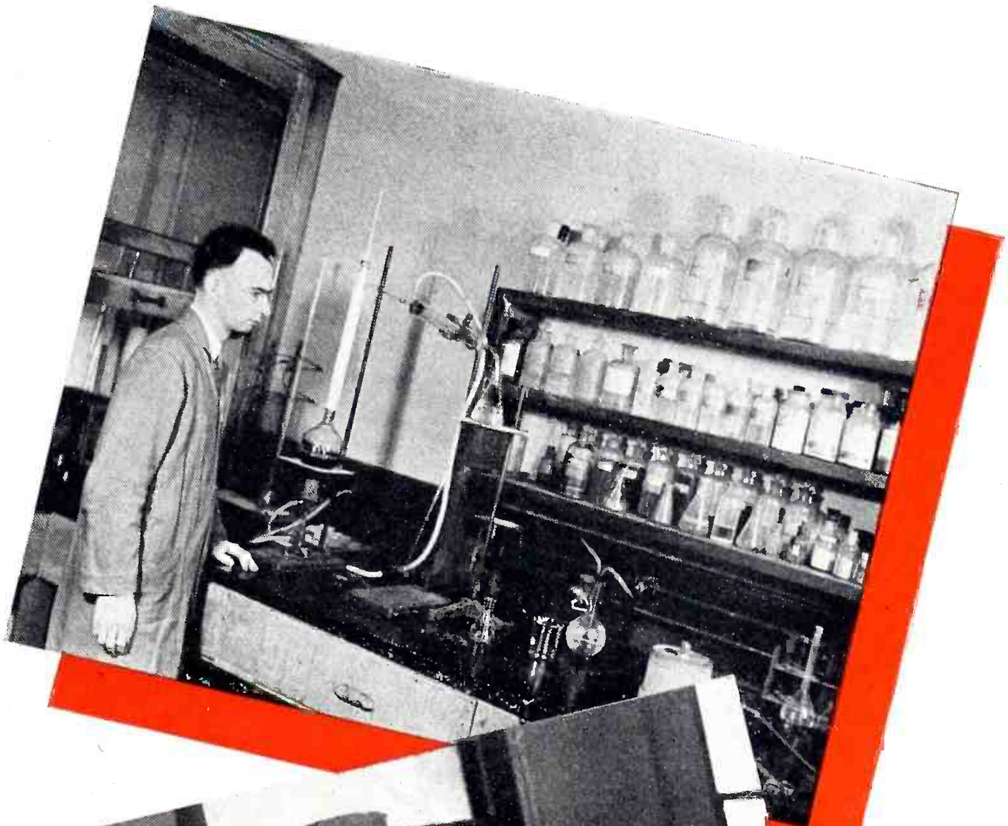
DESIGNED for 15 KV . . . REQUIRES 52 KV to CAUSE FLASHOVER. Shown above is a Dilecto Oil Circuit Breaker Bushing for indoor use. While intended for a breaker of 15 KV, 1200 Amp. rating, specifications called for no flashover between mounting collar and terminals at a voltage under 50 KV. C-D Engineers made certain it took 52 KV to cause flashover.

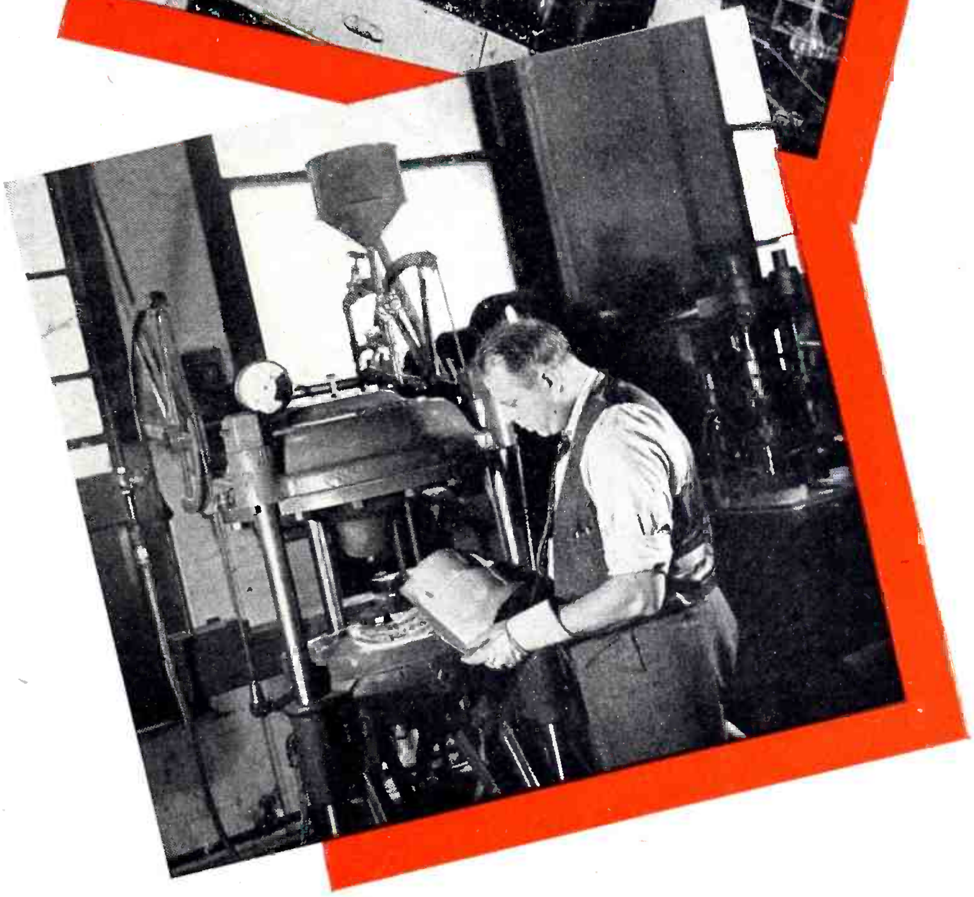
At left is a precision instrument for measuring the power factor and dielectric constant of solid dielectrics. Every grade and thickness of Dilecto gets a control check on this device.

GET THE ANSWERS

• In one of America's most complete research laboratories a staff of specialists in both electrical and physical insulation devote their skills to finding out "What happens?". Their reports and recommendations are passed on to manufacturers so that they can accurately predetermine the performance of their products, enabling them to save time and money, and build prestige.

Continental-Diamond's engineers are working *now* on "The Shapes of Things to Come". If you are planning on product improvements that might be speeded by the use of a C-D NON-metallic we suggest that this is the time to avail yourself of C-D facilities and experience.





The above photograph shows a conventional hat molding press being used for experimental molding of laminated materials, at low pressure in the order of 250 lbs./sq. inch. The part which has just been removed from the mold is a low pressure phenolic laminated aircraft engine baffle.

C-D PRODUCTS

DILECTO   A laminated plastic. High in electrical insulating properties. Of great structural strength. Resistant to moisture to a high degree. Readily fabricated to special shapes from basic standard forms of sheets, rods and tubes.

DIAMOND VULCANIZED FIBRE is a hard, dense, bone-like material . . . tough, pliable and strong. It is light in weight yet mechanically strong and will not deteriorate under constant mechanical strain.

MICABOND   Here is mica in its most usable form. The high heat resistance of mica and its high dielectric strength are almost completely preserved in MICABOND plate, flexible sheets, tape, tubing and punched and formed parts.

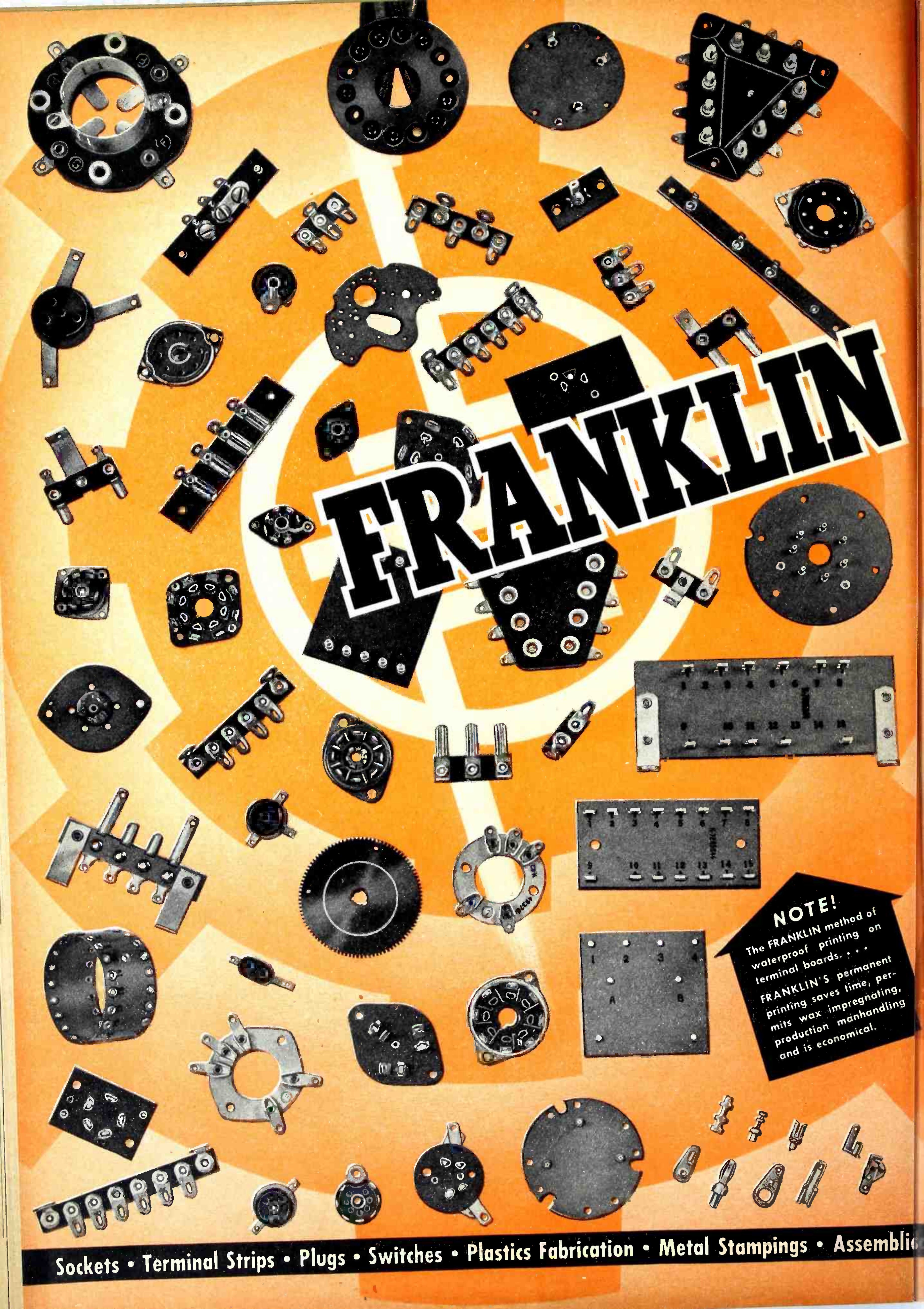
VULCOID   A product of Continental-Diamond's manufacturing experience and laboratory research. A material that offers a combination of the properties of Dilecto and Diamond Vulcanized Fibre.

CELORON   A molded mascerated fabric base plastic that is also readily machined. CELORON combines to a high degree the desirable properties of impact strength, tensile strength, dielectric strength, moisture resistance, heat resistance and dimensional stability.

Continental-Diamond FIBRE COMPANY

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


Amperex

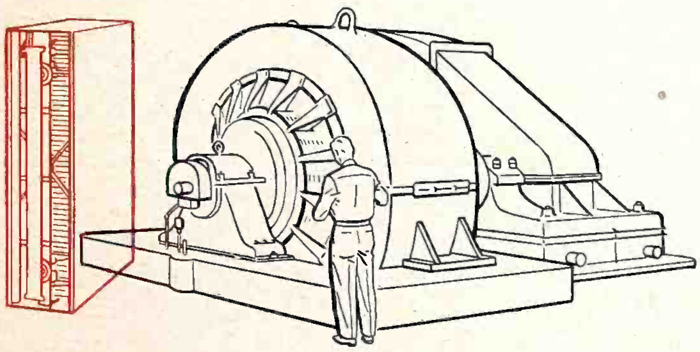

FRANKLIN
NOTE!
The FRANKLIN method of waterproof printing on terminal boards. . . .
FRANKLIN'S permanent printing saves time, permits wax impregnating, manhandling production and is economical.
Sockets • Terminal Strips • Plugs • Switches • Plastics Fabrication • Metal Stampings • Assembli

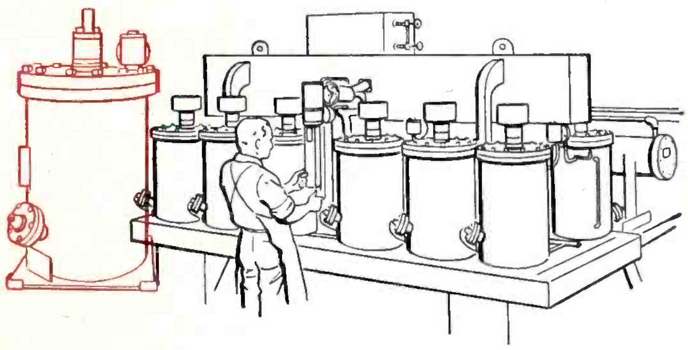
Electronics.

Magnifying Vibration 1,600,000 Times—Electronic tubes are used in this Dynetric Balancing Machine to magnify minute unbalance vibrations in all types of rotating parts. Vibration impulses as small as twenty-five millionths of an inch are located and measured in a few seconds. An infinitely variable ratio of amplification is provided so that either large or extremely small amounts of unbalance can be accurately measured.

. . at Work

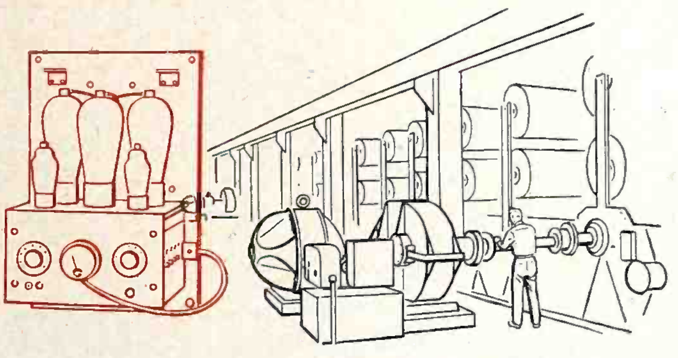
Westinghouse electronic devices are at work today in practically every war industry. They are helping to roll back old limits on production capacity—saving time, cutting costs, improving products. Here are typical examples from a long list of practical applications—showing Westinghouse "Electronics at Work."

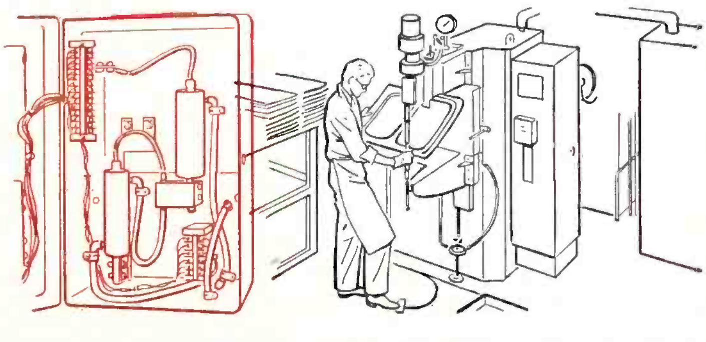




Cleaning the Air to protect rotating electrical machinery against damage from air-borne dust, dirt and soot is a maintenance-saving job performed by the Westinghouse PRECIPITRON. Electronic tubes in the Precipitron power pack transform electricity for a strong (12,000-volt) electrostatic field. As dust-bearing air is channeled through this field, every particle is given an electrostatic charge. Dust particles are drawn irresistibly to the collector plates.

More Efficient D-C Power is being supplied to scores of aluminum plants, steel mills, mines and factories by the Ignitron Rectifier. Each tank in the Ignitron Rectifier is an electronic tube. Each tube conducts current during the positive half-cycle of an alternating current cycle, producing a pulsating direct current. When the pulsating output currents of several tanks are co-ordinated and synchronized, the result is a smooth, continuous flow of current.





Highly Accurate Control of motor performance is essential for uniformity of product in the paper and other process industries. By Electronic means, more precise control of speed, voltage, acceleration and other characteristics can be obtained. Absence of moving parts permits high sensitivity with low maintenance.

Electronic Resistance Welding Control is largely responsible for the development of mass-production methods in metal-working industries. By means of Ignitron tubes, Westinghouse Electronic Timers provide precision control of current and time (to within one cycle) to deliver high quality, uniform welds. J-91007-A

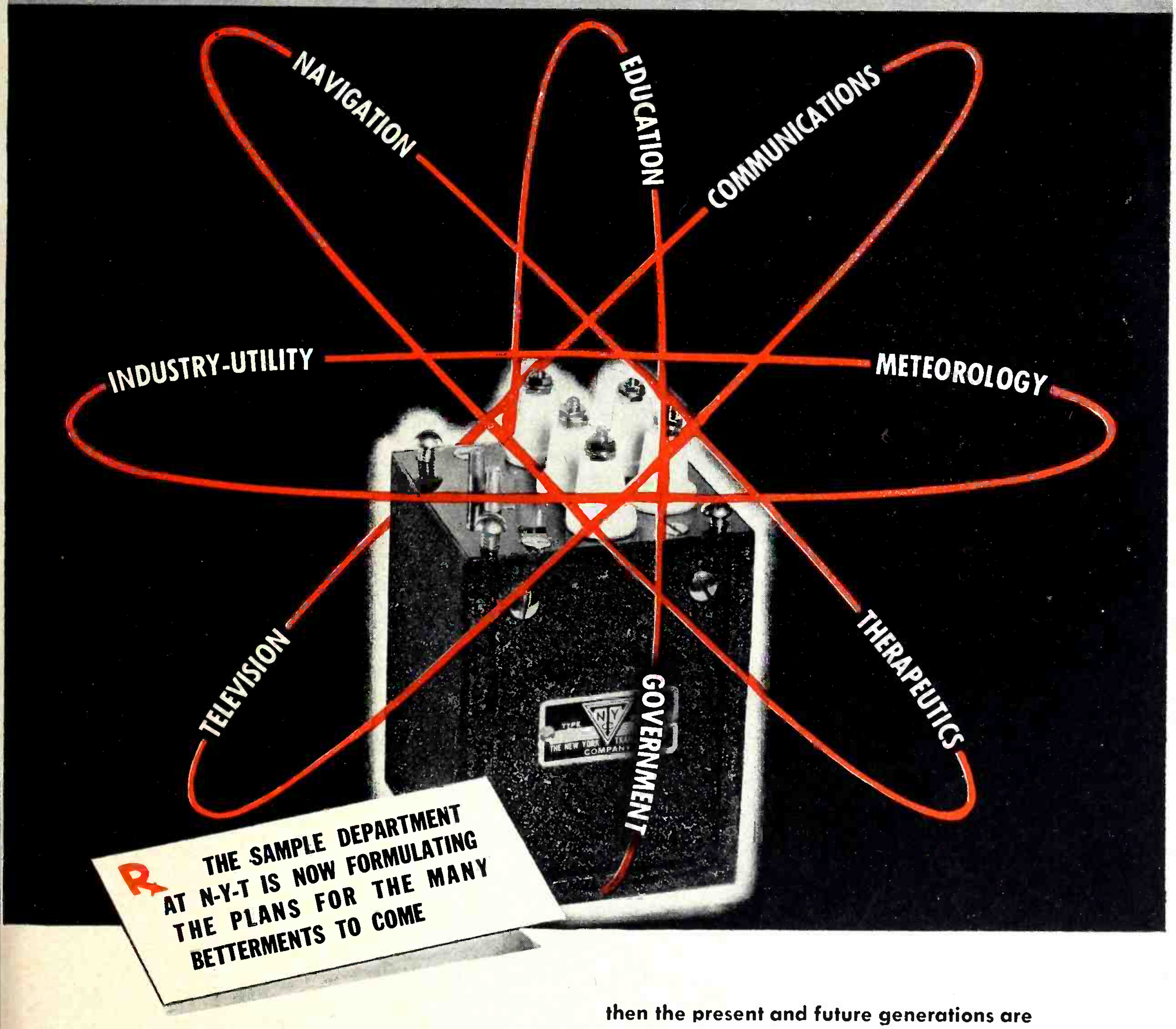
For further information on practical applications of Westinghouse Electronic devices, write or phone your nearest Westinghouse office. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Penna.

WESTINGHOUSE

Westinghouse ELECTRONICS

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Something is coming into our lives in a big *electronic* way!



Just as the war has affected the private and public activities of every American, so will the 'shape of things to come'—electronically—have a direct bearing on our future well-being.

If the planning, designing and research now under way at N-Y-T is a criterion—then the present and future generations are due pleasant surprises.

Engineers, designers and technicians will find it worthwhile to investigate our highly specialized Sample Department — where difficult transformer problems are being solved—quickly. Send us your inquiries.

NEW YORK TRANSFORMER COMPANY

26 WAVERLY PLACE NEW YORK, N. Y.


Speaking of electronics: some FIRSTS by Western Electric
1st
HERE'S THE GRAND-DADDY of high-vacuum tubes! It's the original type telephone repeater tube—made by Western Electric—for use in Long Distance circuits. It made possible transcontinental telephony in 1915—showed the way to the amazing variety of tubes now used in radio, industrial and war applications.
1917 RECEIVING TUBE for the U. S. Government. Today Western Electric is one of the largest suppliers of tubes of many types used by the armed forces.
THE FAMOUS "PEANUT"—made by Western Electric. First commercial ¼ ampere, 1.5 volt filament tube, it played a big part in broadcast receivers in 1920.
1st
FIRST TRANS-OCEANIC radio telephone transmission—from Arlington to Paris and Honolulu in 1915—was made possible by Western Electric 25 watt radiation cooled power tubes.
1st
FIRST WATER-COOLED TUBE using metal anodes sealed to glass—one of Bell Telephone Laboratories outstanding contributions—1920.
1st
FIRST PHOTO-ELECTRIC CELL used commercial picture transmission over phone wires. It was made by Western Electric in 1925.
1st

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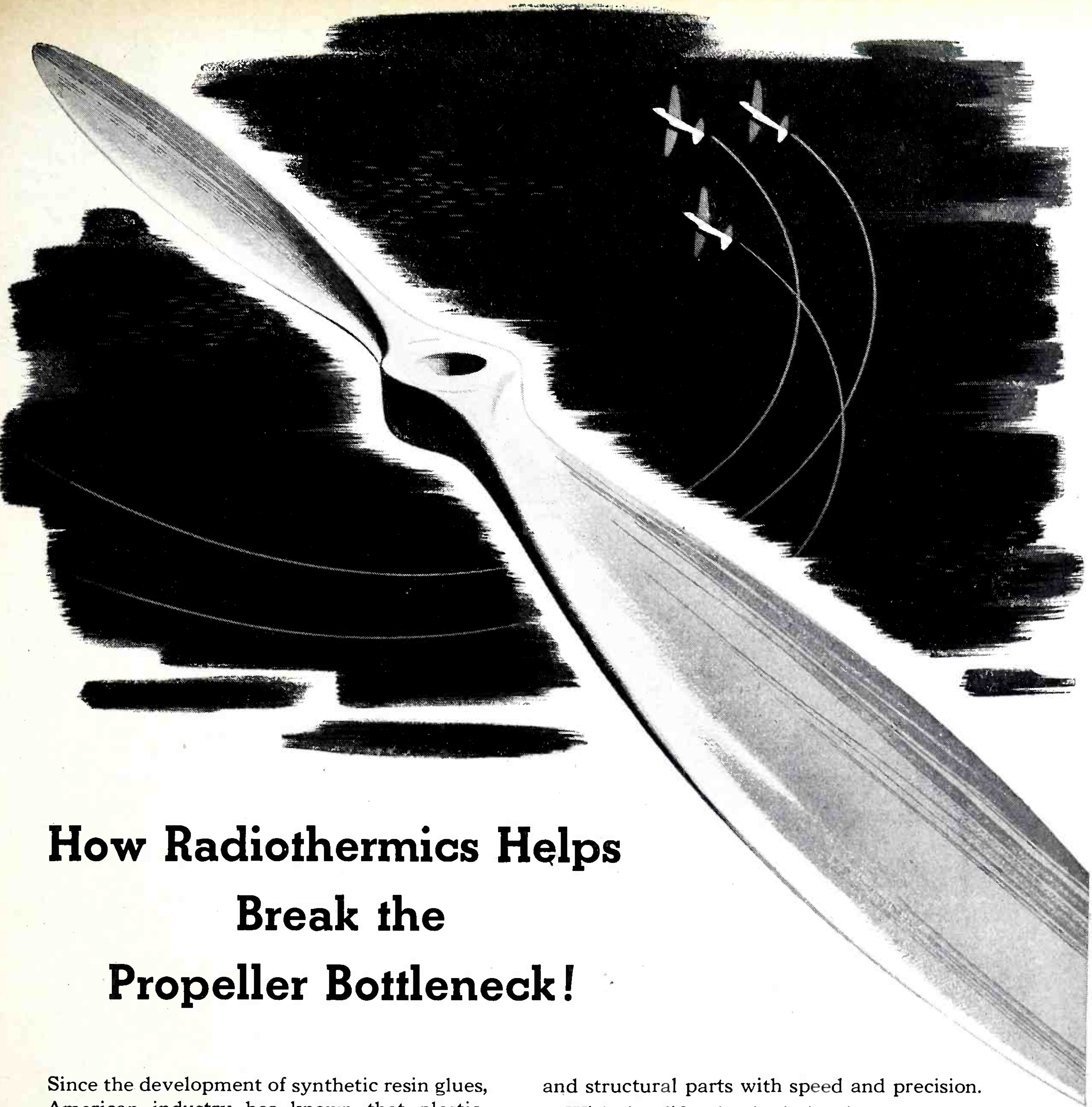
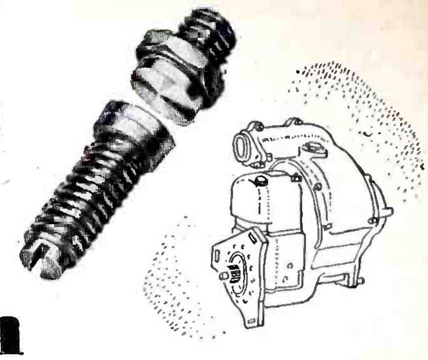


The Case of the Ailing Magneto . . .

Showing That Cooperation Can Lick Almost Any Contact Problem



When you add eagerness to cooperate to engineering experience and "know how," you will understand in some measure why such incredible production results are coming from industry's team work in the war effort. And that goes for any part—from gigantic casting to tiny contact point.

Nowadays, contact production ills demand quick action from the specialist, especially when the prescription must be virtually instantaneous.

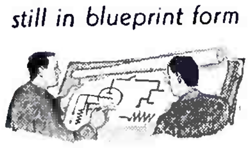
Recently, Mallory had a hurry call for help with ailing aircraft magnetos. Combat planes were grounded by faulty magneto operation. Tests traced the trouble to contact "pitting" which caused the airplane engine to misfire.

Mallory contact engineers sought a better material. Speedy experiments indicated a standard Mallory alloy. Suitable contacts were designed, attached to proper backing and put on test. In a few days, the magneto manufacturer's contact troubles were over. The new contacts were incorporated in the magneto production line and magnetos no longer held up efficient combat plane production.

Some folk might hail this example of Mallory contact development as a success story. We prefer to regard it as an example of eager cooperation—the application of years of experience and "know how" that is merely part of the day's work for war effort.

We think we have learned a lot about contacts over the years—and we know we are adding to that knowledge with every development we make. Consult us when your designs involve contacts and complete contact assemblies.

While the design is still in blueprint form



CALL IN MALLORY *for Contacts and Contact Assemblies*

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

Cable Address—PELMALLO

WASHINGTON FEEDBACK

☛ Radio has now really gone to war. The industry has emerged from the role of an important auxiliary to that of a vital and constantly expanding entity with a gigantic production program of its own. Expenditures for military radio alone are now running $200,000,000 per month, as compared with $15,000,000 monthly a year ago.

WPB—Manifestly, such an expansion has called for the setting up of an adequate radio organization in the WPB. While there has been no official announcement, broadly speaking the work of the division concerned and now in process of reorganization falls into six classifications. First, there is a program group whose function it is to keep informed of military electronic requirements; second, a distribution group seeing to it that critical materials are delivered to manufacturers at the proper time; third, a resources group making certain that the facilities of the industry are adequate to meet military demands; fourth, a field operations section which aims to solve problems for the manufacturer at his plant; fifth, an engineering advisory section which, among other things, keeps close watch on laboratory developments to avoid a time lag between the proven effectiveness of a device and actual placement in production; sixth, a foreign and domestic branch whose function it is to maintain broadcasting and home receiving sets on the present reduced scale through the provision of standardized parts.

It appears certain that Ray C. Ellis will continue to head the radio division. Gerald Miller will undoubtedly be in the program group; Sidney K. Wolfe is expected to head the resources group, aided by Captain W. A. Gray, Myron Whitney, Milton Lowenstein and Elmer Crane; W. H. Anderson and Frederick Boland are slated for important posts; Marvin Hobbs appears to be set for the engineering advisory section; Frank S. Horning is likely to handle field operations and Frank McIntosh is expected to continue as head of the home radio group.

FCC—In view of the existing stringent control of manufactured radio parts, there is much interest in the announcement by FCC that it has completed an 1100-page listing of surplus radio equipment in radio stations and available for rent or purchase. Chairman Fly describes it as "an informational set-up where everybody describes what he has and we give the information to everyone else."

Because of the size of the volume, it appeared impractical to distribute it to all licensees. So copies are to be sent to just a few selected stations and to inspectors in charge of the various radio districts.

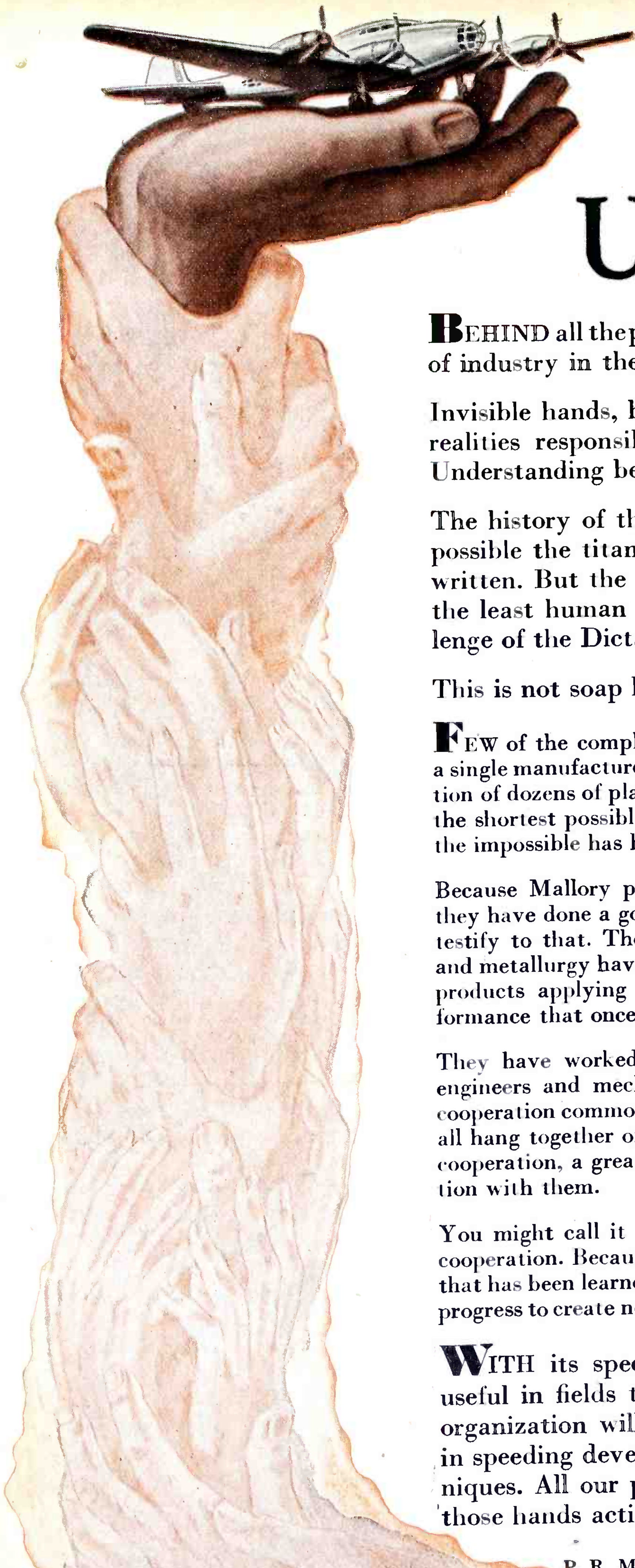
Draft—The War Manpower Commission has amended its occupational bulletin (No. 27) on essential communications services, issued to guide Selective Service local boards regarding occupational classifications of employees. The original bulletin, issued last October, listed as essential communication activities only telephone, telegraph, newspaper, radio broadcasting, newsreel and television services and the repair of such facilities. The amended bulletin includes 120 essential occupations in place of the original 92. It includes, among other services, protective signal systems which supplement fire and police protection to military, public and private industrial and commercial establishments.

Army—The Army reports that a Patent Board has been established in the Office of the Legal Director to review meritorious inventions by Signal Corps personnel. Regulations permit enlisted men to communicate directly with the Chief Signal Officer concerning unpatented inventions and frequently the Board recommends that a patent be obtained for the inventor at government expense. A number of suggestions for slight structural changes in Signal Corps apparatus have proved to be helpful during the redesign of equipment.

Amateurs—Radio amateurs have been requested to sell their shortwave communication equipment to a special purchasing mission of the Army Signal Corps, Service of Supply, for training purposes and operational use. Equipment needed consists of transmitters ranging in power from 25 watts and covering various bands in the shortwave range, as well as corresponding types of receivers and such radio components as capacitors, resistors and installation material. Especially desired are a-f and r-f signal generators, oscilloscopes, precision a-c and d-c voltmeters, ammeters and miliammeters.

Navy—Captain Carl F. Holden, Director of Naval Communications, has added an electronics branch to the Office of Naval Communications. Its purpose is to cooordinate the requirements of the Navy from the standpoint of precedence and allocation. It will work with the Radio Division of the Bureau of Ships. Lieutenant Commander F. R. Furth has been named Assistant Director of ONC in charge of the new branch.

CAP — WERS — Recent conferences between the Civil Air Patrol and the Office of Civilian Defense resulted in a plan to provide War Emergency Radio Service facilities to the CAP. With the concurrence of the Board of War Communications, the Federal Communications Commission has established a new class of stations designated as Civil Air Patrol Stations. In order to avoid serious interference both to CAP stations and civilian defense stations, a cooperative arrangement of sharing frequencies was worked out. Four channels, each 200 kc wide, at the upper end of the 112 to 116 Mc band, have been set aside for CAP stations. These channels are located at 115.3 Mc., 115.5 Mc., 115.7 Mc., and 115.9 Mc. If, in any particular locality, civilian defense stations find it necessary to use one of these channels, arrangements can be made with local representatives of the CAP to share the channel at 115.3 Mc.



Unseen Hands —

BEHIND all the prodigious production and mighty accomplishments of industry in the war effort are the unseen hands of cooperation.

Invisible hands, but not ghostly. On the contrary, they are bright realities responsible for a gigantic step forward on the part of Understanding between men . . . and women in industry.

The history of the amazing industrial cooperation that has made possible the titanic achievements of War Production is still to be written. But the Future will record Voluntary Cooperation as not the least human of the answers made by free people to the challenge of the Dictator and his slave labor.

This is not soap box oratory. It is prosaic fact.

FEW of the complex mechanisms involved in war materiel are the output of a single manufacturer. Most of them represent the hitherto incredible cooperation of dozens of plants all working to the single goal of quality production in the shortest possible time. As folk have learned what cooperation can mean, the impossible has been accomplished with clockwork regularity.

Because Mallory people—from top to bottom—have learned to cooperate, they have done a good job in War Production. The Army-Navy "E" Awards testify to that. Their experience and knowledge in the fields of electronics and metallurgy have been put to vital use in innumerable war devices, mostly products applying new techniques and new materials . . . for critical performance that once might have been dubbed "black magic."

They have worked with military chiefs and governmental agencies, with engineers and mechanics, manufacturers and raw material suppliers—in a cooperation common to all, based on Poor Richard's realization that "we must all hang together or all hang separately." They have not been alone in their cooperation, a great many organizations have become Bachelors of Cooperation with them.

You might call it the "Higher Business Learning," this new philosophy of cooperation. Because—it will be important in post-war adjustments, when all that has been learned in war production will be turned loose on manufacturing progress to create new standards and satisfy the pent-up wants of war-sacrifice.

WITH its specialized knowledge of electronics and metallurgy useful in fields that apparently have no boundaries, the Mallory organization will offer "hands of cooperation" exceedingly useful in speeding developments for the betterment of products and techniques. All our post-war planning is based on the idea of keeping those hands active all the while.

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

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MALLORY
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*Reg. U.S. Pat. Off.

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The fact that an entire issue, except for our regular departments and the article on wave guides is made up of this non-technical story, need not worry our readers. Future issues will be just as technical as they have been since April 1930.

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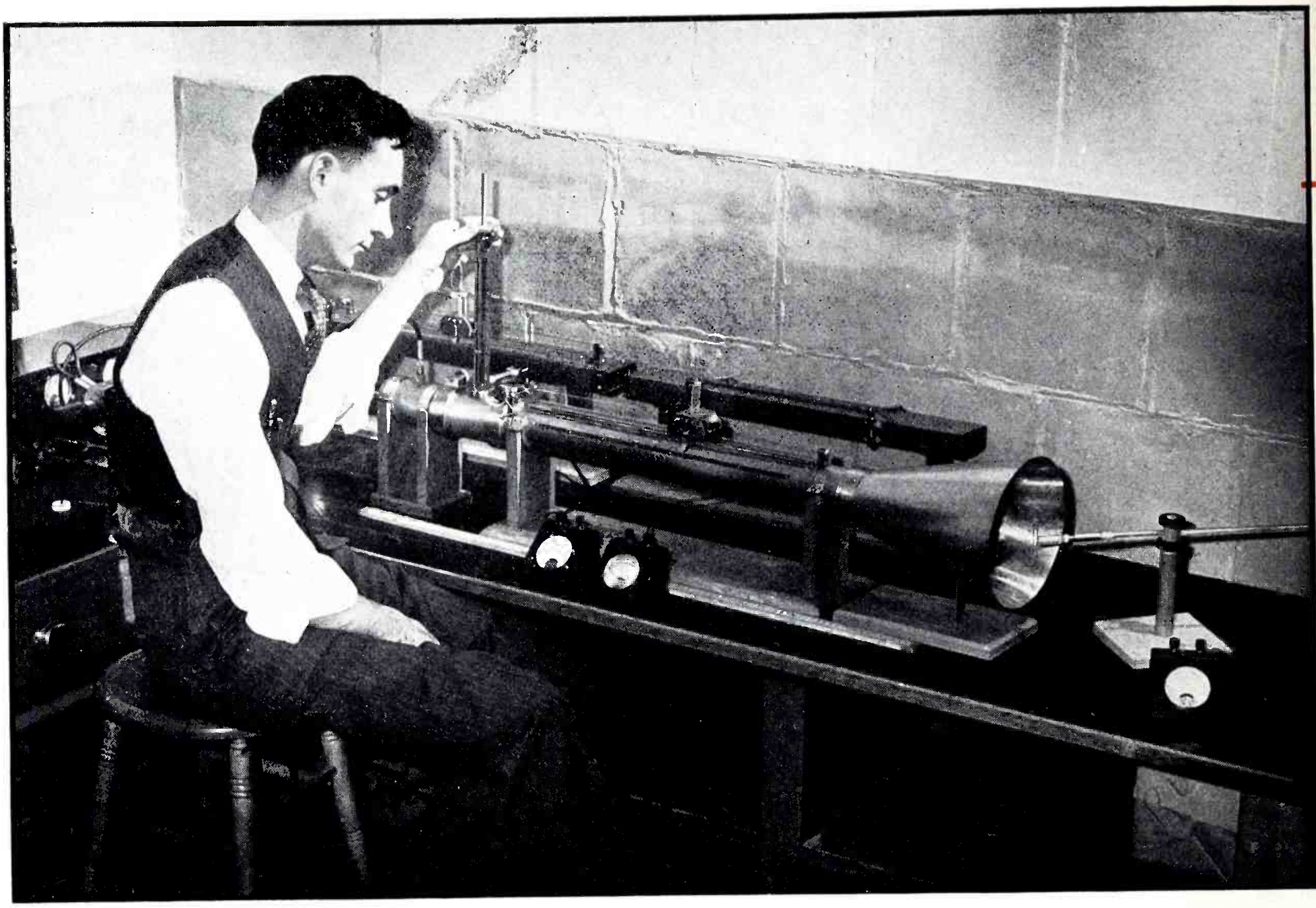

Modern ultrahigh-frequency generators and transmission lines bear little resemblance to those at broadcast frequencies as this laboratory equipment at New York University illustrates

By HUGH SKILLING

Department of Electrical Engineering
Stanford University

WHEN a stone is dropped into a quiet pool, circular waves spread over the surface of the water. When there is an electric spark, or some other electrical disturbance, electromagnetic waves spread through space from the source. Radio waves travel out from a transmitting antenna in all directions, in three dimensions, and just as the water wave is circular, the spreading radio wave is spherical. If the radio wave strikes a plate of metal or the conducting surface of the earth, it is reflected. The wave pattern then becomes as complicated as when circling waves of water are reflected in complex patterns from the shore.

What is a Wave Guide?

A wave guide is a sort of speaking tube for radio waves; it is a means of guiding energy from one point to another without letting it spread out in all directions. There are hollow wave guides; there are concentric transmission lines; there are parallel-wire transmission lines: these are all wave guides in reality, although they are of different form. Before describing these it will be best to say a few words about waves in general.

Wave Facts

Radio waves (and other electromagnetic waves, including light) travel very satisfactorily through empty space. It is best not to inquire how they travel through empty space—how light, for instance, can come to the earth from the sun. Water waves are waves in water, but in what are electromagnetic waves? One may say "aether," but that is merely giving another name to empty space. We cannot do much better than to agree with Michael Faraday who said a century ago "Let us dismiss the aether, but keep the vibrations."

On the other hand, a great deal is known about these electromagnetic vibrations, whatever the medium in which they propagate. They comprise an electric and a magnetic field. A wave traveling freely in empty space consists of an electric field and a magnetic field at right angles to each other, both being at right angles to the direction of travel of the wave. For this reason the wave is called a transverse wave, analogous to a mechanical transverse

# of WAVE GUIDES

This paper is a non-mathematical explanation of how waves travel through hollow metal structures or solid dielectric rods known as wave guides. It also contains a discussion of the conditions under which a wave will or will not be propagated along a wave guide*

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It is quite impossible to have the electric part of the wave without the magnetic, or the magnetic field without the electric, for they produce each other: the electric field of the wave is produced by the changing magnetic field, and the magnetic field by the changing electric field, and they must necessarily go along together. They travel at a speed that is, of course, the speed of light; measured in English units it is about 186,000 miles per second, or in the metric system 300,000 kilometers (or 3×10^{10} centimeters) per second.

Characteristics of Plane Waves

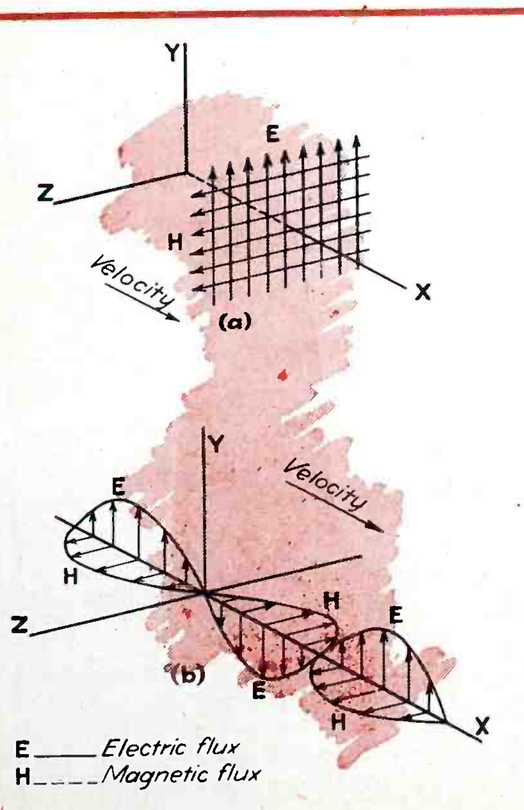
The signal that reaches a radio receiving antenna is part of the spherical wave that spreads out in space about the transmitter. Assuming that the transmitted wave is allowed to spread freely through space, the receiving antenna receives only a small part of it. But a sufficiently small part of a large sphere appears plane, just as the surface of the ocean as far as one can see appears flat. From the point of view of the receiver, therefore, the arriving wave is practically a plane wave. This is fortunate, for a plane wave is the simplest of waves. Let us therefore discuss plane waves.

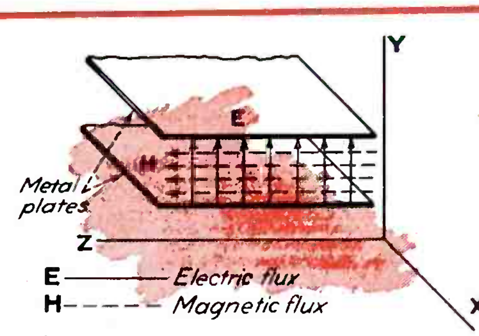
A diagram of a plane wave is shown in Fig. 1a. The electric field E is vertical, parallel to the Y axis; the magnetic field H is parallel to the Z axis; the wave is therefore traveling along the X axis. The cross-hatching of electric and magnetic fields indicates one plane of the wave, but it must be understood that the wave is not limited to this particular plane. If the wave is a sine wave, as it would be from any ordinary radio oscillator, it will have a distribution along the direction of travel (along the X axis) somewhat as shown in Fig. 1b.

To show the complete wave as it exists in three-dimensional space would require a combination of these diagrams, with the electric and magnetic fields shown in an unlimited number of parallel planes. This cannot well be drawn on a piece of paper, particularly since all the fields must extend to infinity, but it is not very hard to imagine. When a mental picture of this kind has been formed, it is a snapshot of a plane wave; to give it action it is only necessary to let the electric and magnetic fields pulsate so that waves of intensity travel through the field from left to right (parallel to the X axis).

The result is a plane wave. It is a specially simple kind of plane wave because it is plane-polarized, which means that the electric field at any point does not change direction as the wave passes. It changes magnitude, but is, in this illustration, always vertical. This wave is therefore said to be polarized with the electric vector vertical. Most radio waves are polarized in some such simple fashion, for the direction of the field is determined by the geometry of the transmitting antenna; but waves that have passed into the ionsphere and been reflected have acquired a more complicated form and are said to be elliptically polarized.

The electric field of the plane wave of Fig. 1a extends to infinity





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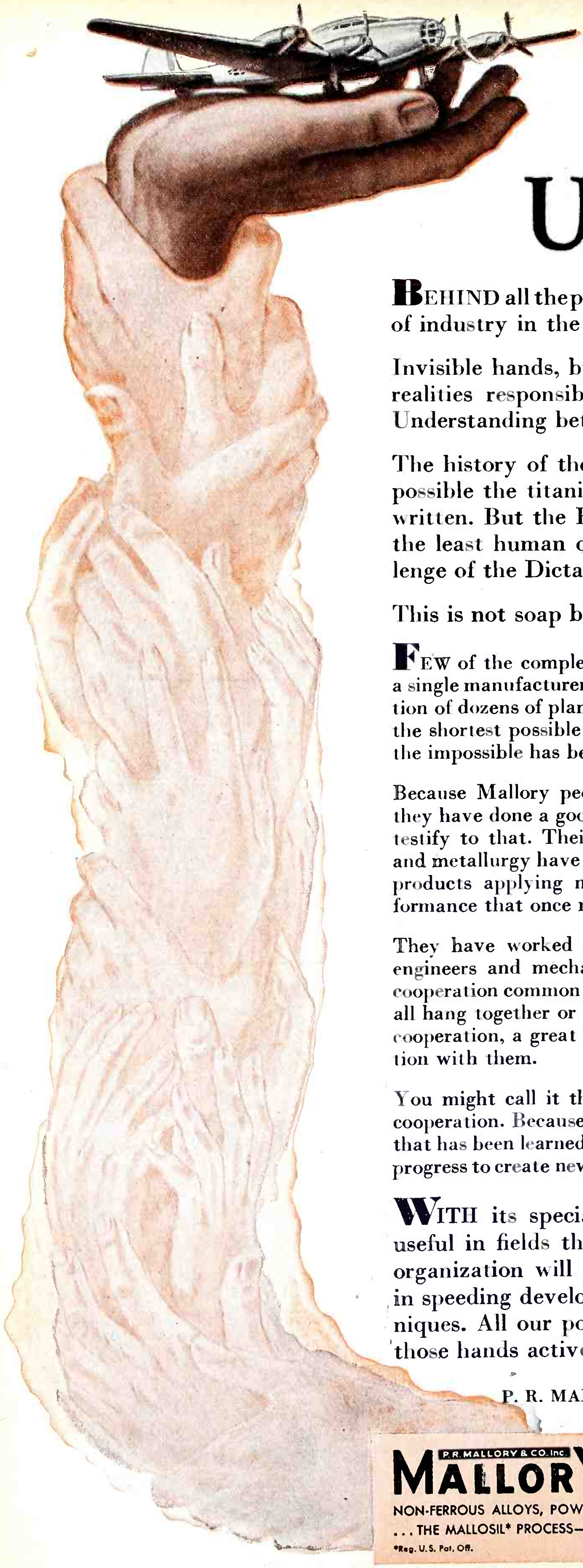

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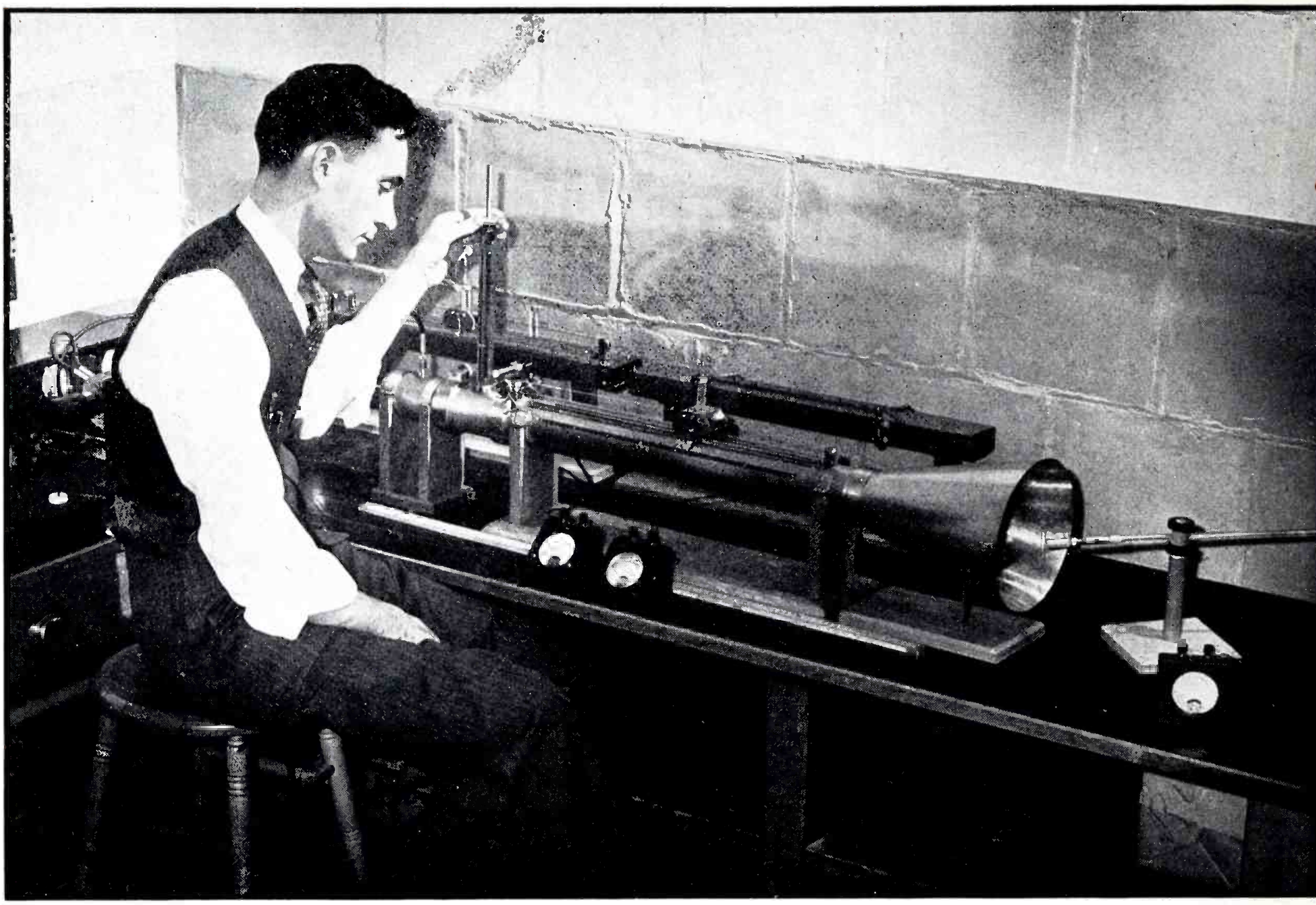

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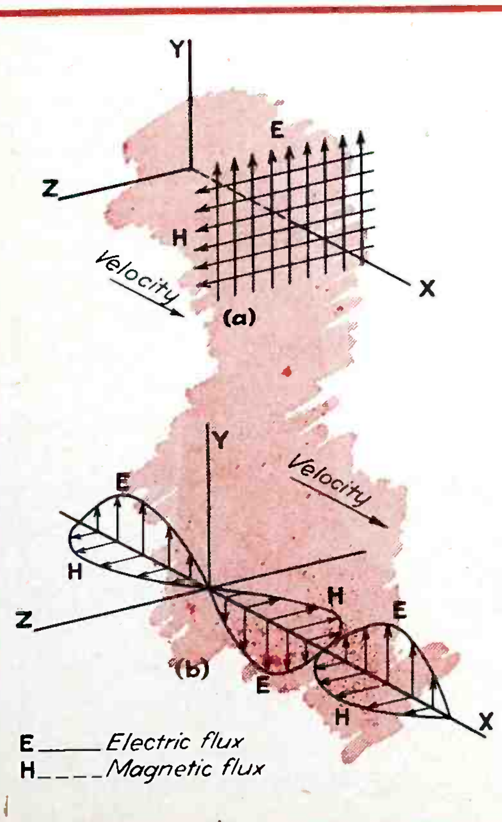

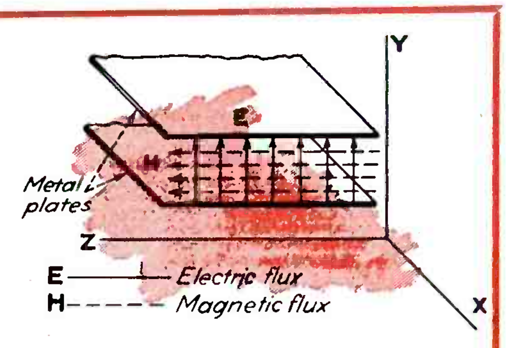

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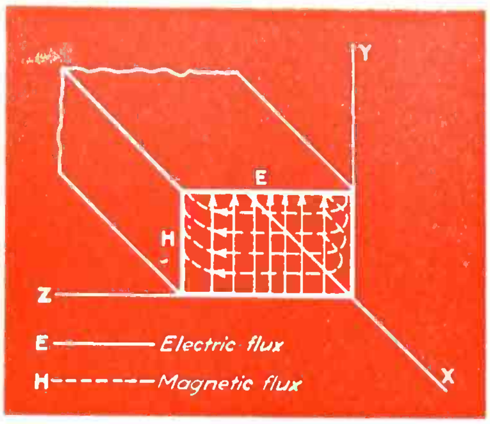


Fig. 3—Rectangular wave guide will transmit microwaves satisfactorily if the electric field is zero at the side walls and greatest at the center. This condition, illustrated in Figs. 4 and 5, can be achieved only if the wavelength is approximately equal to the width of the rectangular pipe

both upward and downward. This must be true of any such field in empty space, for an electric field cannot begin or end in empty space. The electric field begins where there is positive electric charge, and ends where there is negative charge.

One Metal Plate. If a horizontal sheet of metal is placed in the electric field, however, the field may terminate upon it. For this to be possible there must be a proper distribution of electric charge on the surface of the metal sheet on which the field is to terminate.

Two Metal Plates. By using two parallel metal sheets, the electric field can begin on one and end on the other, and an electric wave may thereby be propagated through the space between the metal sheets. Figure 1a becomes Fig. 2.

The metal plates of Fig. 2 form a kind of wave guide, for a wave that is started between them will continue to travel between them. But they do not constitute a practical guide, for they would need to be infinite in extent. It would be necessary for them to extend indefinitely to the left and right.

Four Metal Plates. One is inclined to say that if a pair of horizontal metal plates will form the top and bottom of a wave guide, cannot a pair of vertical plates be used as the sides? But this is not possible with a plane wave of the kind we have been discussing. Conducting plates can be placed perpendicular to the electric field, as in Fig. 2, and they will terminate the field without distorting it, but if they are placed in such a way that there is any component of electric field parallel to the conducting surface, if the metal plate is parallel to the electric field or at any angle except ninety degrees, the conductor will "short-circuit" part of the electric field and there will be distortion of the wave. Either a metal surface must be perpendicular to the electric field, or else the electric field at that surface must be zero.

Making a Wave Fit a Guide. Since it is impossible to take an ordinary plane wave and confine it within the four walls of a hollow rectangular wave guide, let us try the second of the above alternatives: let us reshape the wave so that the electric field is strongest in the center of a hollow guide, as in Fig. 3, and diminishes on either side so that at the left-hand and right-hand walls it is zero. If this is done, the necessary conditions are satisfied all around the guide, for the field is perpendicular to the top and bottom surfaces, and it is zero at both side walls. But can this peculiar kind of wave exist? We find that it can, and that it is merely the sum of two plane waves that travel along the wave guide at the same time.

Consider two sinusoidal waves. Each may be thought of as looking like the waves in a sheet of corrugated iron, or better, because it illustrates the motion, like waves in a rug when it is shaken. The two waves are illustrated by surfaces in Fig. 4, one lightly shaded or white and the other shaded red. The waves in the white surface are traveling almost directly away from the reader, while the shaded waves are traveling more toward the right. Two arrows in the figure indicate the directions of travel of the waves. The waves are cut off at the near edge by a vertical plane which contains the dotted line shown in the figure. They are cut off at the far edge by a parallel vertical plane.

How Two Waves Combine. Now, for our purposes, each of these sinusoidal surfaces represents the electric field strength in a plane wave. The height of the surface above or below its neutral plane (the neutral plane is a horizontal plane through the dotted line of the figure) is a measure of the electric field strength. When the two waves are combined the total electric field is the sum of the two individual fields and is found at any point by adding together the field strengths of the component waves at that point. If the field of one wave is positive, and the field of the other is negative and of equal magnitude, at that point the total field strength is zero.

That condition, giving a total electric field strength of zero, is particularly interesting because it is found to exist all along the near edge of the waves of Fig. 4. Where the red shaded wave is positive (above neutral) the white wave is by an equal and opposite amount negative (below neutral). The same is true along the far edge of the waves shown, where they are cut off by another vertical plane. But in between, throughout all the middle part of the diagram, the waves add to something other than zero. At the points, for example, where the crests of the waves coincide, the total is twice the crest of

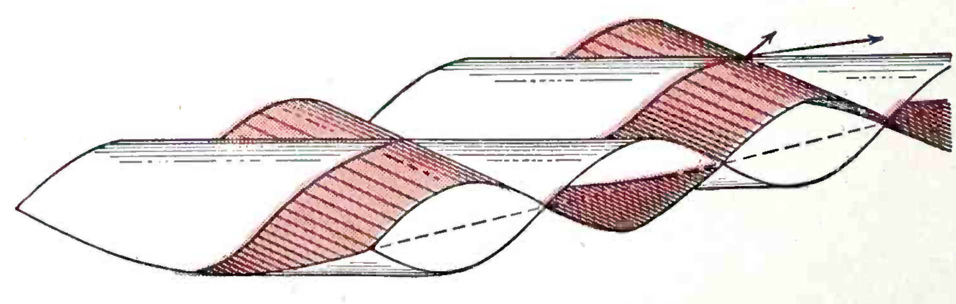


Fig. 4—Two sinusoidal waves traveling in the directions indicated by the arrows produce a resultant electric field meeting the requirements of a hollow wave guide. Note that the algebraic sum of the two individual waves is zero all along the near edges of the waves. The frequency and the wave-guide width determine the angle at which the waves cross

either alone. When the waves are added everywhere the total turns out to be a surface with hills and hollows as shown in Fig. 5.

Now this is exactly what is needed for a wave guide, for the electric field (represented by the surface of Fig. 5) is zero all along the side walls of the wave guide even though a large and useful wave may be going down the center of the guide. This exactly meets the requirements as indicated in Fig. 3. And it is, indeed, the type of wave that is commonly transmitted along a rectangular wave guide for practical use. Another and more complete way of picturing the wave is shown in Fig. 6.

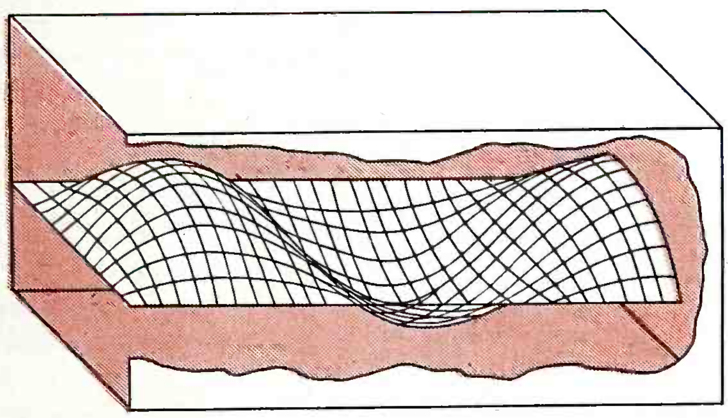


Fig. 5—Resultant surface of the electric field when the two waves of Fig. 4 are combined in a rectangular wave guide

Little has been said about the magnetic field of this guided wave, but the two component plane waves have magnetic fields and the magnetic field of the total wave is the sum of these components. As shown in Fig. 6 the magnetic field is made up of a series of sort of magnetic whirl-pools that travel along the guide. The lines of the magnetic field are all closed loops, as indeed magnetic lines must always be. The magnetic field is produced by the rate of change of the electric field, and the electric field in turn by the rate of change of the magnetic field, for this is how all electromagnetic waves travel.

Reflection of Waves in Guides. Now if this humped wave of Fig. 5, which is what one would see if the waves in a guide were visible, is considered to be the sum of two elementary plane waves, how do these elementary waves behave in the guide? First, as has been seen, they do not go straight along the guide, for they must cross each other. So each one goes at an angle, as in Fig. 7a, and each is reflected back and forth from one wall of the guide to the other, like light between two mirrors.

Angle of Reflection. The angle at which these elementary waves travel is determined by their frequency and wavelength. As may be seen in Fig. 4, the two waves are crossed at such an angle that they overlap one wavelength in the width of the guide. The crest of the red wave is directly above the trough of the white wave on the near side of the guide, while on the far side the same crest of the red wave is above the *next* trough of the white wave, one wavelength distant. So if the wavelength is short, corresponding to high frequency, the waves will not have to be overlapped very far and the angle α of Fig. 7a will be small. But if the wavelength is greater the amount of overlap in the width of the guide will be greater and the angle α will be larger as in Fig. 7b. In the latter case there will be many more reflections while the wave travels the length of the guide.

Group Velocity

One of the puzzling things about wave guides is that a signal travels along the guide more slowly than it would in open air, and this so-called *group velocity* is dependent upon the frequency and upon the width of the guide. But this ceases to be a mystery when the elementary waves are considered. In Fig. 7 it is apparent that an elementary wave following a zigzag path must go a greater distance in traveling from one end of the guide to the other than if it could go straight down the guide. It is therefore slower in reaching its destination. And since the number of zigzags is determined by both the wavelength of the signal and the width of the guide (for these two factors determine the angle at which the elementary waves must travel) these quantities affect the speed with which the signal is sent from one point to another.

Velocity Limits. It will be seen that the shorter the wavelength the more nearly the group velocity will be the same as the speed of an elementary wave, which is the speed of light This is the upper limit of speed. The lower limit is reached when the wavelength is twice the width of the wave guide, for if the wavelength is greater than that it will not be possible for the wave to travel in the guide at all. Let us examine the reasons why this condition must be so.

Cut-off Frequency. If the wavelength is greater than it is in Fig. 4 the elementary waves will have to overlap more than they do in that figure. The angle α will then be large, as in Fig. 7b, and the wave will not advance much between reflections from wall to wall. But as the length of half a wave (the distance from crest to trough) approaches the width of the guide, the angle α approaches 90 deg. At this frequency the wave merely goes back and forth across the guide, making no forward progress at all. The group velocity is then zero.

At still lower frequencies (greater wavelengths) there is no way to satisfy the condition that there must be no electric field at the walls of the guide, and consequently waves of lower frequency simply cannot be propagated along the guide. If such a wave were produced in the guide it would rapidly lose its energy and disappear. Hence the frequency at which the wavelength of the elementary wave is twice the width of the guide is called the *cut-off frequency.*

Attenuation. Yet even above the cut-off frequency the waves do not travel along the guide without a certain amount of loss of energy. This is because there is electric current in the walls of the guide and consequently some resistance loss. There must be current in the top and bottom of the guide because the electric field of the guided wave terminates on charge, and as the wave travels the charge must flow from point to point; this constitutes current. Then too, each time the elementary wave is reflected from one of the side walls it loses a little energy. (This also is because reflection of the wave causes current to flow in the metal wall.) Since a wave near the cut-off frequency is reflected many more times in traveling through the guide than is a wave of higher frequency, it suffers more loss. It is for this reason that attenuation of a wave is very great if the frequency is near the cut-off frequency.

From this consideration it would seem that the attenuation of a guided wave would become less and less as the frequency is increased. And this is true to a certain extent, but at a very high frequency the rate of attenuation begins to increase again because of what may be called the skin effect at the higher frequencies.

For any particular wave guide there is an optimum frequency of least attenuation. This optimum frequency is something like two or three times the cut-off frequency. In practice, the frequencies used are usually lower than the optimum frequency, or, to express the same idea differently, the wave guide for use at a given frequency is not made as large as its most efficient operating size. This is a matter of economy.

Phase Velocity

If the waves in a rectangular guide were visible we would see a series of hills and valleys, as in Fig. 5, traveling rapidly along the guide. It is odd, in view of what has just been said about signals traveling at a group velocity less than the speed of light, that the humps in the wave would appear to be going faster than the speed of light. They would appear to advance at a speed known as *phase velocity.* Phase velocity is not a real speed of propagation—it is merely an illusion that appears because the elementary waves travel at an angle to the walls of the guide.

Ocean Wave Wall Analogy. Some years ago I stood by the sea near Gloucester, watching the Atlantic waves break against a concrete sea wall. The waves were not beating headlong upon the wall, but rolled in at an angle of perhaps thirty degrees. Each long wave dashed first against the wall at the south end, breaking at that point in a cloud of spray. As it rolled obliquely in, the wave continued to shatter itself upon the wall, progressively from south to north. It struck first at the south, but in a moment it was breaking at my feet, and then with a roar it was beyond me, rushing on until the last of the wave finally spent itself upon the north end of the wall.

To one who saw only the spray that flew above the sea wall it would have appeared that some violent action was progressing along the wall from south to north at an amazing rate of speed. From where I stood it was plain that nothing of the kind was happening, but that a relatively slow roller was crashing at an angle against the wall. The appearance of great speed resulted from the angle. The crest of the splash on the wall traveled along the wall much faster than the true wave velocity, and the apparent speed was equal to the true wave velocity divided by the cosine of the angle between the wall and the direction of travel of the wave. That apparent speed is phase velocity. On the wall of a wave guide, as on a sea wall, it is greater than the wave velocity if the wave approaches the wall at an angle.

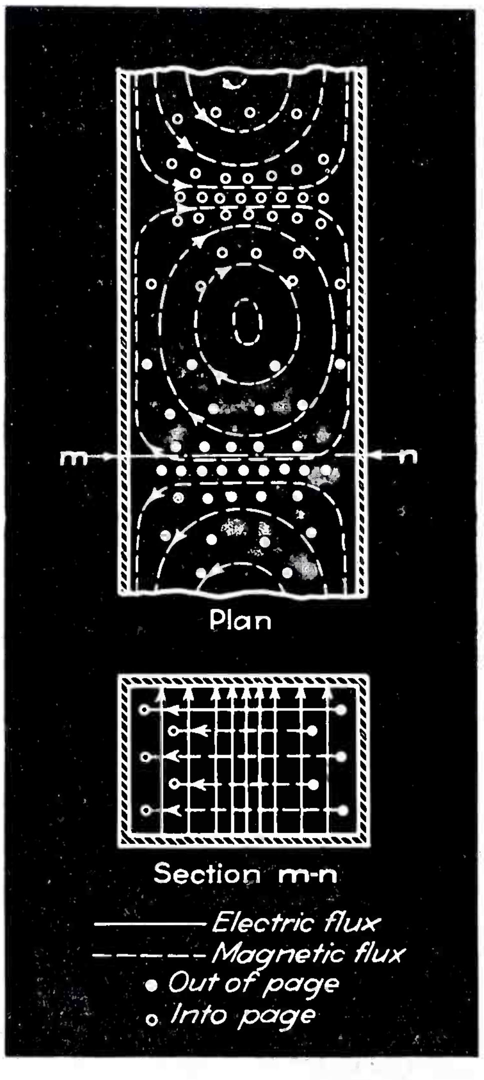


Fig. 6—Plan and cross-section views of a rectangular wave guide, showing both the electric and magnetic components of the resultant wave traveling through the guide

Code Signal Analogy. A signal, as a telegraphic dot or dash or a telephonic modulation, would not travel at phase velocity, but only at group velocity. If one could see a telegraphic dot traveling in a wave guide it would appear as a block of waves, with the block traveling at group velocity, while the waves within the block move forward with phase velocity, which is greater. New waves would be constantly coming into existence at the back of the block-shaped group, while the foremost of the apparent waves would, one after the other, reach the front of the group and simply vanish.

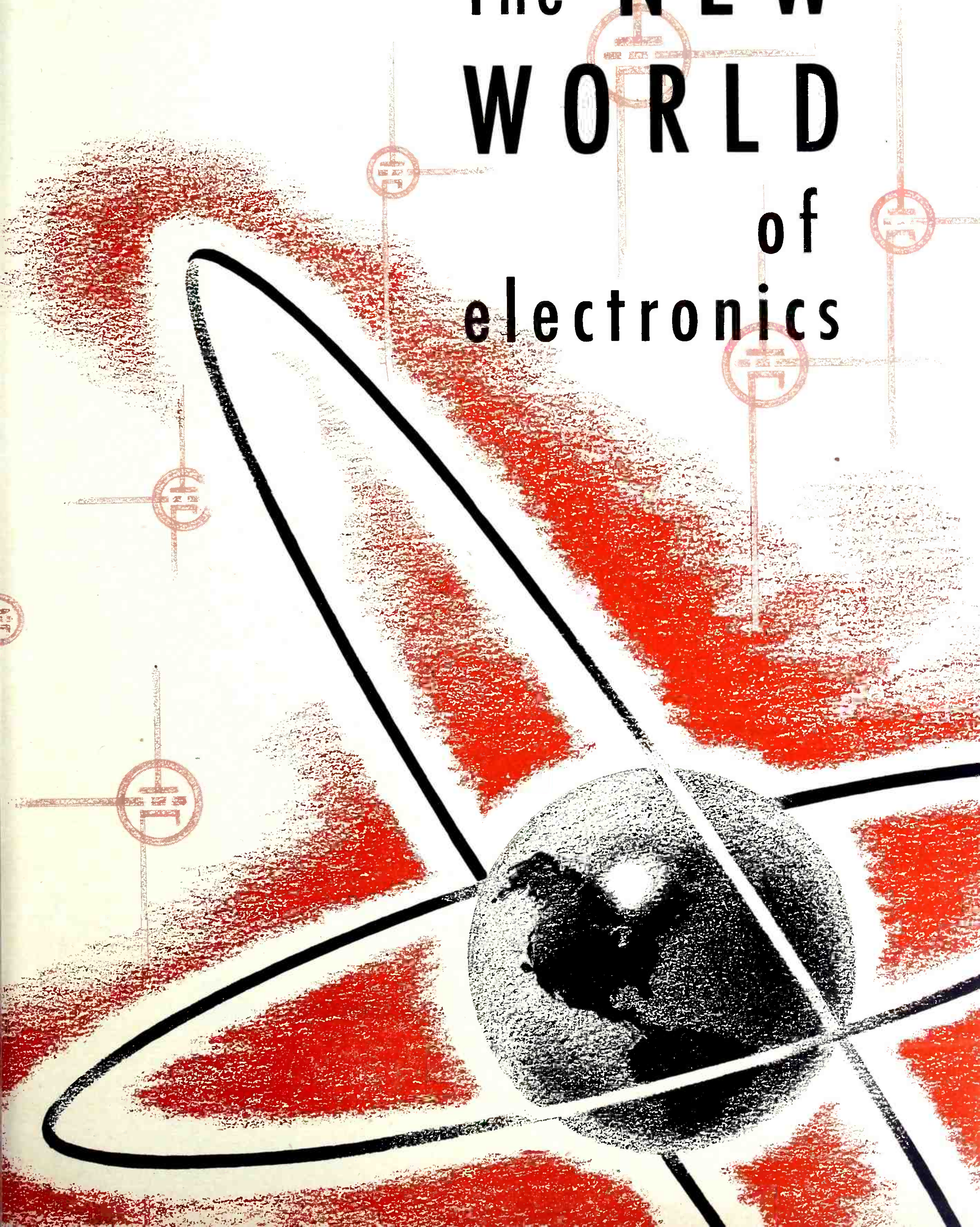
Caterpillar Analogy. I lecture to my class on this subject in the fall so that I can bring a caterpillar to class. When he can be coaxed to hurry across the lecture table, little waves ripple along his back from tail to head. The caterpillar moves at group velocity, while the little waves illustrate, after a fashion, phase velocity. In a guided wave, as in a caterpillar, the apparent waves go faster than that which they are carrying forward.

Circular Guides

In the previous paragraphs, guides of rectangular cross-section have been discussed. Wave guides may also be circular. Indeed they may be almost any shape, and one recent suggestion is to take a low, broad guide and wrap it up like a jelly roll

(*Continued on page* 260)

The NEW WORLD of electronics



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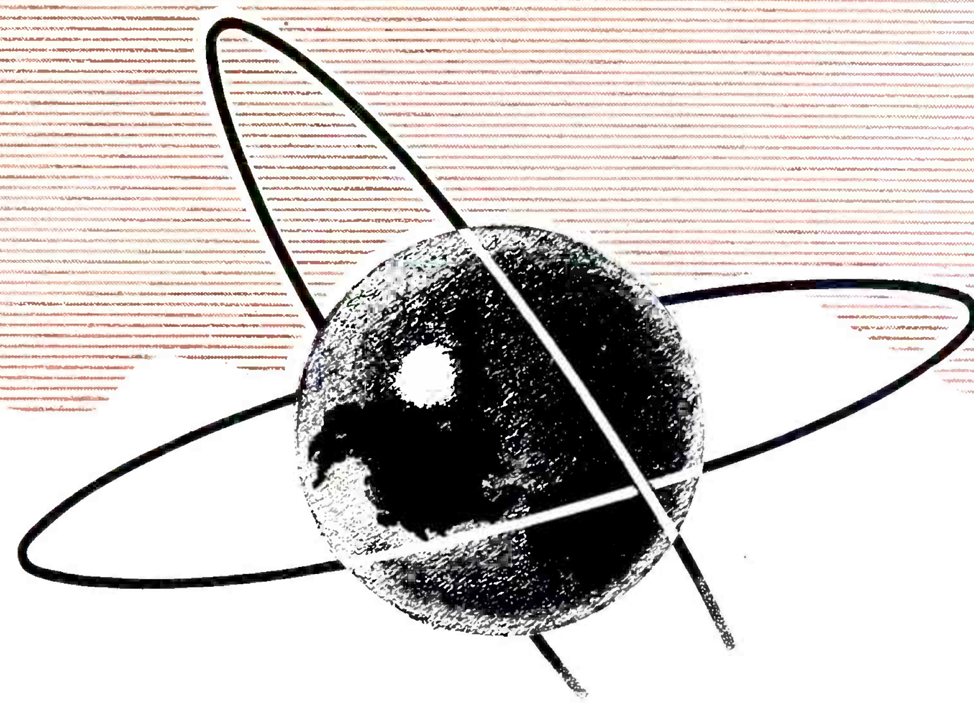


The New World of Electronics

What is electronics? What can it do for me?

These questions are in the minds of manufacturers who are now vitally interested in every possible scientific advance for speeding up production, improving product quality, and for promoting safety. These questions are also being asked by manufacturers looking for post-war products to make and to sell, and who have heard, somewhere, that one of the new industries is going to be something called electronics.

What is the future of electronics?

This question naturally occurs to manufacturers who already have a stake in one or more branches of this industry but who, because of their preoccupation with problems directly related to the war, find it difficult to visualize the overall potentialities of this thing called electronics.

To answer these questions, the following pages have been prepared by the Editors with the aid of men with specialized knowledge in each branch of the field. These men have contributed liberally of their time and energy and have also allowed themselves to speculate somewhat upon the future.

The articles will tell the reader what electronics *is* by telling him what electronics *is doing* in the fields of communication, industry and in research. It is impossible to cover every phase of electronics here. There are few jobs at which electronic engineers have not tried their hands. Furthermore, there are many applications of electron tubes which, because of their current military significance, had to be omitted entirely. It is felt, however, that the many articles and illustrations (very largely added by the Editors) present a sufficiently broad picture of the field to enable readers with imagination to speculate intelligently concerning the future size, shape and complexion of electronics.

It should be evident that even without extension of many new developments, now secret because of the war, the field of electronics is certain to be among these contributing in a major way to an enhancement of the way of living enjoyed by Americans. There will be mass production items for general use; and there will be many applications to industrial processes.

Individual articles within this symposium, which have taken months to prepare, are neither highly popular nor highly technical. They steer a middle course which, it is hoped, will prove informative to industrial executives, merchandising personnel, production people and men at work on industry's machines. The very scope of the text, if not the detail, will serve to broaden the thinking of engineers who now have an intimate picture of one or more phases of electronics but who, because of their concentrated interest in these aspects, do not have opportunity to see the picture as a whole.

electronics

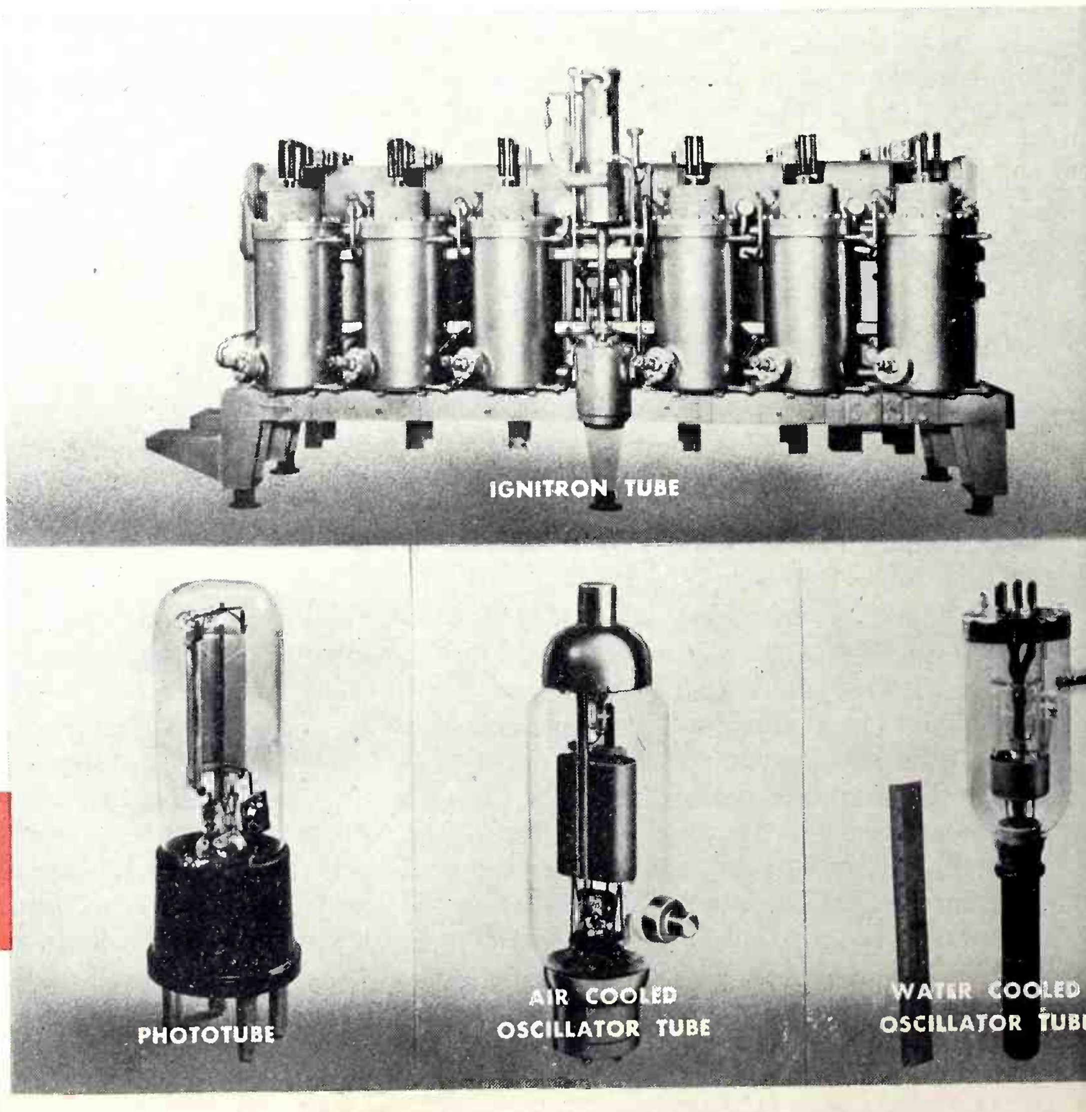
Today the electron, fundamental building block of the universe, is put to work by scientists and engineers to build a better world for the future. The great benefits already derived from wire and radio communication, x-rays, and navigation, television, and industrial electronics are but a prelude to developments making for a New World of Electronics

A SCIENTIFIC and fascinating drama of many acts has, in the last few decades, brought to us a new branch of electrical physics called "electronics". Because of its rapid growth and its frequent overlaps with other fields, this new science is difficult to define.

Whether "electronics" is a branch of electricity or includes electricity, depends greatly upon the scope of our definition. Most people, including some of scientific training, think of electronic as limited to the science of electronic and gaseous discharge phenomena in vacuum or low pressure tubes. We often hear people speak of electronic devices, meaning equipment containing vacuum tubes. Any such understanding of the scope of this science would place it as a branch of electricity. A broader definition would be: *electronics is the science relating to discharge phenomena of, and phenomena initiated by the action of, free electrons.* This more inclusive scope, generally acceptable to physicists and electrical engineers, will be assumed in what is to follow. It should be pointed out, however, that the knowledge of physical science, gained since the acceptance of the electron theory, seems to justify a realignment of the main branches of physics and 'putting electronics, which might be defined as the science relating to the action of electrons, in a most prominent place.

Why should we distinguish between electricity and electronics when the phenonmena of both result from electronic action? The distinction seems to be that electricity becomes electronics when the electron does its work in the open. This rather universal idea of limiting electronics to phenomena involving free electrons is hardly justifiable. To illustrate: In a phototube *free electrons* are produced by light impinging on the sensitive cathode. This is electronics. In a cathode-ray tube, *free electrons* produce light from the screen. This is the reverse action and classified as electronics. On the other hand, radiation produced by ultraviolet rays exciting fluorescent materials, as in a fluorescent lamp, is not considered an electronics phenomenon as no free electrons are involved. Both fluorescent phenomena, however, are the result of electron action in the atoms of the material.

We still hear people say, "We make and use electricity without knowing what it is." Current and well-founded theories have cleared most of the mysteries, and we can now say with considerable confidence that electricity already exists as corpuscular charges in matter. Electricity is not made, but is merely separated



According to their function and power rating, electron tubes take various forms and sizes. The examples shown here are a few of the many electronic devices in daily use in communications, industry and research

—SCIENCE OF TODAY

By L. W. CHUBB

Director of Research
Westinghouse Electric and Manufacturing Co.

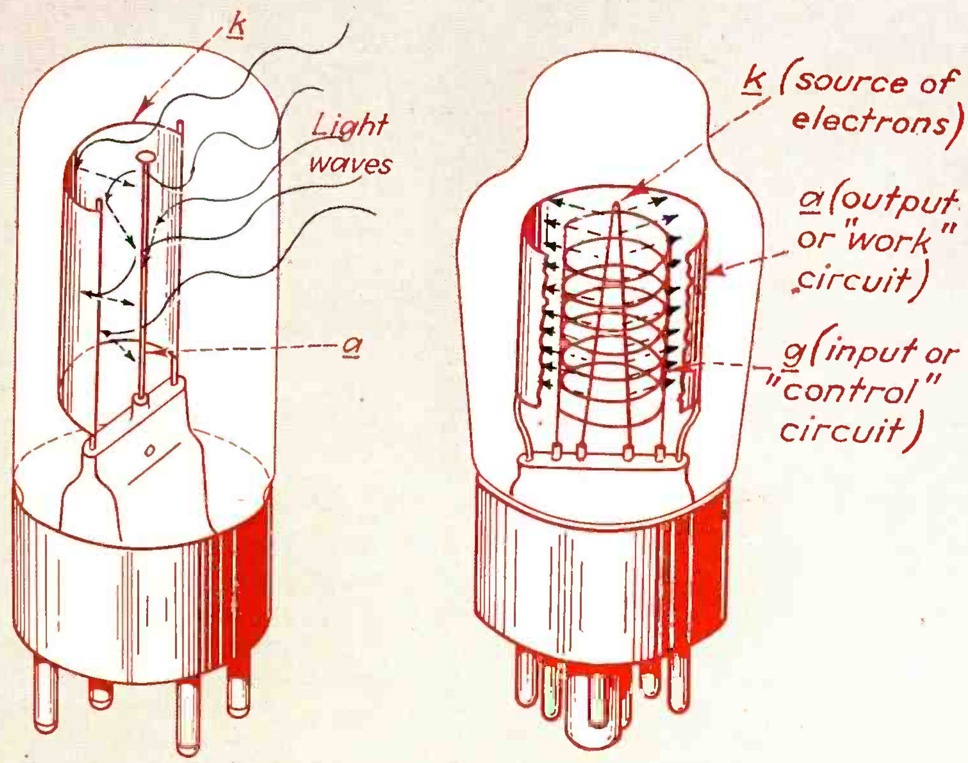
into its positive and negative components, making its presence apparent in some way. Electric current in conductors is the simple passage of electrons through the conductor. A charged body is merely one in which there is an excess or deficiency of electrons. Magnetic fields, light, x-rays, in fact all radiations, with the exception of those from nuclear reactions in the sun and stars, are of electronic origin. Substances absorb radiant energy because of the presence of electrons in their structure. Chemical reactions proceed because of the arrangement and number of electrons in the outer orbits of the atoms. The ferromagnetic atom of iron obtains its polar properties because of certain uncompensated electron rotations.

Since electronic action is the almost universal source of manifestations of energy, why shouldn't electronics be very broadly defined as *that branch of physical science relating to phenomena resulting from the action of electrons.* We would then include in electronics the formerly mysterious electricity, magnetism, radiations, chemistry, etc.

It is realized that this suggestion of the reclassification of the natural philosopher's basic science will meet with many objections. However, such a rearrangement seems logical in view of the present knowledge. Heat, electricity, magnetism, light—now subdivisions of physics—could quite well be included as subtopics of electronics.

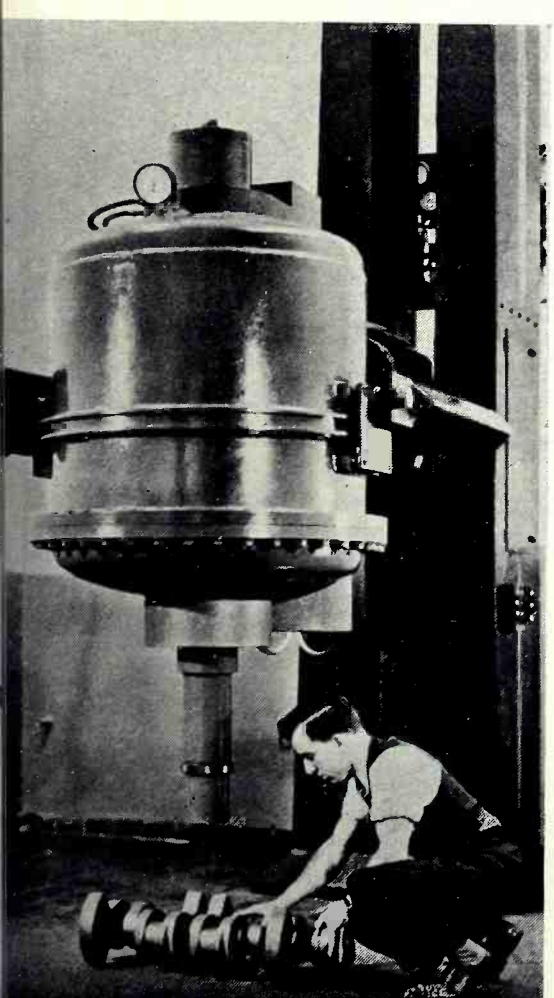
For an understanding of electronics, in all its ramifications, one should consider the composition of matter. Modern physics teaches us the electrical nature of matter. We may say, with some slight limitations, that all matter is constructed of three fundamental entities: electrons, protons, and neutrons. Two of these three basic particles—the electron and the

HEART of the ART

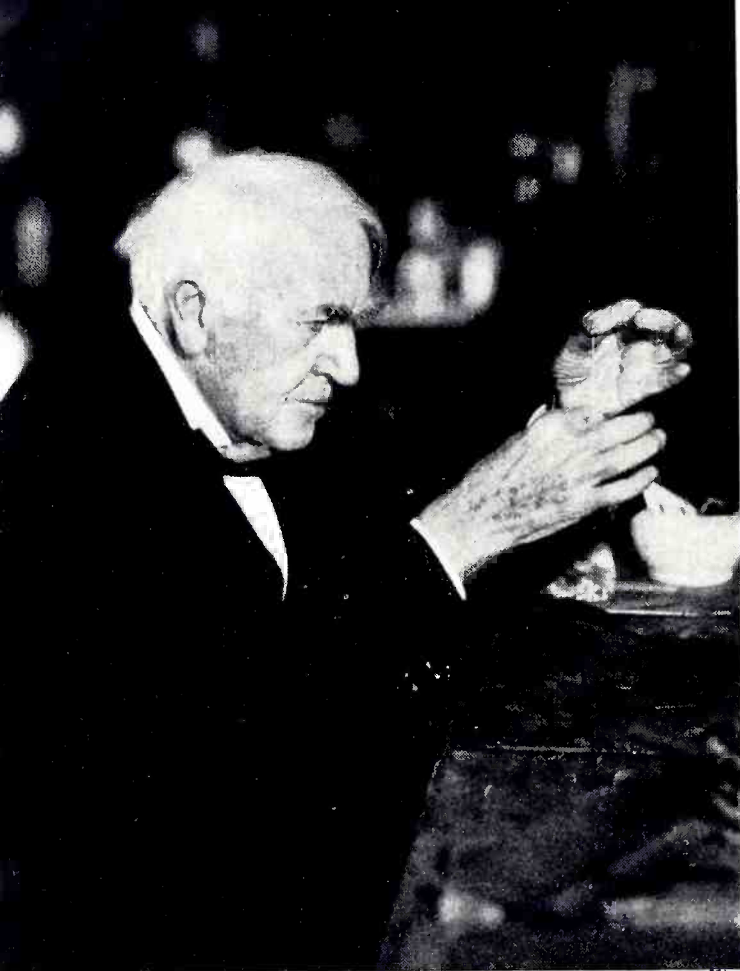


PHOTOTUBE . . . Here, a light-sensitive surface serves as the cathode. Light impulses in the input circuit appear as electrical impulses in the output circuit

ELEMENTAL TRIODE . . . The broad usefulness of the tube stems from the fact that inertia-less electrons emitted by cathode *k* may be caused to flow to anode *a* with almost no time loss. Uni-directional flow phenomena permit functions such as "rectification" and "detection." Equally important, an additional structural element such as grid *g*, interposed between cathode and anode, may be used to increase or decrease the electron flow, a *small* amount of power applied at this point controlling a *large* amount of power in the anode or "work" circuit. This phenomena facilitates "amplification." Amplification may be changed to "oscillation", turning the tube into a generator of electricity



INDUSTRIAL X-RAY TUBE



Researches in the perfection of the incandescent lamp in 1883 led Thomas Edison to observe the rectifying properties of the simple two element tube. This year marks the fiftieth anniversary of the "Edison effect" which was followed by an extremely active program of electronics research

proton—contain strong electrical charges. Each element has its characteristic atom, consisting of a small dense positively charged nucleus or core, composed of protons and neutrons, around which the negatively charged electrons rotate in quite definite orbits, just as the planets rotate around the sun in our solar system. The elements differ greatly in mass and complexity. Hydrogen is the simplest with a nucleus of one positively charged proton which holds one electron in the surrounding orbit. Next comes helium with a core of two protons and two neutrons surrounded by two orbital electrons. So it goes, up to the ninety-second element, uranium, having a nucleus of ninety-two protons and one hundred and forty-six neutrons, around which is a swarm of ninety-two electrons.

In all cases the balanced atom has as many protons in the nucleus as there are electrons in the neighborhood of the nucleus. Equality of the total positive charge of the nucleus and the negative charge of all the electrons results in a system having no external field, obscuring the electrical nature of the material.

It is not surprising that atoms

HIGHLIGHT DEVELOPMENTS IN ELECTRONICS

1883	Unilateral conductivity discovered by Thomas A. Edison and called the "Edison effect".
1884	First quantitative measurements of Edison effect made by Preece.
1888	Discharge of electroscope when illuminated by ultraviolet light discovered by W. Hallwachs.
1891	Term "electron" coined and used by George Johnstone Stoney.
1895	Discovery of x-rays by W. C. Roentgen.
1897	Braun tube, forerunner of cathode-ray tube, designed by F. Braun.
1897	Discovery of, and measurement of mass of electron, by J. J. Thomson.
1900	J. J. Thomson advanced the electron theory.
1903	Diode used as rectifier for high frequency oscillations by J. A. Fleming.
1903	Investigation of emission of electrons from oxide coated filaments by by A. Wehnelt.
1905	Albert Einstein offered interpretation of photoelectric effect.
1907	Introduction of grid in tube by Lee deForest.
1910	Millikan determined the charge carried by an electron.
1911	Child developed 3/2 power law of current flow, for plane electrodes.
1911	Research in wireless telephone undertaken by many investigators.
1912	Development of vacuum tube repeaters by engineers of Bell System.
1913	Armstrong and de Forest in United States, Franklin and Rund in England, and Meissner in Germany credited with invention of use of tube as oscillator.
1913	Langmuir developed 3/2 power current law for cylindrical electrodes.
1913	Molecular high vacuum pump introduced by Gaede.
1914	New York-San Francisco telephone circuit opened, using vacuum tube repeaters.
1915	Study of electron emission from pure tungsten, by Irving Langmuir.
1915	Diffusion pump introduced by Gaede.
1915	Regeneration described by E. H. Armstrong before Institute of Radio Engineers.
1919	Superheterodyne receiver circuit described by E. H. Armstrong.
1919	Use of second grid in tube suggested by W. Schottky.
1919	Mass spectrograph devised by Aston.
1920	Van der Bijl's book on "Thermionic Vacuum Tube" appeared; first book entirely devoted to electron tubes.
1921	KDKA broadcasts inaugurated era of broadcasting.
1921	Magnetron devised by A. W. Hull as electronic switch.
1923	Glass to metal seal, by W. G. Houskeeper, made possible high-power tubes.
1926	Screen grid tube developed by A. W. Hull and N. H. Williams.
1927	Cold cathode rectifier (Raytheon, BH) developed by C. G. Smith and V. Bush.
1928	Magnetrons used as u-h-f oscillator by Okabe.
1930	Cathode-ray tube developed to commercial practicality.
1930	Tube for measuring minute currents developed by G. F. Metcalf and B. J. Thompson.
1931	Electron microscope devised by E. Ruska in Germany.
1931	Variable-mu tubes invented by S. Ballantine and C. Snow.
1933	Acorn tubes for u-h-f use developed by B. J. Thompson and G. M. Rose.
1934	Image dissector tube described by P. T. Farnsworth.
1935	Metal cased tubes made available commercially.
1936	Beam power tube developed by RCA engineers; critical distance tube developed by J. W. O. Harries in England.
1936	Secondary multipliers developed by Farnsworth, Bell System, and RCA.
1938	Image iconoscope described by Iams, Morton, and Zworykin.
1939	Velocity modulated tubes described by Varian brothers.
1939	Orthicon developed by Rose and Iams.
1941	Million volt industrial x-ray unit made commercially available.
1942	Trigger tube using secondary emission developed by A. M. Skellett.
1942	Study of mechanism of emission of Wehnelt cathode by H. C. Rentschler.

were considered indivisible elementary particles until nearly the end of the last century. All objects, all matter built of them, show no evidence of their electrical nature and the internal forces that hold them together (and apart), until the electrons, which are relatively loosely bound to the nucleus, are torn away revealing the electrical components and give electrons and ions which may be put to work in many ways by the electronics engineers.

Origin of Electronics

Electronics was born of research. However, many of the commoner known electronic phenomena were discovered before there was a definite knowledge of the mechanisms involved. X-rays, accidentally discovered at the end of the last century, were so named because Roentgen could not explain the action. Electron emissions were discovered accidentally and independently by Edison and others. Photoelectric effects were discovered in 1887 when Hertz showed that ultraviolet light would lower the breakdown voltage of a spark gap, and it wasn't until 1899 that J. J. Thomson identified photoelectric emissions as electrons. These isolated and somewhat chance discoveries stimulated important physical research. In the same year that J. J. Thomson showed that photoelectric emission consisted of electrons, he measured the ratio of the electron charge to its mass. In 1902 Richardson measured the current carried by electrons from different hot metals. He later gave us the laws of thermionic emission and the flow of electrons in vacuum.

It was Millikan's classical oil drop experiment that really started the flood of research in electronics that greatly increased scientific knowledge of energy and matter. Millikan was first to measure the charge of the electron. This also gave us the mass, for the earlier work had shown the ratio of the charge to the mass.

Fleming's valve, de Forest's grid, Armstrong's inventions, and other well-known milestones have brought forth many electronic devices, combined with special circuits, which enable the electronic engineer to perform almost any electrical function.

Applications of electronic research and development have, in the last two or three decades, advanced engineering, communications and industrial processes in a manner never before equaled in such a short period of time. Today there are available vacuum tubes, gaseous tube and circuits having the necessary characteristics to amplify, generate, control, transform or convert electrical energy in almost any manner desired. Electronic devices and knowledge of electronics provide the auxiliaries to do things in a better way or that cannot be done otherwise.

It should not be forgotten that arc and spark discharges and ionization phenomena at atmospheric and higher pressures must be included in the field of electronics. Extensive studies regarding lightning in the field of lightning protection, circuit interruption, electrical precipitation, arc welding, and in many other fields, have removed the limitations to growth of our power and industrial activities. These studies have enabled us to meet the ever increasing requirements in the normal growth of the electrical industry and have been especially valuable in the enormous expansions necessary under the present war emergncy.

Electronics in the War

At the present time when all effort is directed toward war, it is interesting to reflect upon the part played by electronics. Probably the most important and obvious application of electronics is in the field of communications. The world-wide long distance system of wire and radio communications, as well as the many types for inter-communication between planes, ships, troops and trench, are of vital military importance. They have all been made possible by the application of old and new principles of electronics.

In the power industry, the adoption of electronic devices has been greatly retarded because of a lack of confidence in the fragile tubes used in places where a failure may result in serious disturbance or damage. In spite of a seeming prejudice to the new devices, industry is generally adopting electronics in many ways. It has proven particularly useful for regulation and control, for safety devices, for power conversion, light, welding, induction heating, etc. For the most important examples having to do with the war effort and involving electronic applications in industry, we might mention the enormous use of ignitrons to convert power for the production of aluminum and magnesium, so vitally needed for airplane construction. Another good example is the extensive use of fluorescent lamps for the efficient and economical lighting of war plants.

It would take pages to list and describe the multitudinous applications of electronics in research, development, and quality control laboratories. In almost any laboratory project one finds electronic devices for instrumentation or for performing other functions which cannot be accomplished in any other way. Tubes and special circuits are the tools of the research scientist.

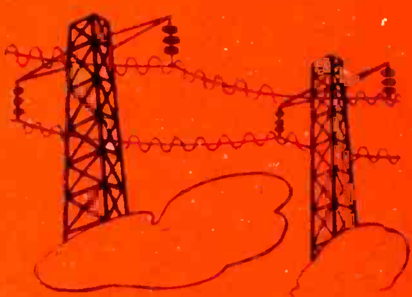
In times of war, research and development are tremendously accelerated to bring forth new instruments of defense and destruction. This is particularly true in the field of electronics at the present time. A careful analysis would probably show that there has been more expansion in personnel for the study, research, development and productions of electronic devices than in any other war development.

Radio and electronics science has entered a new era. Radically new methods and most miraculous devices have been brought forth and applied as the tools of war. When the stories of these new things and the performance of them can be told, there will be many thrilling talks.

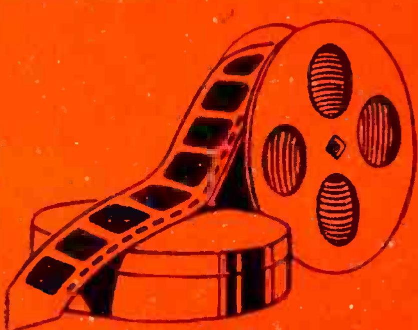
Fortunately the new electronic techniques, so useful in war, will have great peacetime value. Already many applications can be visualized and many other unforseen uses and possibly new industries will appear when the peace is won.

From time to time it is desirable in any important field of endeavor to have a series of articles which will record the progress, the present status and the future possibilities. In this issue, authorities in the fields of communication, industry, science, and measurement have presented articles closely related to or made possible by electronics—the science of today and the science of the future.

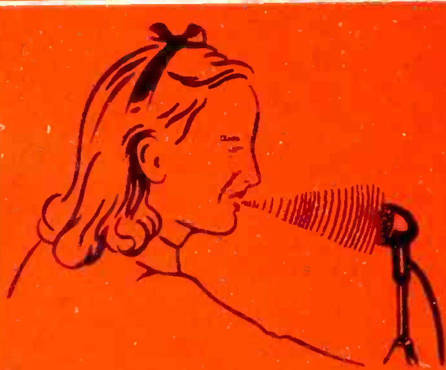
TELEPHONE



CARRIER-CURRENT

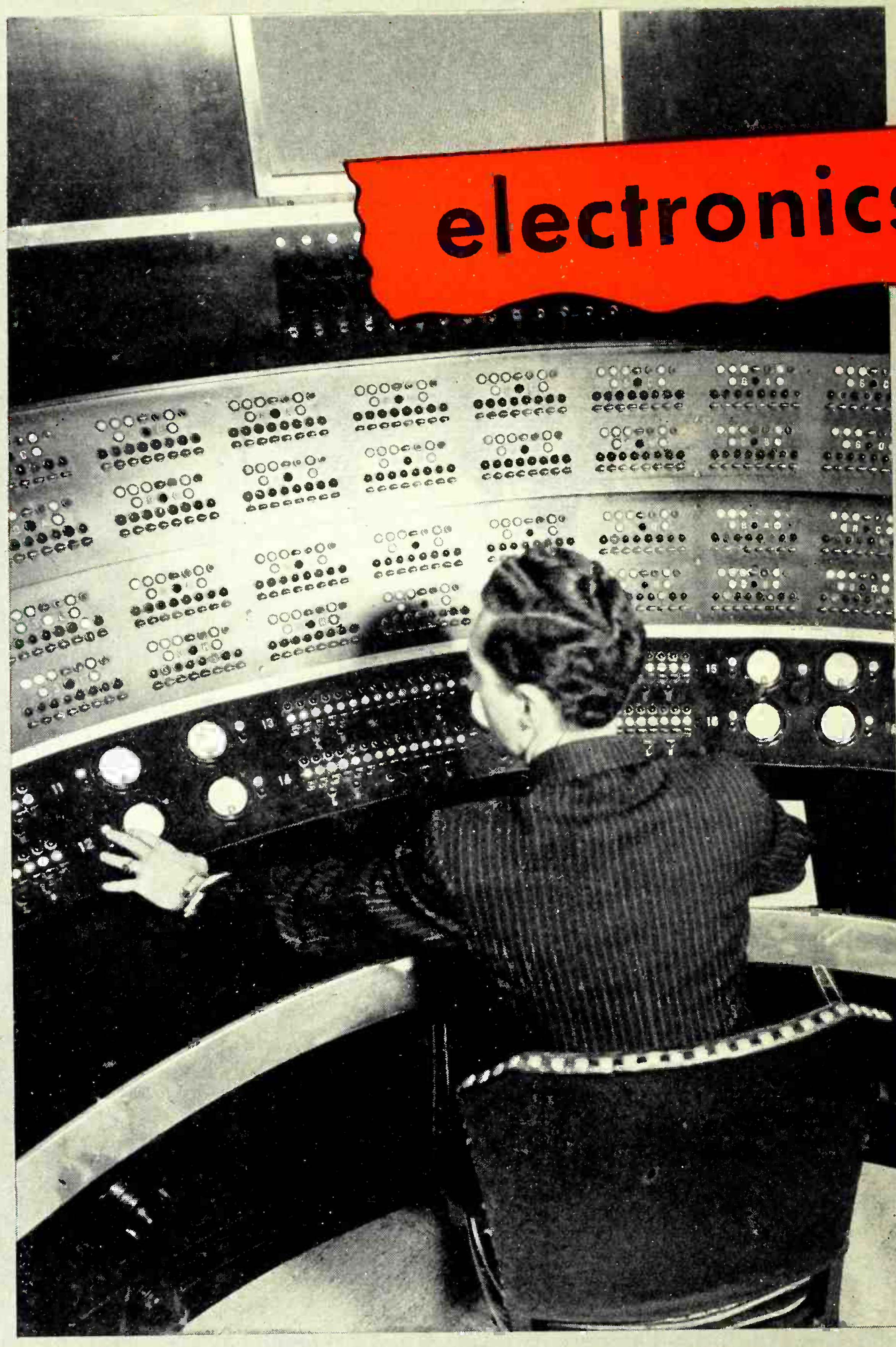


MOTION-PICTURES

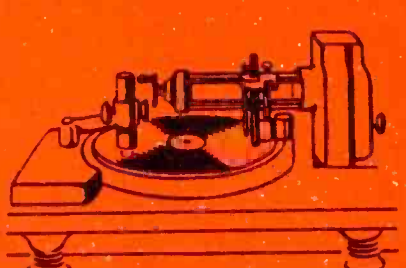


SOUND

electronics



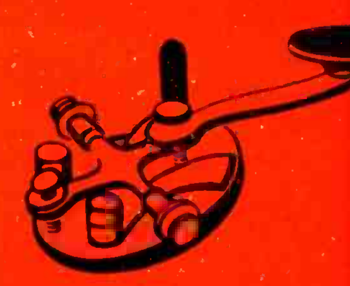
Wire and radio communication facilities serving the nation converge at the master control panel of the National Broadcasting Company



RECORDING

RADIO

TELEVISION



TELEGRAPH

Cornerstone of COMMUNICATION

TELEPHONE and TELEGRAPH vast users of electronics

By FRANK A. COWAN

Transmission Engineer
American Telephone and Telegraph Company

NO time in the history of electronics has been more appropriate than the present for a review of the developments and application of this science in the field of communication. Each year in the last quarter century has seen new and important inventions linking these fields together and increasing their effectiveness. Today so wide and varied are the applications of electronic devices in telephony that a detailed consideration of all of them is beyond the scope of this article but some idea can be gained by reviewing the major steps in the development of electronic communication devices and the more outstanding present applications.

Today the most important assignment for communications and electronics is the war. Communications for battle fronts, transportation, war production and essential civil activities are all part of this job. The services performed by the telephone system have become so much a part of modern business activity that they are accepted as commonplace.

The first application of electronics in telephony was in the telephone repeater and today the use of the vacuum tube as an amplifier is still perhaps its most important use since it is also the amplifier that makes possible the widely used multichannel carrier telephone and telegraph systems. The need for an amplifier to strengthen the voice currents was apparent almost from the start of telephony. The early telephone repeaters employed a mechanical type of amplifier. First tested with success in 1904, a total of 41 such repeaters had been installed for use in the Bell System by 1910. The early work had paralleled Richardson's now-classic work on the laws of thermionic emission. The possibility of securing improved operation by substituting electronic coupling and control for mechanical coupling led to the orderly and imaginative research by Dr. H. D. Arnold. Employing mercury arc devices by July 1912 he had produced an amplifying element of this type which was used commercially to a limited extent. His attention had also been called to the audion of Dr. Lee deForest. Although it was a relatively crude instrument incapable of being used as a repeater, Dr. Arnold recognized its possibilities and undertook the development which resulted in the production in 1913 of the first prac-

AMERICAN TELEPHONE & TELEGRAPH COMPANY
RADIOTELEPHONE CIRCUITS
(January 1943)

To Europe

New York to London
" Berne
" Madrid
" Lisbon

To South America

New York to Buenos Aires
" Santiago
" Rio de Janeiro
" Lima
" Paramaribo
Miami to Colombia (Barranquilla, Cartagena, El Centro
" Venezuela (Caracas)

To Pacific

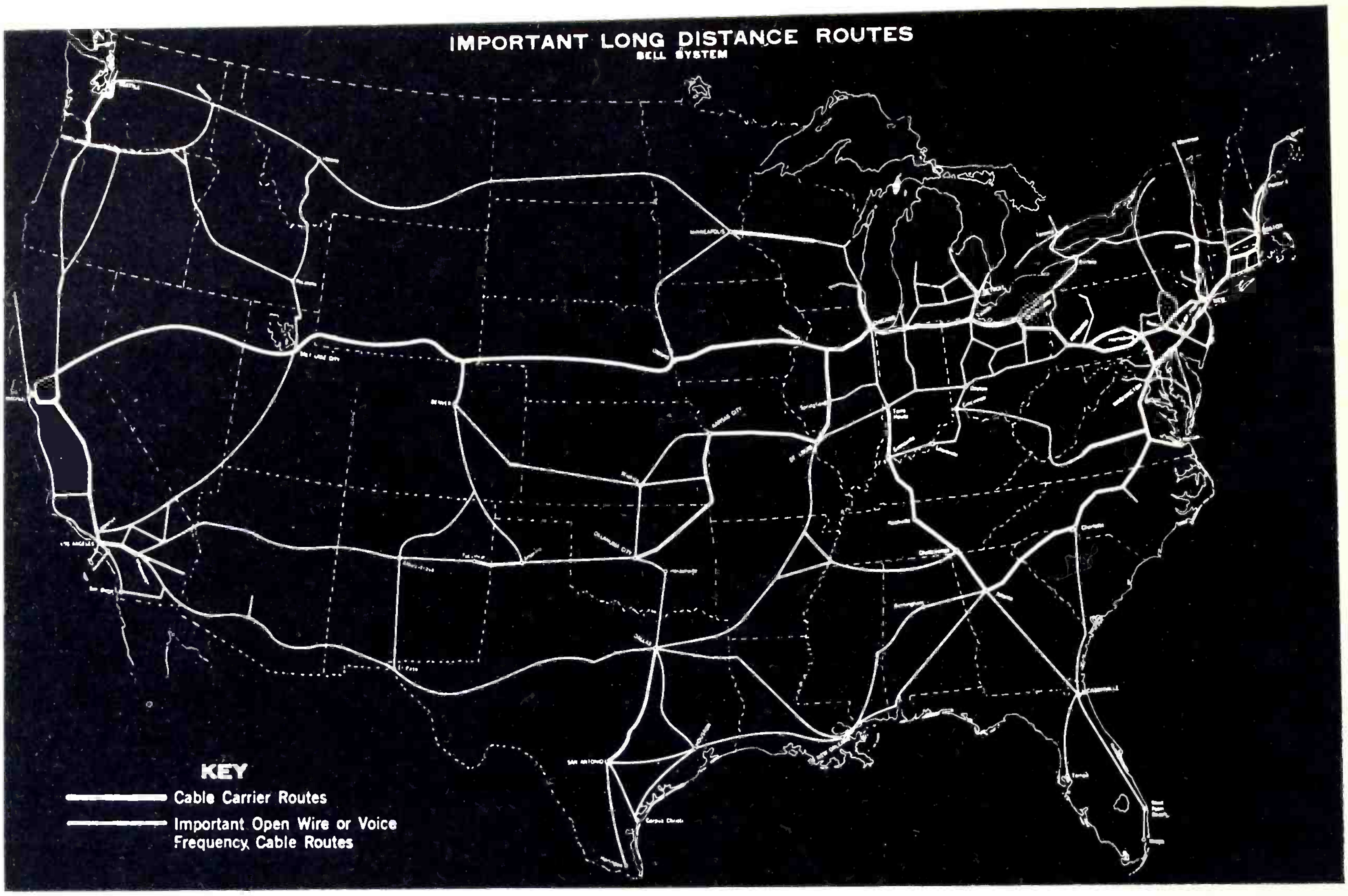
San Francisco to Hawaii
" Australia

To West Indies

Miami to Bahamas (Nassau)
" Dominican Republic (Trujillo)
" Haiti (Port au Prince)
" Jamaica (Kingston)
" Puerto Rico (San Juan)

To Central America

New York to Panama (Panama City)
Miami to Costa Rica (San Jose)
" El Salvador (San Salvador)
" Guatemala (Guatemala City)
" Honduras (Tegucigalpa, La Lima)
" Nicaragua (Managua)
New York to Bermuda



Steadily, through the years, many miles of cable carrier telephone circuits have been added to the important open-wire or voice-frequency circuits. Some picture of the telephone's role in the production of ships, tanks and planes is carried in current telephone advertising which says, "It takes 10,000 telephone calls to build a plane"

tical termionic vacuum tube for use in a telephone repeater. This vacuum tube in 1915 was used in the opening of the first transcontinental telephone service, the first transmission of speech by radio across the Atlantic, and the first demonstration of a practical carrier telephone system.

These developments coming in the early part of the first world war were naturally turned into uses of war. Radiotelephone systems provided communication between airplanes and ground and telephone repeaters of the new type extended the utility of the wire communications systems at home and with the expeditionary forces.

Following the end of the war in 1918, attention was again turned to improving electronic instrumentalities and applying them to advantage in the expansion of the telephone and telegraph systems serving continental United States and in furnishing connections with other parts of the world. Advances in telephony and telegraphy were accompanied by the introduction and development of radio broadcasting, telephotography, facsimile and television. Important steps in this era were the demonstration of one-way radio telephone transmission from the United States to England in 1923 followed by the opening of commercial service in 1927, commercial telephotograph service in 1924, nationwide network broadcasting in 1925, the first intercity television in 1927 and two-way television between two stations in New York City in 1930. The two decades between the wars witnessed such extensive application of electronic systems to communications with accompanying advances in both fields that the contributions of electronics to this war dwarf the achievements in the earlier conflict.

Applications to Telephony

An amplifier can be made to serve two general purposes, (1) to increase the strength of signals above their initial level and (2) to compensate for losses encountered in the transmitting medium and to restore the strength of the signals to a usable intensity. The first application would, on the one hand, permit a 100-piece orchestra to be presented as though it were composed of a thousand pieces or, on the other make possible the detection or observation of minute sounds or currents which might otherwise pass unnoticed. Applications of the second class are of greatest importance where it is desired to overcome the inherent losses of the transmitting media and is the most important communications application. With improvement in amplifier design and adaptability, the two fields, separated initially only by the concept of relative levels, have tended to merge into one. The ready availability of amplification today has made it possible, in the negative feedback amplifier, to trade amplification for a stability and fidelity which would otherwise be difficult or impossible.

Various other and important applications of the vacuum tube in communications work are as variable impedance elements, relays or switches, oscillators and modulators. Some of these uses are really the vacuum tube amplifier employed in a particular manner. This is illustrated by some of the present day oscillators which are multi-stage amplifiers arranged with external feedback or oscillation control paths and serve simultaneously as amplifiers and oscillators.

Probably the most unlikely place one would expect to find electronic devices in the telephone plant is in the familiar telephone instruments in his home. Yet hundreds of thousands of cold-cathode tubes are used in these instruments for the control of the selection and ringing on party lines.

Voice-Frequency Amplifiers

The voice-frequency amplifier has had a large effect upon the design of the telephone plant. First, it made it possible to establish a truly nationwide telephone service which otherwise would have been impossible with the best types of line construction using the largest practical gauge of wire. Second, it made it practical to provide a large part of the long distance plant in cables employing small gauge conductors which possess virtues so obvious that it is always desired to employ them to the fullest extent. Thus circuuts in cable are inherently more stable than open-wire pairs because they are shielded from rain, sleet and snow and are less liable to physical interruption and to inductive disturbances from paralleling electrical structures. They are particularly desirable where the density of traffic becomes large enough to require many circuits over a route since a cable may carry many times the circuits possible with any reasonable open-wire construction. One disadvantage of cable as compared to open-wire construction, is a much higher attenuation loss resulting from the facts (1) that the wires of each being close together, the distributed electrostatic capacity is large and (2) that the resistance of the small gauge conductors is high. Consequently, until a satisfactory repeater was available, every reasonable effort was made to keep the amount of cable on a long distance circuit to a minimum. To avoid cable, the original transcontinental line was routed so as to avoid cities and the necessary intermediate test stations were located in the outskirts of larger cities.

In 1915 when the vacuum tube repeater was being introduced, the cables used for long distance service employed a relatively small number of heavy wires and their use was limited to short distances between the larger cities along the Atlantic Seaboard. With improvements in the design of the electronic telephone repeater, long distances and a larger number of finer gauge wires within a cable sheath were made possible and the field of use of cable was consequently greatly extended. After the close of the war in 1918 a program looking to the provision of long distance service over the heavier traffic routes in cables containing small gauge conductors was undertaken. In 1921 the cable network along the Atlantic Coast was extended to Pittsburgh, in 1925 to Chicago, in 1926 to St. Louis, in 1931 to Omaha, in 1932 to Dallas, in 1935 to Atlanta. This expansion of cables operating

(*Continued on page* 162)

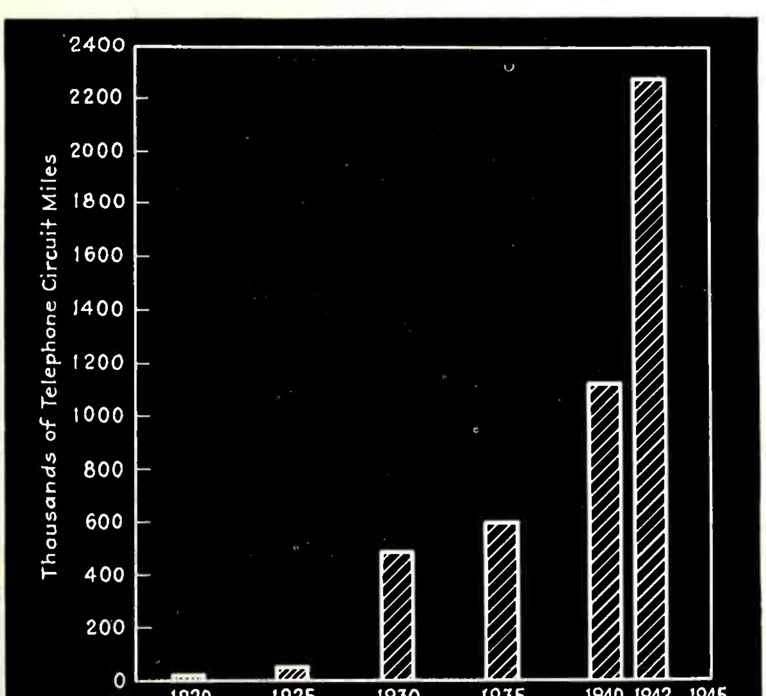
VOICE-FREQUENCY REPEATERS INSTALLED IN BELL SYSTEM

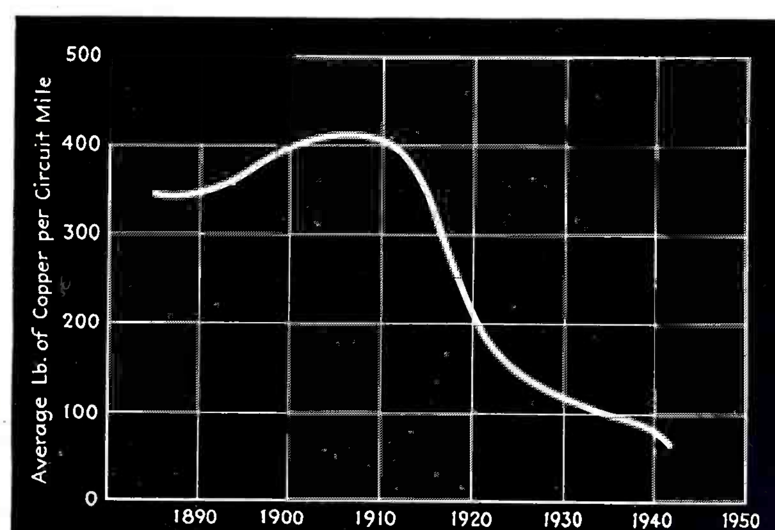
Year	*Total*
1908	16
1910	41
1915	136
1920	1,250
1925	7,500
1930	80,000
1935	102,000
1940	110,000
1942	123,000

Carrier Telephone Circuit Mileage

(Bell Telephone Systems)

Growth of circuit mileage using carrier telephone methods. Electronics provides the carrier frequencies, modulates them with voice frequency currents, removes the modulation at the receiver provides power for the tubes





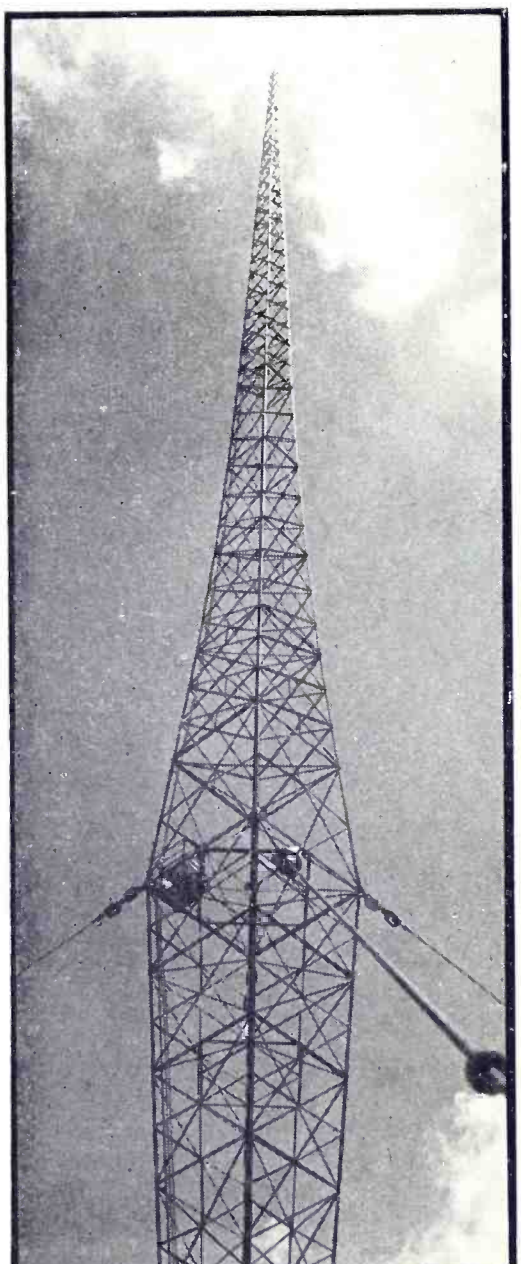
Copper in Long Distance Circuits

Electronics decreases the quantity of copper required for wire circuits. Had the 1915 rate of copper usage continued to the present and had the same growth continued, total copper used to the end of 1942 would have been 1,500 million pounds greater than actually used; equivalent to an entire year's output of United States copper mines in the 1930-40 decade

RADIO...

Out of the last war came practical wireless communication. The war in which we are now engaged is accelerating extension of service toward the higher frequencies. This will have profound influence upon many aspects of life in our time

By RALPH R. BEAL
Research Director
RCA Laboratories



OMEN—Radio antennas have always sought the sky. In these two photos are signs of the future. Present practice is to erect vast expensive antennas out in the country far from the center of population; the future trend will be to erect small, compact, inexpensive antennas on high buildings in the center of the area

THE foundations of radio's expansion in this war were laid during World War I. Then, radio was known only as a new and relatively undeveloped means of communication, employing the simple dots and dashes of code. Only one section of the radio wave spectrum, long waves, was available. The spark method of transmission, requiring vast amounts of electrical power, was inefficient and wasteful, according to modern standards.

But men of science, working under the pressure of war just as they are today, labored over development of the vacuum tube and of new electrical circuits. They studied radio wave propagation, so that new sections of the spectrum could be opened for use. In 1919, radio was ready for its first great expansion.

What was accomplished with radio in the two decades of peace that followed World War I is shown by what radio had to offer at the outbreak of World War II.

What Has Radio to Offer Today?

The United States is the center of highly efficient and flexible world-wide systems of international and marine point-to-point radio communication. The services of these systems, which early in the 1920's were shifted from long to short waves, included high-speed automatic radiotelegraphy, radiotelephony, radiophoto, radionavigation, or direction finding, and radio-safety.

Here, too, was the world's greatest application of radiotelephony to broadcasting as a means of mass communication. Some 55,000,000 radio receivers were in the homes of Americans, served by more than 900 radio stations scattered throughout the country. Linking the majority of these stations were four national broadcasting networks, providing outstanding services of entertainment, education, news and information.

Less apparent, but equally vital, were the domestic services of point-to-point radiotelegraphy and radiotelephony. These included commercial message traffic, commercial aviation, police and fire work, highway traffic control, forestry, and other interests requiring a high degree of communication.

...and its post-war prospects

FOREST SERVICE — All radio is not broadcasting entertainment or news or educational programs. Much use is made of modern "wireless" for communication between ships at sea, between airplane and land, in the police, forest, fire and other services where no other means of communication can serve as well

Just beginning was the new service of television, adding radio sight to broadcast sound. Regular television program schedules had been started in New York, and plans for similar services in many other large cities of the country were afoot. Manufacturers were ready to build and sell home television receivers to the public. Means of establishing inter-city television networks by either coaxial cable or radio relay systems had been developed.

Concurrent with the development of television was the opening of still another portion of the radio wave spectrum—ultra-short waves. This not only made room for the services of television, but also enabled the application of frequency modulation to sound broadcasting. Just beginning, also, was the broad development and application of radio-electronic principles to non-communication purposes, for example to industry and to research.

Behind all these services of radio was a vast industry, employing more than 500,000 persons and doing a yearly business in excess of $1,000,000,000.

Immediately after the Japanese attack on Pearl Harbor, the American radio industry began converting from peace to war production, accomplishing the job in a few months.

It was well they did. Fortunate, too, was the fact that American industry had developed and expanded radio to a point unequalled by any other nation; for modern warfare, especially when fought on a vast global scale such as this one is, requires a type of fast, flexible communication that only radio can supply.

War calls for stronger, sturdier, more dependable instruments than we use in peace-time, and it requires that we develop new devices and new services. We are meeting this demand today in our laboratories, our engineering workshops, and in our manufacturing plants.

War Accelerates Scientific Development

Until the war is won, much of what is being done must remain a military secret. It can be said, however, that under the force of urgent necessity, we are making rapid advances in the development of new electronic tubes and in the design of radio circuits. New areas of the

TWO YEARS OF FM

Broadcasting has always thrived on new ideas. What post-war radio may do for American industry may be gleaned from a two-year record of frequency modulation.

In two years, the number of stations grew from one to 45 regularly on the air, with a total of at least 125 signifying interest. Between 500,000 and 600,000 receivers were sold and placed in service. At present there are perhaps 40 million people who could be adequately covered with FM if the transmitters were available.

radio spectrum are being opened. Prior to Pearl Harbor, we had made a good start with ultra-short waves, measured in lengths of 10 meters or less, and were beginning to use microwaves of 40 to 60 centimeters in relay systems. It can be expected that research now being done will open for use wavelengths of 1 to 3 centimeters.

What Will Post-War Radio Offer?

What, then, can be expected of radio in the post-war period? It is impossible, especially at present, to be exact in predicting what is to come. On the other hand, some of the possibilities can be indicated in general terms.

Broadcasting. New methods and new radio-electronic devices will greatly improve the quality of reception on broadcast frequencies.

There should be greater use in broadcasting of ultra-short waves. Because of the nature of these frequencies, it is possible to use modulation methods and systems which not only improve the quality of reception, but also reduce atmospheric and other noise.

Greater use of the ultra-short waves through continued expansion of frequency modulation and television will bring about, in the years to come, some readjustment in sound broadcasting. Sound broadcasting, however, will retain considerable importance even after television is established on a wide scale.

In the field of international short-wave broadcasting, we may look forward to a much higher degree of technical perfection. The time is coming when this type of broadcasting will have a quality comparable to the best in domestic broadcasting. Improvements are coming in both short-wave transmitting and receiving instruments. Moreover, we are rapidly accumulating new knowledge of the "space circuit," or the behavior of radio waves in the atmosphere.

Television. One of the most fascinating prospects is offered by television. More sensitive cameras will be capable of operating indoors as well as out; images will be brighter, bigger and clearer; transmitters will be linked by intercity networks; three-dimensional and color television are well within the long-range view. I know of nothing that will give such a broad range of employment as the introduction of this new art on a wide scale.*

International Communication. As is the case with international short-wave broadcasting, transoceanic point-to-point radiotelegraphy will be greatly enhanced. Improved circuits and electronic devices, together with the increased knowledge of "space circuits," will heighten efficiency and quality.

We may expect an added number of transmitting channels to become available, especially for code. For one thing, there should be a more efficient use of the available frequencies. More channels of information will be put into a given frequency space. Better directional and "steerable" antennas will improve both voice and code transmissions. More sensitive receiving devices will permit the use of less power.

Methods for transmitting large quantities of information, such as facsimile, possibly will find application on the international circuits.

Multiplex transmissions, automatic and error-proof printers, and voice and code "scrambling" devices, which will improve the secrecy of radio circuits, should come into greater use.

Marine radio will benefit much in the same manner as international communications.

Domestic Communications. On the domestic scene, there is the possibility of radio relay networks being established to carry from

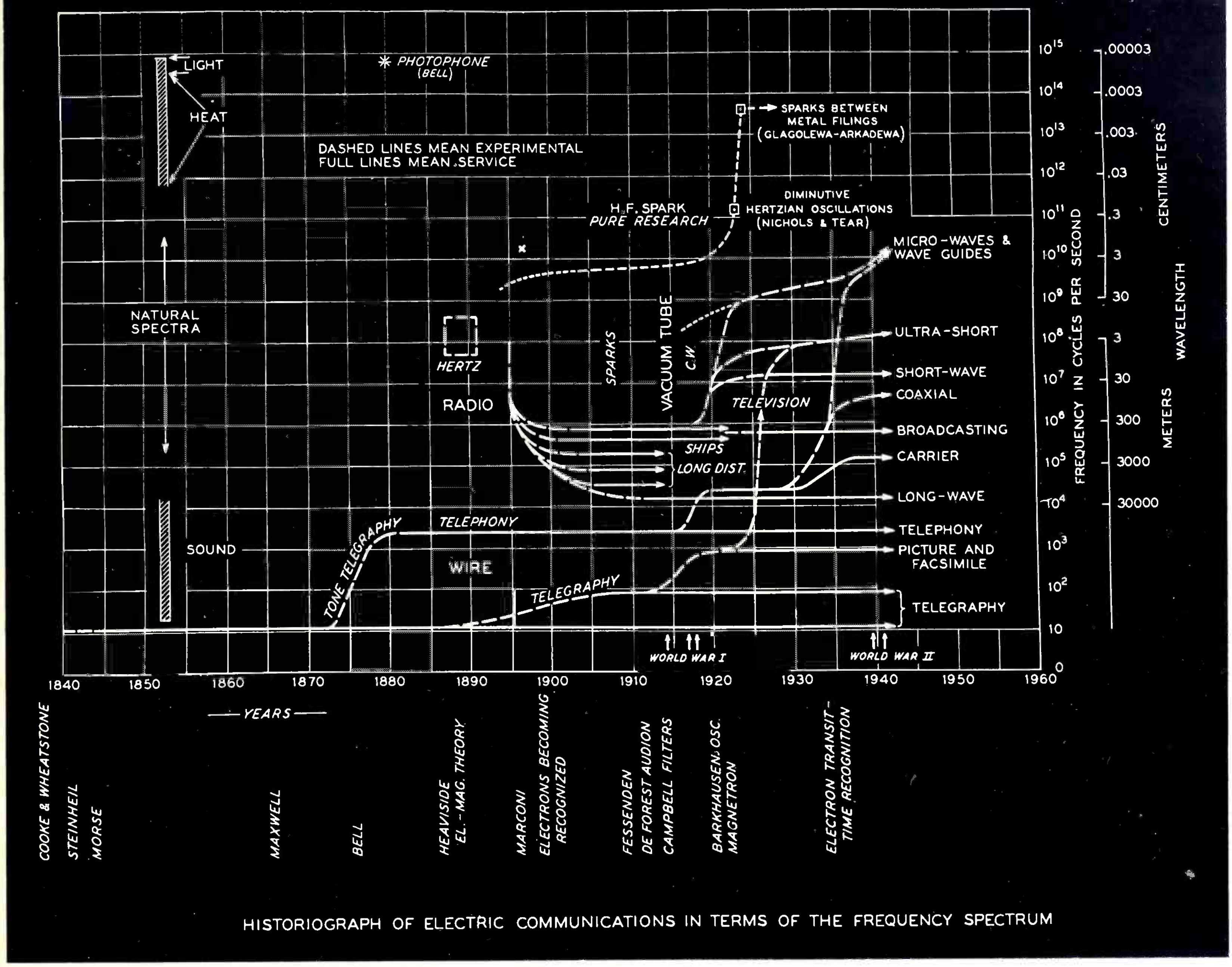
RADIO STATIONS IN THE UNITED STATES

June 30, 1941 ‡

Alaskan Service	
Fixed Public	321
Experimental	2
Special Emergency	6
Aviation	112
Coastal	159
Subtotal	600
Aviation	
Aeronautical	438
Aeronautical fixed	210
Aircraft	2,140
Airport	75
Flying School	25
Subtotal	2,888
Broadcast*	
Standard Broadcast	897
H-f Broadcast	69
Low-frequency Relay	229
High-frequency Relay	269
Developmental	8
Television	47
International	12
Facsimile	4
Studio Transmitter (S.T.)	4
Non-commercial Educational	5
Experimental	1
Subtotal	1,545
Coastal Service	
Marine Relay	37
Coastal Telegraph	52
Coastal Harbor	32
Coastal Telephone	4
Limited Gov't Service	3
Subtotal	128
Emergency Service	
Municipal Police	1,196
State Police	513
Zone Police	69
Interzone Police	30
Special Emergency	340
Forestry	807
Marine Fire	6
Subtotal	2,961
Experimental	
Class 1	216
Class 2	231
Class 3	1
Subtotal	448
Miscellaneous Service	
Geological	269
Motion Picture	12
Provisional	7
Mobile Press	4
Relay Press	7
Subtotal	299
Point-to-Point Telegraph	
Public	69
Press	3
Agriculture	7
Subtotal	79
Point-to-Point Telephone	
Public	15
Ship Service	5,214
Grand Total	14,177

*July 1, 1941. ‡FCC Seventh Annual Report to Congress, June 30, 1941.

* Editor's Note. Mr. Beal's survey on television has been shortened since his opinions parallel those of Mr. Shelby to be found in the section to follow.



Chronological extension of frequency bands for communication (Espenschied)

city to city the services of television, sound-broadcasting, high-speed facsimile, message printers, and other forms of communication in voice and of record. This development may occur in parallel with the growth of similar services by coaxial cable and by wave guides.

There should be an expansion of the use by aviation and the railroads of radio as an important aid to the movement and control of traffic. An example of a possible application in this line would be a "radio traffic chart," which would show, from moment to moment, the exact location of trains in motion on the ground or airplanes in the sky.

Aviation radio, already highly developed, will show vast improvement. Services of both voice and code communication will be more widely applied. Radio-electronic devices will aid navigation through the ability of a plane to locate itself automatically anywhere in flight. They will be used to guide and land planes blindly, and to avoid collisions in the air and on the ground. Television and television techniques will enable airplanes to "see" through fog.

In fact, we may expect radio to become, to an astounding degree, the "eyes," "voice," "ears," and "feelers," of all mobile craft.

A broad expansion of radio's services in the specialized fields of police and fire work, forestry and safety can be readily foreseen.

Studies of the space circuits traveled by radio signals, more sensitive receiving devices which require less transmitting power, ultrahigh frequencies and microwaves, radio facsimile and television—all should find extensive applications in the problems of community service.

Greater use of radio in the control of motor highway traffic seems probable. An outstanding example of this type of service is the ultra-high frequency radio system of control on the Pennsylvania Turnpike.

Television could be widely used in police, fire and forestry work, providing instantaneous visual communication where it is desirable.

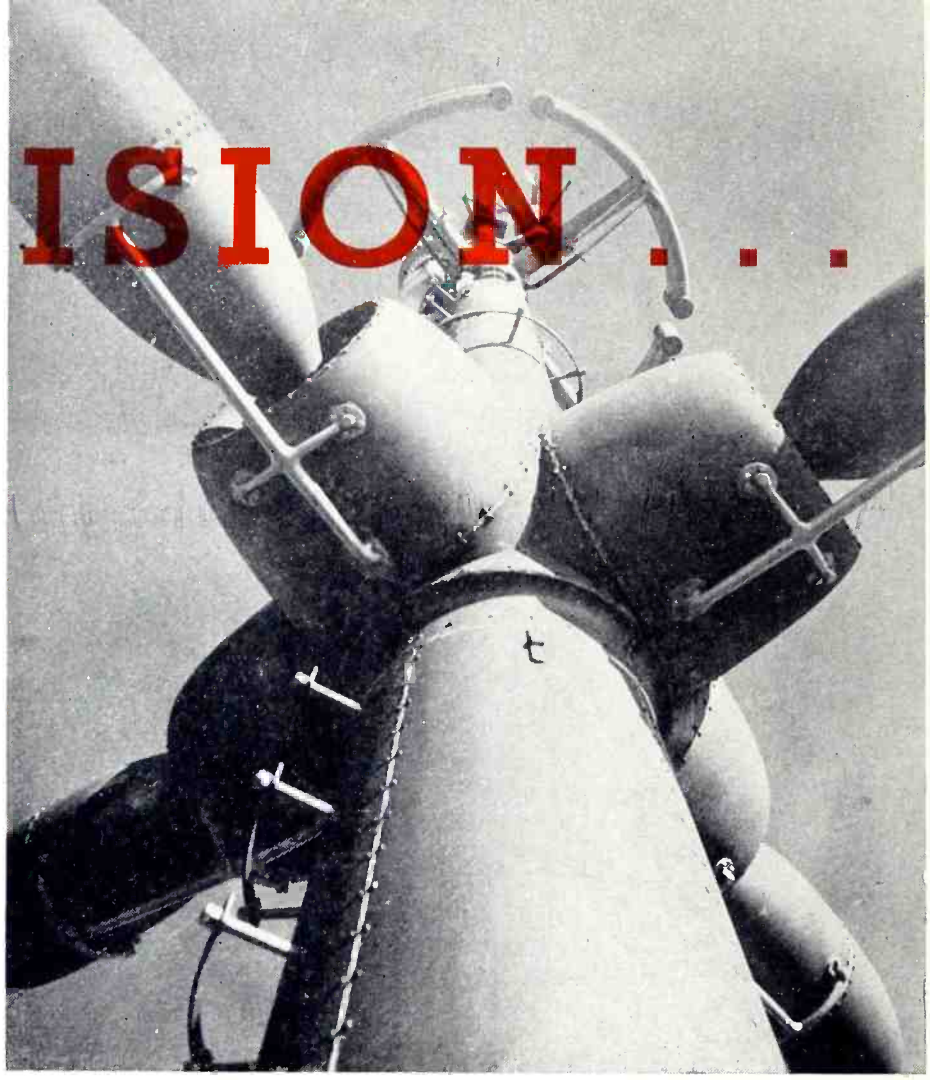
The Micro-wave Region

Further development of radio in the micro-wave field will make available some services which now seem fantastic. These would include the possibility of a motorist, while traveling on a highway, dialing a telephone number and talking to home or office without stopping his car. Passengers on moving trains might have the same advantage. In the more distant future, enough wavelengths may be available to permit pedestrians to carry personal radiotelephones. It is probable that such services as these would tie into the regular wire-line systems through special radio stations located at intervals along streets and highways.

Non-communication Applications. In recent years, many of the principles of radio-electronics have been applied to fields other than communications. Radio tubes have been

(*Continued on page* 176)

TELEVISION . . .



ANTENNA—Looking toward the top of the television antenna on the Empire State Building, New York City. The peculiar shape of these antenna elements arises from two desires—to transmit a wide band and to concentrate radiation in the horizontal plane

By ROBERT E. SHELBY

Development Engineer, National Broadcasting Company

THE scientific concepts of television are not new as judged in relation to the pace of modern engineering developments, but it has been only within the last 15 years that rapid progress in the field of electronics has made possible the development of a television system adequate for a commercial service. During this period the electronics art and the television art have been extensively interlocked, many electronic developments having resulted directly or indirectly from the search for better television. Modern television is electronic television, and the electronics art in turn owes much to television.

The television principle of breaking a picture up into elementary areas and transmitting the information in sequence to a distant point where the scene is re-assembled, was suggested in 1884 by Nipkow.

This operation is necessary because the electrical circuits and the radio channel associated with the television system are incapable of transmitting at once all of the information contained in the usual scene. Instead, this information is sent for one elementary area at a time, the scanning rate being made high enough so that many complete pictures are transmitted in a second (30 per second is standard), and the eye, due to the phenomenon of persistence of vision, sees a complete picture on the reproducing screen in spite of the fact that only an elementary area is actually being presented at any given instant.

Early Television Depended Upon Mechanics

The first method utilized to achieve this picture analysis and synthesis involved the use of a mechanically rotated scanning disc, consisting of a circular sheet of metal with a series of spirally located holes near the edge of the disc. It operated by causing a small spot of light to fall in sequence on each elementary area of scene being televised. The light reflected from each area was gathered by one or more photocells. Then, as each unit area of the subject scene was illuminated in order, the output of the photocell varied to control or modulate a light source at a receiving point. Since the light source at the receiver varied in accordance with the variations in reflected light from the scene being televised, it was then only necessary to provide a similar scanning disc at the receiving point running in synchronism with the disc at the pickup point and the original picture would be reproduced.

This mechanically operated scanning system had fundamental limitations and disadvantages. To give high definition in the reproduced picture, the scanning discs became prohibitively large. To provide a high repetition rate for the complete picture in order to allow smooth motion in the reproduced scene and eliminate visible flicker, the peripheral speed of the scanning discs had to be unreasonably high. Synchronizing was a problem, as was the noise of the large rotating disc.

Electronic Scanning Overcomes Inertia of Mechanical Systems

The limitations of a mechanical television system were soon recognized and experimenters cast about for some scanning device possessing lower inertia which would permit the desired higher rates of scanning. It was inevitable that their attention would turn to a consideration of the possible use of the electron—smallest particle of matter, possessing an inertia even at high velocity which is negligible in relation to television scanning requirements. An electronic device for use on the receiving end was already available in a crude form. This was the Braun tube, consisting of an evacuated envelope, a fluorescent screen and a set of electrodes to direct a stream of electrons (cathode-ray) against the fluorescent screen.

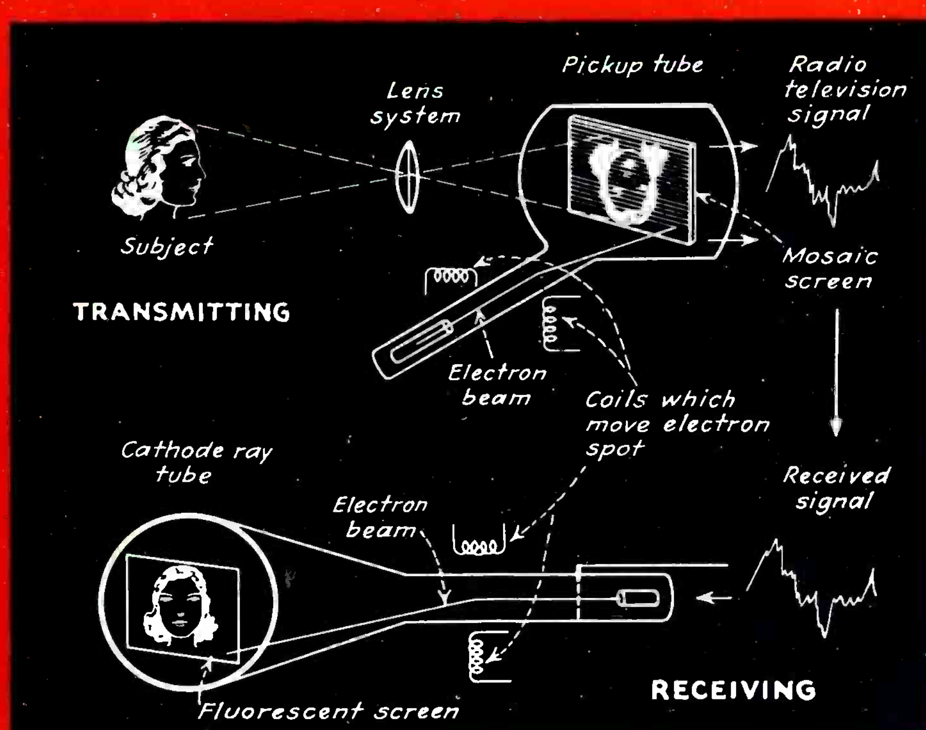
Far-seeing Eye of the Future

On July 1, 1941, television became a commercial broadcasting service in this country after many vicissitudes. Except in a few outstanding laboratories and studios, however, television has since become another casualty of the war. All this will change the day peace comes

The modern television kinescope is, however, a highly refined version of the early Braun tube, special features having been added to provide sharp focus of the cathode ray (i.e., small scanning spot), high light output, white light from the screen. The extended research work from which these refinements were evolved contributed much to the electronics art. For example, development of the field of electron optics, which today rivals in importance the much older one of light optics, received its greatest impetus from the search for a sharply-focussed high-intensity beam of electrons for television scanning devices.

The situation with respect to an all-electronic pick-up device for television was very different from that for the reproducer. No device was known in the previous art which would reverse the process of the Braun tube. This very fact, however, served to stimulate the imaginations of early workers in the field and it is interesting to note that as long ago as 1911, A. A. Campbell-Swinton in England proposed a method for obtaining all-electronic television pick-up. In many respects his proposal visualized present day systems although it lacked the important factor of storage of the electric charge between successive scannings—the principle that would give the all-electronic pick-up device the sensitivity to make it practical with high definition scanning. This early proposal of an all-electronic television pick-up device was not reduced to practice. Further development was necessary before necessary electronic tools and techniques were available for all-electronic television.

In 1923, V. K. Zworykin applied for patents on his Iconoscope—a cathode-ray television camera tube having inherently greater sensitivity than any previously proposed by virtue of its property of accumulating, over relatively long periods of time, the electric charges resulting from photo-electric emission. The Iconoscope or modifications of it are now used in a majority of all modern television cameras. It consists essentially of a mosaic (light-sensitive plate) and an electron gun, assembled in a highly evacuated glass envelop. The gun is an electron-optical system serving to produce a fine stream of electrons (cathode-ray) which is made to scan the sensitive surface of the mosaic by means of suitably varying magnetic fields produced by coils placed around the



How Electronic Television Works

An image of the subject is focussed through an optical lens upon a special screen inside a television pickup tube. On the surface of this screen are millions of tiny photocells, each producing an electric charge according to the light or shadow existing in the portion of the image focussed upon it. An electron "spot" is swept over this screen, back and forth, up and down, neutralizing the charges produced by the image. The difference in these electrical charges makes up the television signal transmitted to the receiver where another electronic device, the cathode-ray tube, recreates the original image on a fluorescent screen

Military Communications . . .

By Lt. Col. C. J. McINTYRE

Headquarters, Services of Supply, Office of the Chief Signal Officer, U. S. Army Signal Corps

COORDINATION—Tanks on the ground and planes in the air are in constant radio contact with each other and with headquarters

It is difficult to imagine military operations across the vast global distances of the present war being carried out, or even adequately planned, without the facilities of instantaneous communication made possible by the electron tube and all the radio apparatus that has been built upon and around it. The Signal Corps, the agency of the Army which procures all communication apparatus and coordinates its tactical use, is ever conscious of the significant contribution of electronic science to the tools which are used in modern war.

Communications have always been a matter of prime concern to the military commander. The factors which distinguish modern war from the campaigns recorded in history are greatly multiplied fire-power, armor, mobility and communications. All military leaders from the most ancient times until a century ago had to rely for communication on couriers afoot or mounted and on such visual signals as beacon fires and flags. Napoleon improved upon the visual signal system by employing Galileo's invention, the telescope, in a chain of semaphore stations to form what was then known as a "telegraph." It remained for the American Civil War, in which the Signal Corps had its baptism of fire, for the electric telegraph to prove itself in a major role as an instrument of military communication. The pioneering discoveries and inventions in electricity were made in the nineteenth century, and they gave us telegraphy and telephony. The great discoveries in electronics in the twentieth century have given us the art of radio communication. This had its military try-out in the first World War and has affected in many ways the strategic and tactical maneuvers which are being used in the present conflict.

Radio plays a crucial role in coordinating our operations in this

DIRECTION—Nerve centers of operations are headquarters set-ups such as this protected from bombs yet with electronic fingers on every pulse

. their part in GLOBAL WAR

The contributions of electronics to our war effort have been many. Without some of them, it is difficult to see how current gigantic operations could be planned and executed at all. Tubes, too, are proving themselves indispensable for non-communications purposes

global war at every stage of the way, from the powerful fixed transmitters of the War Department Signal Center in Washington to the man on the front line reporting the effects of artillery fire over his back-transported walkie-talkie, and to the bomber winging hundreds of miles beyond the enemy's lines. At every stage of the way, armies of electrons pulsating between cathodes and anodes of evacuated tubes, setting up magnetic fields in coils and electric fields in the dielectric of capacitors, serve to speed onward vital messages of military importance to the men waiting upon them for the signal to action.

Army Signal Service Appropriations by Congress

Fiscal Years Ended June 30	
1930	$ 8,224,900
1940	18,236,616
1941	170,875,362
1942	3,723,604,696
1943*	2,617,506,025

*Exclusive of supplemental appropriations

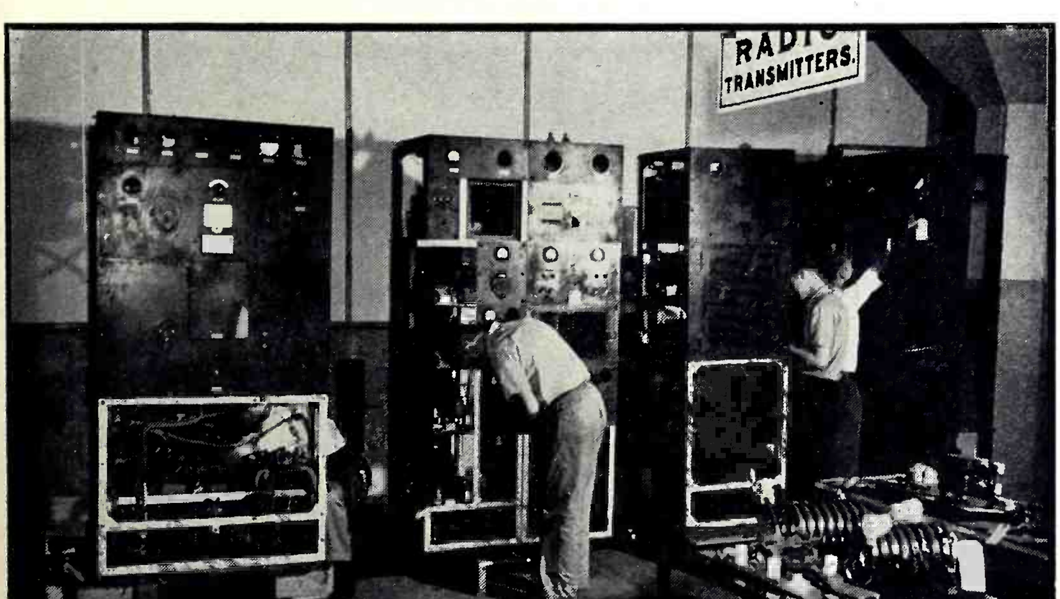
The above figures cover, of course, much more than purchases of electronic gear, including the training and clothing and housing of a number of Signal Corps troops larger than the entire United States Army in 1939. The Signal Corps is, however, procuring radio and electronic equipment for the Army alone at a rate greater than the entire production of the industry for all purposes in peacetime years

Signal Center, War Department's Hub of Communication Network

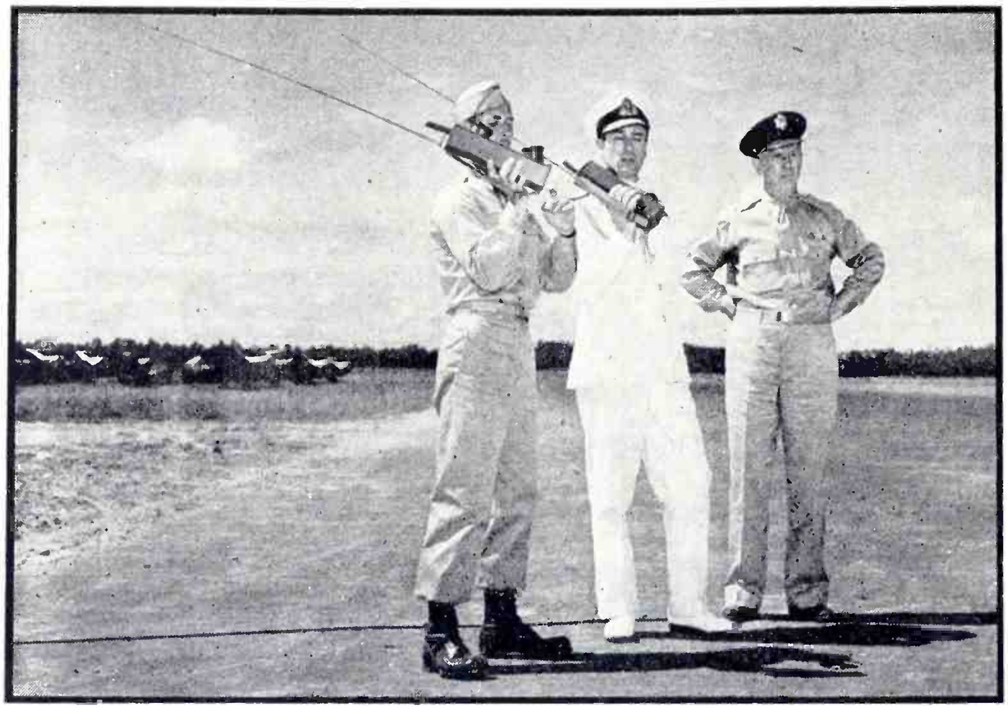
The focal point for all communications between the War Department and its task forces in all continents is the War Department Signal Center in Washington. By means of numerous radio networks, messages are sent to and received from all major domestic installations of the Army and the headquarters of all overseas commands.

The War Department Signal Center provides for communication by both wire and radio. The radio section is known as Station WAR, although actually it consists of a number of stations operating on different frequencies and directionally beamed to different parts of the world. Among the distinguishing features of the War Department Signal Center is the high degree of flexibility in the interconnection of equipment to different circuits and the extensive use of high-speed automatic transmitting equipment, not only for wire communication but also for radio communication. This makes it possible to carry a greatly increased volume of traffic for a given number of wires or radio channels.

If we follow a directionally beamed radio wave from the War Department Signal Center to a particular theater of operations, we would find that the distant station on the main War Department radio



MAINTENANCE—Signal Corps men with thorough training keep equipment in repair, in the field at centralized bases



MOBILITY—"Walkie-Talkies" of many types are used by the Army, Airforce and Navy. Here a paratroop Major demonstrates to British Commando chief Lord Mountbatten while our own General George C. Marshall looks on

net becomes in turn the control station of another net which serves the needs of the commanding general of that theater. Whenever a unit or combat team goes into action, smaller radio networks are set up, linking the radio transmitters and receivers housed within its vehicles, in its aircraft and at its stationary command posts.

The Army uses the term "net" in preference to the broadcasting terminology "network." The radio net for tactical purposes consists of two or more transmitters and receivers. A single net may include sets both on the air and on the ground, both stationary and in motion. Usually each net has a net control station which is in turn a secondary station in a larger net serving the next higher unit of the Army. Tactical radio nets vary greatly in accordance with their purpose.

An interesting feature of a tactical radio net, from the standpoint of the engineer, is that the traffic load actually carried may be quite small compared with its message-carrying capacity. This results from the military consideration that the best operated field radio net is usually the one which is least overheard by the enemy intelligence. The value of a radio set in an area of active operations is measured not by the number or length of the messages sent over it, but rather by the importance of those messages which are sent. A single message—an order from a command post, a report from a forward observer—may often mean the difference between success and failure of a skirmish, a battle, or a campaign. This means that the Army, by comparison with commercial communications networks, has had to put an enormous capital investment into its communications system. Every communications line must be duplicated, if possible, both by wire and by radio, for there must always be, regardless of possible destruction of equipment by enemy action, an alternative method of getting the message through.

Communications for Mobile Forces

The most spectacular use of radio communication in active combat occurs in the Air Forces and in the Armored Force. There are quite a few similarities, as far as communications are concerned, between the operation of bombers and fighters in the air and the operation of tanks and tank-destroyers on the ground. In both cases the vehicles have cut loose entirely from wire communication and must depend exclusively (except for short range visual signals) on their radio sets. In both cases, the noise conditions are such that members of the same crew talk to each other by means of an electrical interphone system. Every combat tank and airplane, therefore, is equipped with two or more complete communication sets, in which electronic tubes play an important part.

Because of the speed and stress at which men must carry on their duties in airplanes and tanks, their radio equipment must be of such a design that it can be worked with the utmost ease and simplicity. The newest tank radio sets are designed to eliminate the twisting of dials. Their channels, crystal-controlled, are pre-set and are selected by simply pushing a button.

Great pains must be taken in advance to guard against the effects of all types of interference—the impairment of reception by atmospherics, by unwanted signals and by the effects of electrical apparatus or machinery. To take fullest advantage of the most recent developments of electronic science in reducing the effects of interference, frequency-modulation has been adopted for use in tanks, tank destroyers and the Field Artillery.

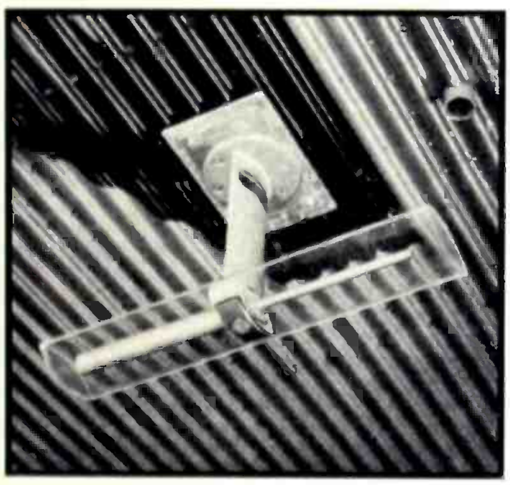
A complete radio system was put into effect during 1942 for tanks and tank destroyers, permitting short-range communication between tank commanders and the individual tanks under their control. Each tank is equipped with two-way shortwave radio, frequency-modulated and crystal-controlled. The tank carrying the commander of a tactical unit will have two complete radio systems, over one of which he communicates with the men under his command, while the other serves him for communication with the commander of the next higher echelon. Thus, the principal and subordinate radio nets are interlinked to provide continuity in the flow of orders and information even during the heat of a mechanized encounter. The radio system for the armored force includes smaller sets for reconnaissance use which can operate on the same frequency with those in the tanks.

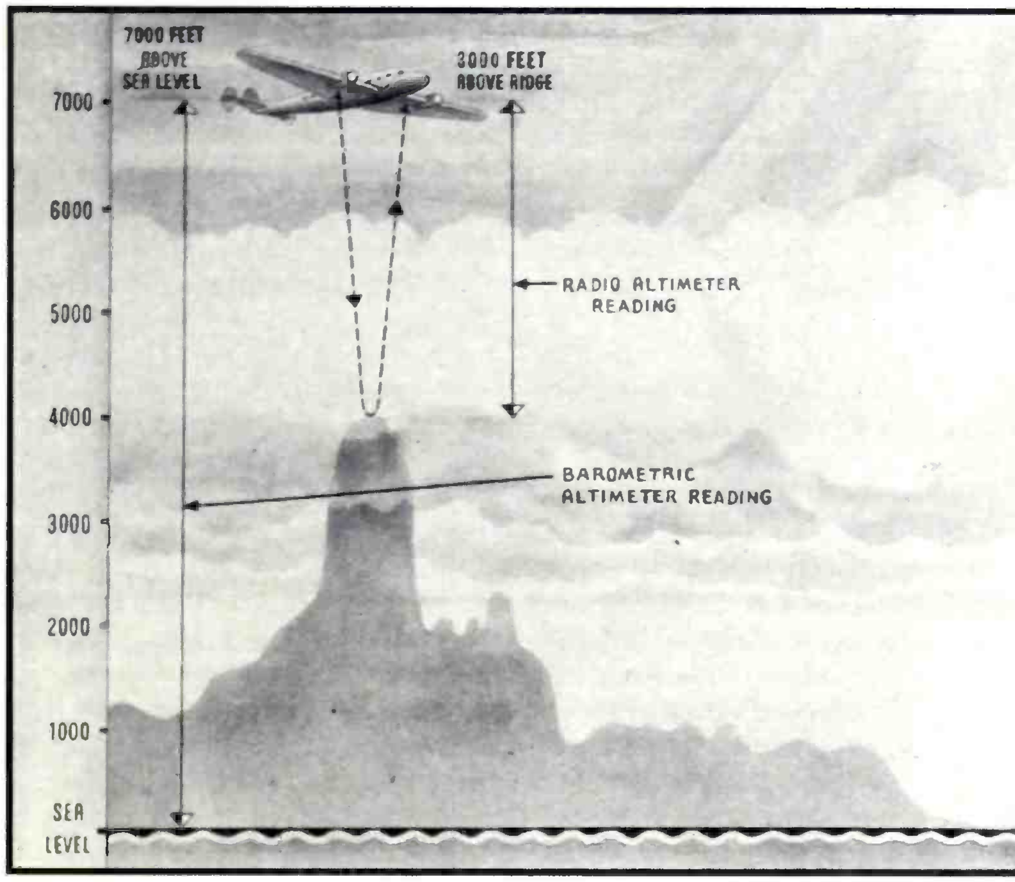
A similar system has been set up for the Field Artillery. The sets operate with frequency modulation on high-frequency channels which, again, are accurately calibrated by crystal control. Some of the sets

(*Continued on page* 180)

AVIGATION AIDS . . .

promote flying safety





ABSOLUTE ALTIMETER—Old height indicators operated by barometric pressure merely showed altitude above sea level. New ones, operated by radio signals transmitted from and reflected back to the aircraft, show altitude above terrain. The small photo shows a typical Western Electric absolute altimeter antenna installed beneath a wing

BY LT. Col. P. C. SANDRETTO

U. S. Army Air Corps

WITH the development of simple directional antenna systems and the Bellini-Tosi goniometer, direction-finding systems were developed and applied to ships. Previous to the advent of these direction finders, boats navigated by the use of magnetic compasses and celestial methods. While it appears that the addition of a third method of navigation to the two previously employed should have been enthusiastically received by mariners, such was not always the case. The masters of the ships were not familiar with radio (or wireless as it was known in the early days) and, therefore, did not trust the bearings given by the radio equipment.

Because of the low sensitivity of the receiving equipment available at the time of installation of the first direction finders, the necessary range for the bearing-taking systems could best be obtained by the use of very large antennas. Such antennas could conveniently be installed only on shore.

Strange as it may seem to those familiar with radio, the use of shore installations was one of the factors that contributed largely to the unpopularity of radio navigation on boats. The captains argued, "How can people located at great distances from the boats know the location more accurately than the men on the boats?" This misunderstanding, together with the occasional poor bearings caused by the phenomenon, then not understood, of night effect, prevented confidence from being built up in radio navigation systems by the captains.

Vessels traveling at their usual slow speeds seldom have instant need for making positional determinations when on the high seas; thus it was not *absolutely* necessary that this navigational system be adopted by ships. The installation of direction finders on shipboard which allowed bearings to be taken quickly when the ships were near shore, under fog conditions, and in danger of going aground served to reverse the previous opinion of direction finding by the ships' masters, and radio navigation has since been a highly valued facility on every ship.

Aviation Added a Third Dimension

The advent of aviation brought forth a conveyance for traveling in a medium as unmarked as the sea, which added a third commonly traveled dimension. Further, the new conveyance travels at speeds greatly in excess of those maintained by ships at sea, and it was not possible to stop while the location was being determined. Motion at all times had to be continued. Therefore, without exaggeration it can be said that the growth of aviation, and particularly air transportation, was made possible only by the development of radio avigational facilities.

Shortly after the last war, when commercial aviation service was inaugurated in Europe, the airplanes used were of the cabin type, seating more than one person; therefore, the method of avigation adopted followed shipboard practice. A radio operator was employed; he released a long, trailing wire antenna and used long waves to ask a ground station for a bearing. The ground station took the bearing on the airplane's transmission and reported back to the operator.

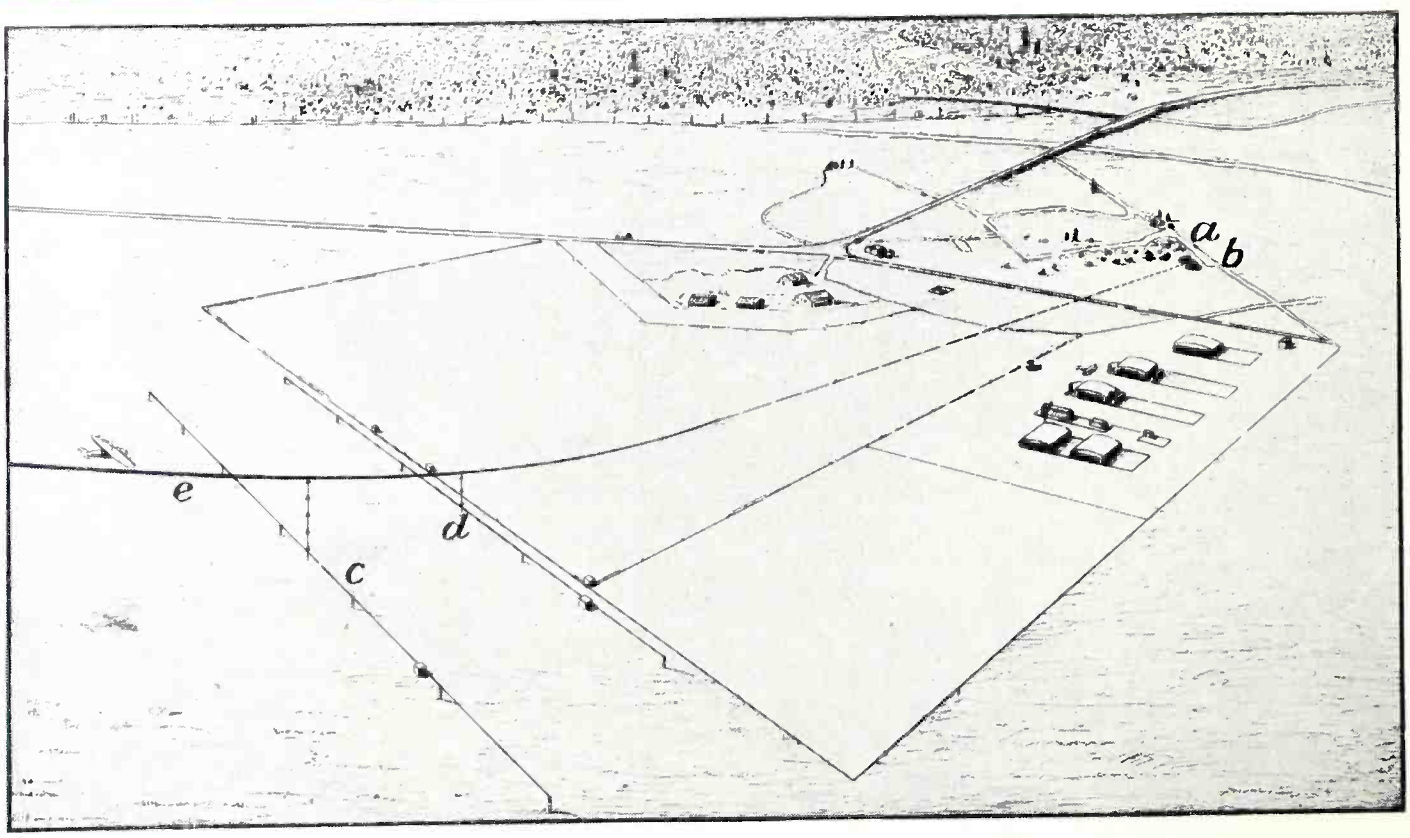
In the United States, however, the airplanes placed into use were of the single-seat type and intended mainly for carrying mail. In this type of airplane one pilot had to fly the airplane and do his own avigating; therefore, a more rapid and more nearly automatic avigation method was required. Such a method was devised by the United States Army and the Bureau of Standards in about 1927. This system consisted of a means for establishing in space a narrow radio beam. By means of a lightweight receiver, the pilot could follow this narrow radio beam to his destination. This system, then, was in fact a radio road which the pilot followed as he would a road on the ground; however, he used his ears rather than his eyes.

To employ radio waves with the most stable propagation characteristics known to the art, the long waves were used. Since it is difficult to obtain a sharp radio beam with long waves, the radio road was established by alternately making transmissions in two directions at right angles to each other. The directions actually followed were those where the signal strengths from the two directional beams were equal. By the use of this method, the radio road laid out had a width of approximately three degrees.

Considerable development of these radio roads has occurred since the initial work in 1927. The purpose of these developments was to secure freedom from certain effects, such as night error caused by transmission via the Heaviside layer, the addition of simultaneous voice transmission, etc. The United States Government maintains a chain of over 200 stations in the continental United States, operating in the band of from 200 to 400 kilocycles. The radio beams are shifted and bent to form connected airways which link together the principal cities throughout the entire United States.

Application of Ultrahigh Frequencies

Just before the outbreak of the present war, extensive development was undertaken by the Civil Aeronautics Administration and an experimental airway was established with a radio range system employing ultrahigh-frequency transmitters. The development decided upon for installation throughout the United States but which, of course, cannot be installed under the present conditions, presented in many respects a novel facility. This consisted of a radio range producing in effect a single beam which indicated on a visual meter. The pilot could tell whether he was to the right or to the left of this radio beam by noticing whether the needle on a meter indicated to the right or to the left. In addition, the pilot of an airplane could tell whether he was approaching the station or had al-

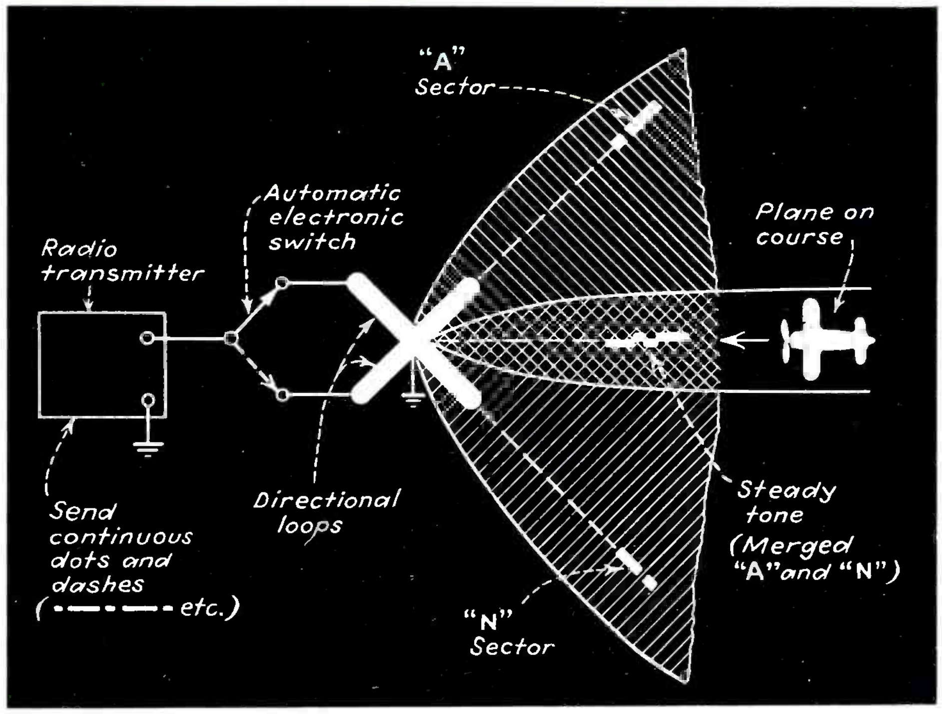


BLIND LANDING—After aural radio ranges guide aircraft to airports there is still the problem of getting down safely in bad weather. One method involves (a) a runway localizing beacon which sends up what might be called a vertical radio "wall" which lines approaching ships up on the runway, (b) a horizontal radio beam leaving the ground at a gentle angle, (c) an aproach marker radio signal and a similar boundary marker signal. Instruments operated by these beams guide the plane to earth over glide-path (e) ready passed it by listening to an audible signal in his headphones.

The output of a radio receiver intended to receive these ultrahigh-frequency signals can be connected to the airplane's automatic pilot and, thus, automatically guide the airplane along the new type airway. The freedom from static which is enjoyed by the ultrahigh-frequency waves should provide an extremely excellent avigational facility for the after-the-war commercial transport.

It is often necessary for a pilot to leave an airway road in order to skirt a thunderstorm or to maneuver while waiting for permission to land. Therefore, it was realized that a direction finder on the airplane would be very valuable. Since the transmitters for the long-wave radio ranges were already installed on the ground, the aircraft direction finders were designed to operate from these facilities.

The first direction finders were manually-operated devices and, while they were of some help to the pilots, the necessity for turning a crank to operate them was an obvious disadvantage. The automatic aircraft direction finder with a needle which pointed to the radio stations on ground was placed in use in about 1938 and was greeted with great enthusiasm by the flyers. With this device it is necessary only to tune the receiver to the desired station; the needle on the dial then points to the station, and bearings are read directly. These direction finders employ a small loop about 10 inches in diameter protruding from the airplane. The total weight of equipment is rather heavy (about 65 lbs), but the facility provided by this device is considered to outweigh this disadvantage. With such an instrument it is possible to fly anywhere in the United States without reference to the established airways.



RADIO ROAD

Elementary explanation of aural radio range: Transmitter sends continuous succession of dots and dashes. Automatic electronic switch is timed so that dot-dash sequences forming code letter "A" go to one directional loop while dash-dot sequences forming code letter "N" go to other directional loop. Pilot approaching on proper course, in sector where signals from both loops overlap, hears steady tone due to merger of "A" and "N". Divergence from course causes one letter or the other to predominate

Direction Finders on Ground

Because the lower frequencies had been allocated for use by radio ranges, they could not be used for transmission on the airplanes. The medium-high frequencies were more suitable for communication but were not eminently satisfactory for direction finding. Only comparatively recently did direction finders for ionosphere-propagated waves become commercially available for use on the ground for taking bearings on the transmission from airplanes. The question naturally arises as to the necessity of taking bearings on airplanes from the ground when all of the other facilities are available to the airplane. The reason lies in the trend toward giving the men on the ground greater control of the flights. There have been several instances in the past when assistance from the ground helped to avert accidents. The Civil Aeronautics Administration made several experimental installations of these direction finders and some of the airlines had plans for several installations. Plans have been suggested for a nationwide network to be Government installed and operated; however, these plans have all been held in abeyance for the duration.

While the radio range provides a road, it can be readily understood that it is necessary to provide some means of identifying the positions along the road. When the radio range was planned it was intended chiefly as an aid under conditions of low visability but not necessarily as a means for allowing flights to be made when low ceilings were present at the terminals, necessitating letting down through the overcast. No effort was made to provide adequate markers. A phenomenon associated with the long-wave radio range was present, which provided a means for identifying the location of the radio range. This was due to the coupling between the range antenna on the ground and the range receiving antenna on the airplane. When the airplane is directly over the transmitting antenna there is a momentary cessation of signals. The position of the airplane where these indications are received serves as a reference point which the pilot can use for calculating his further maneuvers. This indication has not been entirely satisfactory for several reasons. The momentary loss of signal caused by failure of the transmitter or receiver, or any associated equipment, serves to give the same "cone-of-silence" indication. Also, since the indication is a function of the antenna coupling, there are likely to be large variations in the exact location of the "cone."

A definite marker was established in 1938 by the installation of a new and independent facility. This new

(*Continued on page* 192)

FACSIMILE . . .

Facsimile, older than the electron tube, now becomes a practical means of rapid and inexpensive communication due to electronics. Ultimately facsimile machines in bus, railroad and plane terminals, office buildings, and drug stores, may replace the branch telegraph office

By J. H. HACKENBERG

Engineering Department
Western Union Telegraph Company

It may seem paradoxical, but the art of facsimile telegraphy, which owes so much to electronics, was well developed years before the vacuum tube made its appearance. That is to say, the fundamental principles were well understood, a great number of scanning and reproducing methods had been developed, and systems of facsimile transmission were in actual operation. There were, however, two great stumbling blocks in the path of progress in the art which at that time prevented any widespread commercial use of facsimile telegraphy. These were the necessity for special preparation of the subject copy and the lack of suitable means of amplifying the signals so that they could be transmitted over appreciable distances. The photoelectric cell has since made it possible to scan satisfactorily almost any kind of subject copy without special preparation. The vacuum tube amplifier has made it possible to transmit these signals over great distances. Thus, electronics has made possible the commercial use of facsimile telegraphy which otherwise would still be the fascinating toy it was 50 years ago.

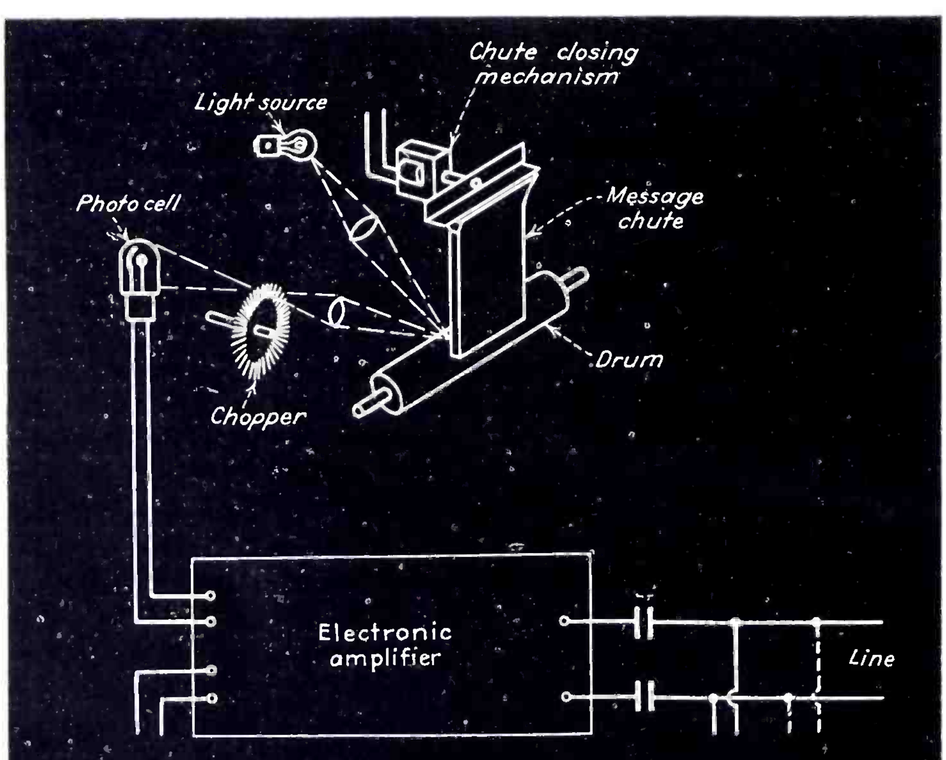
Even after the advent of the vacuum tube and the photoelectric cell, facsimile telegraphy was for some time more or less confined to one field, namely the transmission of photographs for news gathering agencies. This was dictated by the high cost of the photographic recording methods customarily employed and the individual attention required for each transmission. It was apparent that any extended use of facsimile telegraphy for the handling of telegrams would have to await the development of a simpler, cheaper and faster method of recording, as well as simplified and more nearly automatic transmitting and recording equipment.

Within the last ten years, great strides have been made towards the solution of both of these problems. The Western Union Telegraph Company has developed a record sheet known as Teledeltos which is fast, inexpensive and easy to use. It is dry, permanent and requires no processing of any kind before, during or after recording. It is light grey in color and recording appears black where a current (applied by means of a stylus riding on the surface) passes through the sheet. Either alternating or direct current may be used for recording, and individual pulses as short as 1/10,000 second duration are easily recorded. It has a fairly good half-tone characteristic, although the contrast is not as good as with photographic film due to the grey background. This paper is now being employed in all kinds of recording instruments where a simple, inexpensive record sheet is desired.

Western Union has developed for the use of its patrons a combination transmitter-recorder, the size of a teleprinter which requires no more than the wrapping of a blank around its drum and the throwing of a switch to send or receive a telegram. These machines are used to handle telegrams between a patron and the Telegraph Company's main office where the patrons' circuits terminate in an automatic concentrator at the main office. They may also be used between two patrons or between a patron's home office and his branch, etc.

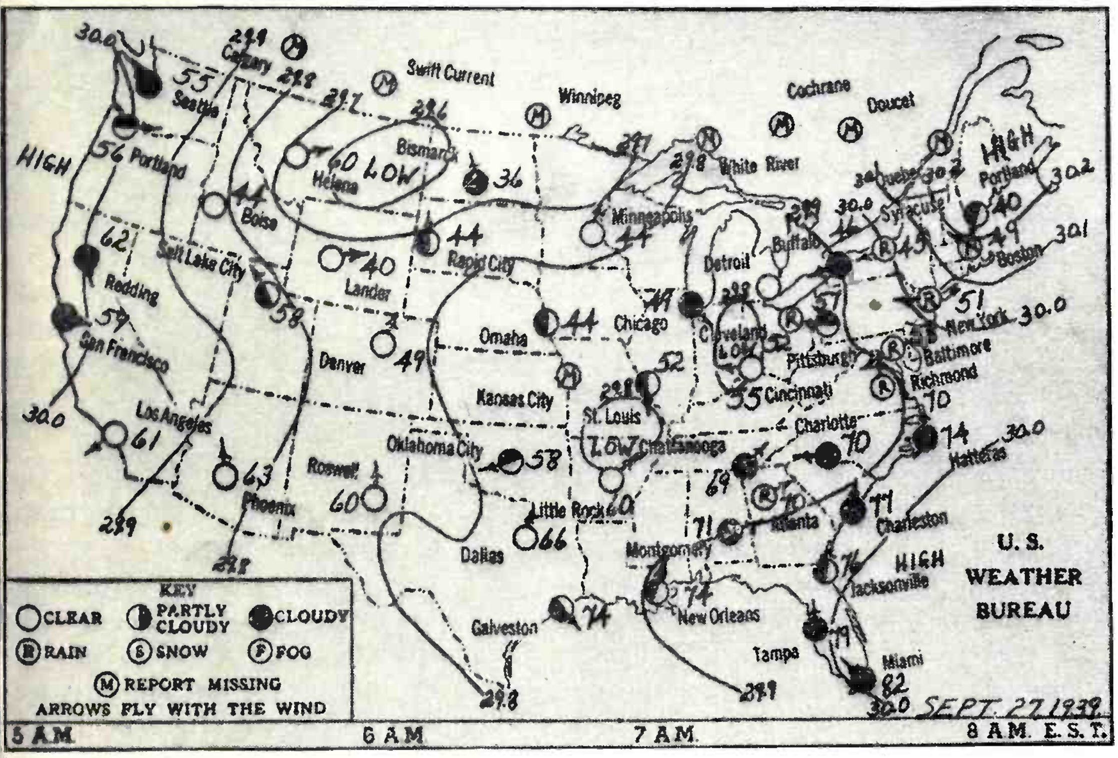
Transmitters and recorders are in

Automatic Transmitter



AUTOMATIC—How facsimile machine aids customer to get his telegram "in the works." He places his written message in a machine which wraps it around a cylinder, where it is scanned by a beam of light, a phototube transmitting to the central office the variations in light and dark of the original telegram

...OLD in Principle NEW in Practice

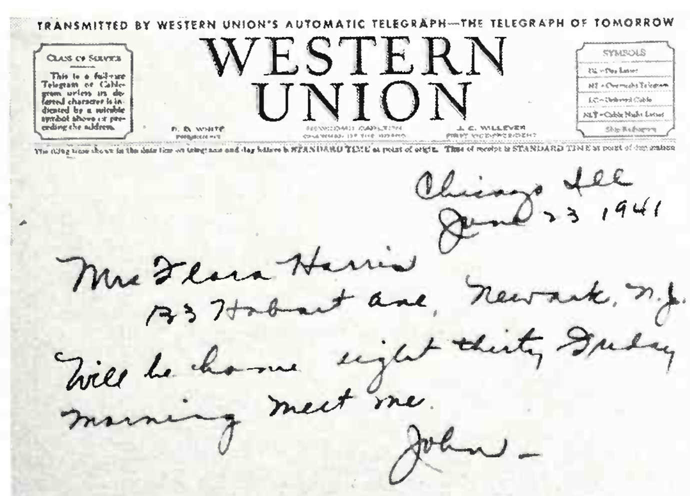


use on both trunk circuits and branch office circuits which employ a hopper of drums which feed in and out of the machines automatically as fast as the telegrams are scanned and recorded. The attendants at each end of the circuit simply keep the drums loaded with the messages to be transmitted and the recording blanks.

A Facsimile Machine Anybody Can Operate

A transmitter has been developed and has been in quantity use for some time which is as easy to operate as a mail box. The patron simply pushes a button and drops his telegram into a slot in the front of the machine. The telegram wraps itself around a drum, is scanned automatically and discharged into a receptacle in the bottom of the transmitter. Recorders have been in use for several years which employ a roll of Teledeltos, the recorded message being automatically cut from the roll and deposited into a receptacle. Another recorder has been developed which employs a roll of cut blanks which are automatically fed onto the recorder drum as needed, and stripped from it after recording and deposited into a receptacle in the front of the machine.

MAP—Application of facsimile to weather map transmission



FACSIMILE—Typical telegram in *exactly* the same form as it was written out in the telegraph branch office—not as a stunt or primarily to aid the customer, but as an actual aid to speedy pickup and transmission of message traffic

All of this automatic telegraph equipment employs Teledeltos as the recording medium. In some special cases other methods are employed as, for example, in the transmission of news pictures over submarine cable where, due to the high fidelity required, photographic recording is used. Another method, percussion recording, is employed where multiple copies are required. This is available on trunk circuits. Wax stencils or hectograph master carbons are produced from which multiple copies are made. This type of recording has been incorporated in a business machine produced by Western Union known as Multifax. This machine combines a facsimile transmitter and percussion-type recorder and produces wax stencils or hectograph master carbons of printed, typed, handwritten material, drawings, sketches, blueprints, etc.

A reproduction speed of approximately 14 sq. in. per minute is employed in most of the facsimile equipment although much higher speeds may be employed where circuit conditions permit. This is the equivalent of about 140 words per minute for single spaced typewritten subject copy, or 400 words per minute for newsprint. While the frequency band required (about 2500 cycles) makes facsimile transmission somewhat less economical of line than high-speed multiplex carrier telegraph systems, this factor is outweighed in most instances by the many advantages which facsimile possesses.

In order to secure the most efficient use of trunk circuits, facsimile is at present generally superimposed upon carrier telegraph sys-

(*Continued on page 200*)

SOUND . . . and Its Place in the Sun

The chief commercial market for amplification equipment today is in industrial plants and it is probable that this application will remain near the head of the list even after manufacture of equipment for entertainment, advertising and other peacetime uses is resumed

By F. D. WILSON
Operadio Manufacturing Company

THE ELECTRON TUBE can do more extraordinary things than any other device yet created by man. Its potentialities in the fields of industry, television, radio, medicine and many others are seemingly limitless. Billions of invisible electrons, racing through space inside vacuum tubes, are at the heart of one of industry's newest and most logical developments for speeding up production and human efficiency in both the war plant and the office—electronic intercommunication and paging systems.

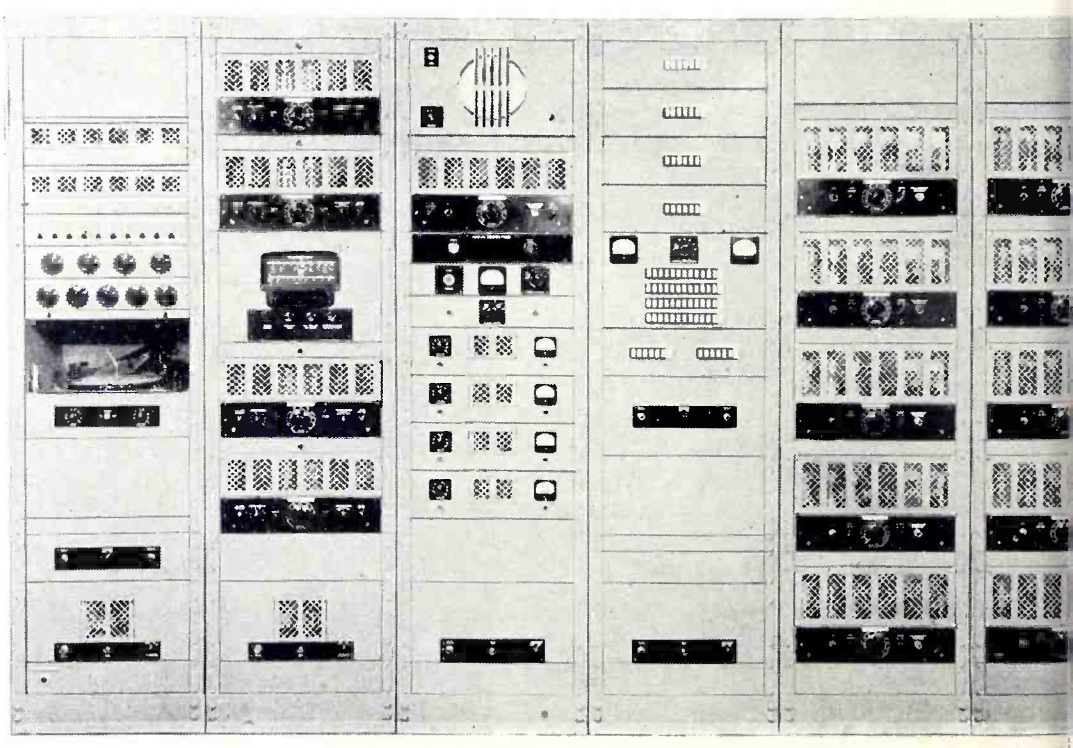
The "brain" of such a system is the amplifier rack and panel, where circuit priority is automatically determined and where the audio frequency impulse is received, filtered and clarified, increased in intensity and carried to any number of outlets—all in a split second. The "ear" of a paging system is the microphone—catching the slightest whisper and literally making it a command by passing it to the electronic "brain." The many "mouths" of a paging system consist of a large number and variety of loudspeakers and air-column horns, each engineered to its specific job and to its environment factors such as the noise in the area to be covered, acoustical factors, and specific functions required of the system. Loudspeakers may be mounted in the open or behind grilles . . . on ceiling, pillar, or wall . . . inside, or outside exposed to the weather.

Modern Industrial Installation

In a vast aircraft engine plant designed for Wright Aeronautical Corporation, such a sound system conserves executive time, builds worker morale, speeds production of vital equipment for the men on the fighting front. This modern installation is used to broadcast voice, music, time signals and other information all over the enormous plant at any hour of the day or night.

Two separate equipment groups are used. The main system handles: (1) Fire signals, (2) Time signals, (3) Plant police calls, (4) Switchboard paging, (5) Maintenance calls, and (6) Local operation. Precedence is established in that order. For example, if the fire signal is sounded it automatically locks out any other service that is using the system. A smaller, supplementary system, is used to bring radio or phonograph music to five cafeterias.

The fire signal is a tone produced by electronic oscillation. From any fire box in the plant a signal can be sent over the entire system, cutting out any other service in use at the time. The signal is coded to indicate the location of the box originating the alarm. The time signal is used for stopping and starting work on each shift. The tone is different from



BIG JOB—This installation, in a Wright Aeronautical plant, performs many functions. It furnishes entertainment, permits paging from a central switchboard, may be used for intercommunication between specific points, transmits time signals, handles maintenance, fire and private police calls

MORALE—Sound got its initial toehold in industrial plants when early installations proved that "music while you work" increases production. Two Westinghouse factory employees here are selecting records for the day

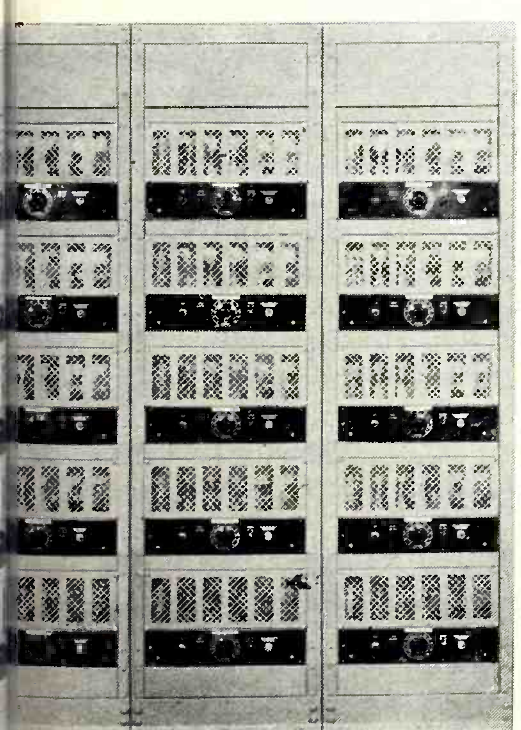
the fire signal. When machines are in operation an automatic control doubles the volume of the signal to carry above the noise. Police service is maintained by the use of coded voice signals to the guards throughout the plant.

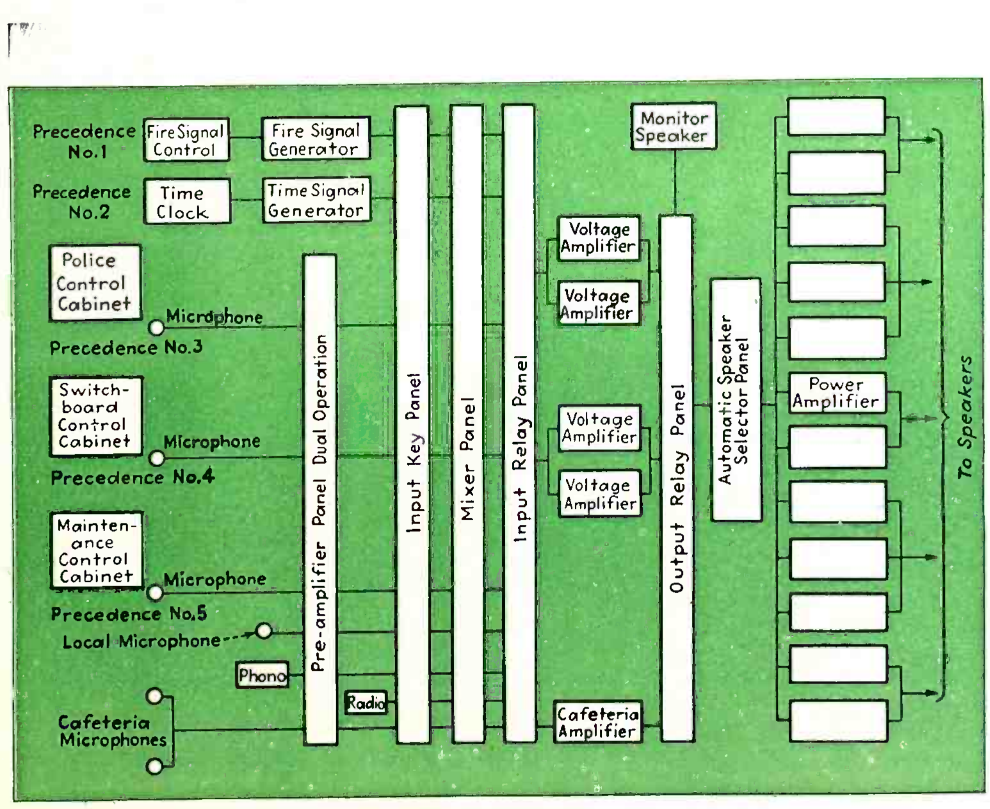
One microphone is in constant use for switchboard paging. There is such a large volume of calls to the plant that one girl is employed full time to handle telephone requests for paging. The plant telephone system has a dial number for paging service and when this number is dialed the girl answering fills out a "Paging Requisition." She passes this form to another girl, who selects the proper key for paging the area to be covered. Paging is done over five different circuits. Five different areas can be paged separately or in various combinations. A master key cuts in all five circuits at once.

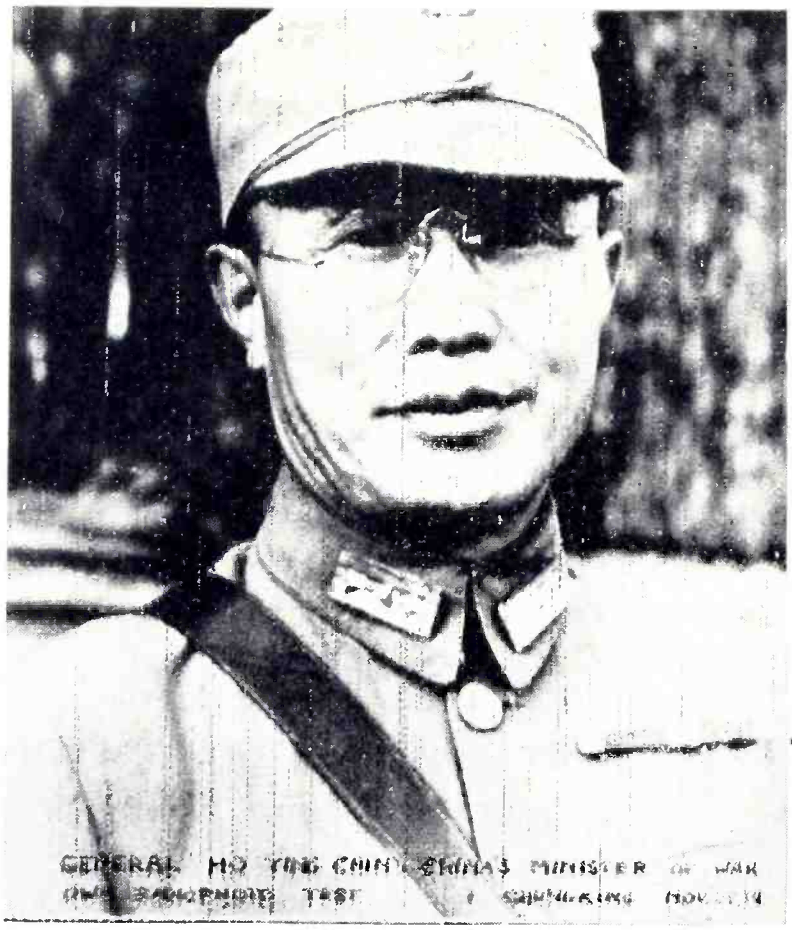
The plant's Chief of Maintenance is provided with a panel similar to that in the office of the Chief of Plant Police. If a machine should break down, or other trouble develop, the maintenance crew can be summoned and instructions instantly given over the voice paging system.

For local operation, announcements can be made direct from the amplifier panel and rack in the control room. Executives may issue instructions or make addresses to the entire factory personnel by plugging in the microphone at the control panel. Radio programs, or phonograph music, can be sent into the entire plant, or to any part of it.

Dual equipment is installed and so wired that the failure of any vital part of the sound system automatically switches a reserve unit into the circuit.







PICTURES

First cousin to facsimile and second cousin to television, transmission of illustrations along with a story fills an obvious need in the newspaper business. Future expansion of the service depends upon the speed with which additional portable units can be placed in use

EXAMPLES—These two illustrations were sent over a relatively low power radio transmitter in China to the *New York Times*. They are shown exactly as they were received, without re-touching

From the Technical Viewpoint

By AUSTIN G. COOLEY
Times Telephoto Equipment, Inc.

FACSIMILE telegraphy, the art of transmitting pictorial and other graphic subject matter, is nearly as old as code telegraphy. Early difficulties in the way of securing satisfactory recording of facsimile copies retarded commercial adoption whereas code transmission faced no such problem.

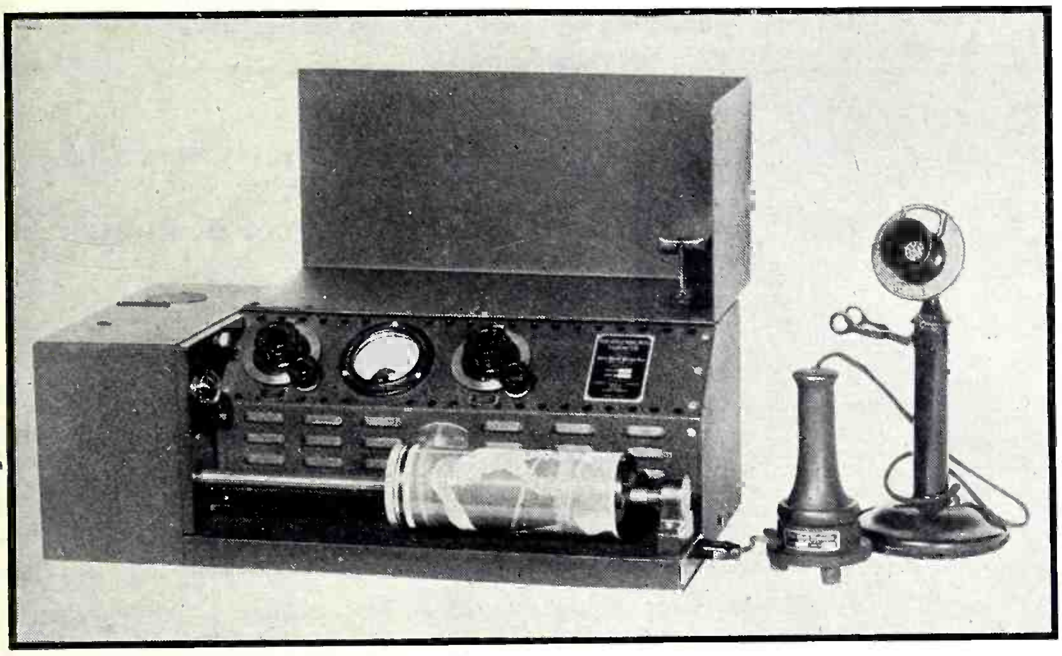
Past, Present, Future

In 1912, Prof. Arthur Korn, had a photo transmission network operating on a commercial basis between London, Paris, Berlin, Manchester, Copenhagen and Munich. Little was done in the United States, however, until shortly after 1920, when the science of electronics was applied to the basic system as developed by Korn. Ever since the 1924 Republican Convention in Cleveland, leading American newspapers have been able to give us up-to-the-minute news pictures on all the more important stories.

The Associated Press opened up an elaborate picture transmission network between fixed stations in January, 1935. In February of that year the *New York Times* published news pictures from San Francisco, transmitted by portable equipment developed in its own laboratories. Shortly afterward, International News Photos made tests with portable equipment. Associated Press similarly developed a portable system and competition for technical superiority was further enlivened by the entry of Acme News Photos into the field.

As war clouds appeared on the horizon in Europe, portable newspaper facsimile equipment presented the reading public with a preview of Army maneuvers and proved that

by Wire and Radio



EQUIPMENT—Pictures are transmitted or received over telephone lines by this typical portable machine by removing the receiver from the hook and placing it on a pickup unit

equipment was no laboratory toy but could rough it in the field and deliver the goods. Certain features were eventually added in accordance with Signal Corps requests. We cannot describe the resulting designs now. We can only say that facsimile is transmitting important weather maps and has carried hand-written notes between our President and the Generalissimo in Chungking.

Brooks Atkinson of the *New York Times* reports from Chungking that facsimile equipment will be placed throughout China with the result that, after the war, facsimile may replace all Chinese telegraph systems. The reason is obvious. In transmitting copy for one edition of a newspaper in China, ten Chinese are required at the transmitting end to convert the characters into a cipher code which can be transmitted by Morse or printing telegraph. Ten more are required at the receiving end to convert the copy back into Chinese characters.

Typical Transmitters and Receivers

Most transmitters carry subject matter on a rotating drum driven by a synchronous motor whose speed is accurately controlled by a tuning fork. Either the optical system moves on a carriage along the length of the drum or the drum travels along its axis in front of the optical scanning system. Signals developed in a phototube, included in the optical system, are amplified by other tubes sufficiently for transmission over a communication channel.

For direct telephone line or radio connections an output signal having a level of zero db is generally sufficient. For newspaper work, some systems have been providing an output signal level of plus 25 db so that equipment may be inductively coupled to telephone receivers. Inductive coupling arrangements permit photographers to set up portable phototransmission equipment at any telephone substation without installation delays which would be involved if direct line connections had to be made.

For high quality photographic work recorders are mostly of the drum type, having a crater-lamp or light-valve in the optical system. Crater-lamps are usually of the gas-discharge type, similar to those used in the early days of sound movies. Light valves used include an incandescent lamp and a magnetically controlled mirror or shutter, similar to those used in most present-day sound movie recording equipment.

Receivers intended only for black and white copy are sometimes built for direct recording on a continuous strip of paper fed from a roll about eight inches wide. Recording is accomplished by a magnetically controlled stylus in some systems. Others make use of color changes produced by the passage of current through a paper dampened with a chemical. A relatively recent continuous strip method makes use of a direct recording paper such as the Western Union "Teledeltos" type. In this case marks are made by the electrical burning off of a white surface coating over a black paper backing.

From the Press Viewpoint

By LEON DECKER

Press Association, Inc.

ONE OF THE MOST revolutionary advancements in news gathering—the transmission of pictures by wire—owes its development largely to the magic of electronics.

Readers of today's newspapers scan the headlines for the day's big news, then capture with their eye all the drama and impact of the news. This is possible through pictures which are flashed to all corners of the land with the speed of light. Readers give little thought to the innovation that enables them to enjoy this second dimension of news. But the development of what may truly be called "the miracle of modern news gathering" is an exciting story.

Dramatic Commercial Debut

The beginning of this new era in American journalism came with the start of the new year on January 1, 1935. A big airliner had crashed deep in the Adirondack Mountains in New York. Searching planes had found the wreckage and an aerial picture had been made. It was "page one" picture news everywhere.

Technicians put the picture on the

(*Continued on page* 208)

SOUND RECORDING Depends Upon Electronics

Sound-on-film for motion pictures; sound-on-disc for broadcasting, for the home and for industry rely upon electron tubes for recording and play-back and for control of quality

MANY of us think of sound recording as a comparatively recent development, particularly in the case of talking pictures which came into commercial use about 1926. However, the basic principles of recording sound on films were suggested over sixty years ago. Various improvements were made during the following forty years but no practical application was found until the early 1920's. An important reason why this development did not take commercial shape for such a long time is that the principles involved were impractical until the development of the electronic art reached the stage where amplifiers and phototubes could be produced commercially.

The introduction of amplifiers permitted the use of less efficient sound pickup and engraving methods, but the lower efficiency was more than compensated by the wider range of frequencies recorded and by lower distortion.

Amplifiers Have Many Advantages

Amplifiers also make it possible to "monitor" and to play back a record as soon as it is made so that any defect in the recording may be detected and a new recording made, if necessary, while the musicians are still assembled. Amplifiers also make it possible to engrave several records simultaneously from the same source, and to re-record from one record to another in order to add other sounds or to alter the relative intensity of various bands of frequencies. Examples of "equalization" used in disc recording are (a) reduction of amplitude at low frequencies to avoid overcutting, (b) pre-emphasis or accentuation of high frequencies to reduce the relative amount of noise reproduced from the record, and (c) equalization to compensate for non-uniform response of any of the elements of the recording system.

Similar improvements have also been introduced in the reproduction of disc records. Electrical pickups are much more uniform in their response than the best mechanically operated types. Another advantage of the electrical system is that the frequency response can be readily adjusted to accurately match the recording characteristics. It is also very easy to adjust the level of the sound reproduced from the record and to a certain extent the scratching noise may be reduced by electrical filters.

Sound-on-film Depends Upon Electronics

Sound-on-film recording is virtually impossible without electronic devices. Aside from the ever-present amplifier, electron tubes are used for such widely different purposes as changing light fluctuations into electric currents, as in the phototube, and regulating motor speed, especially on d-c circuits.

One recent contribution of considerable importance is the volume limiting amplifier. This permits recording sound at a comparatively high level on the film (giving proportionately less noise when reproduced) without the danger of overmodulating, and also protects the recording element from excessive currents. Another device is a noise reduction unit which, in addition to the usual amplifier and rectifier tubes, may utilize a carrier frequency oscillator, modulator, and a copper-oxide rectifier as a d-c amplifier.

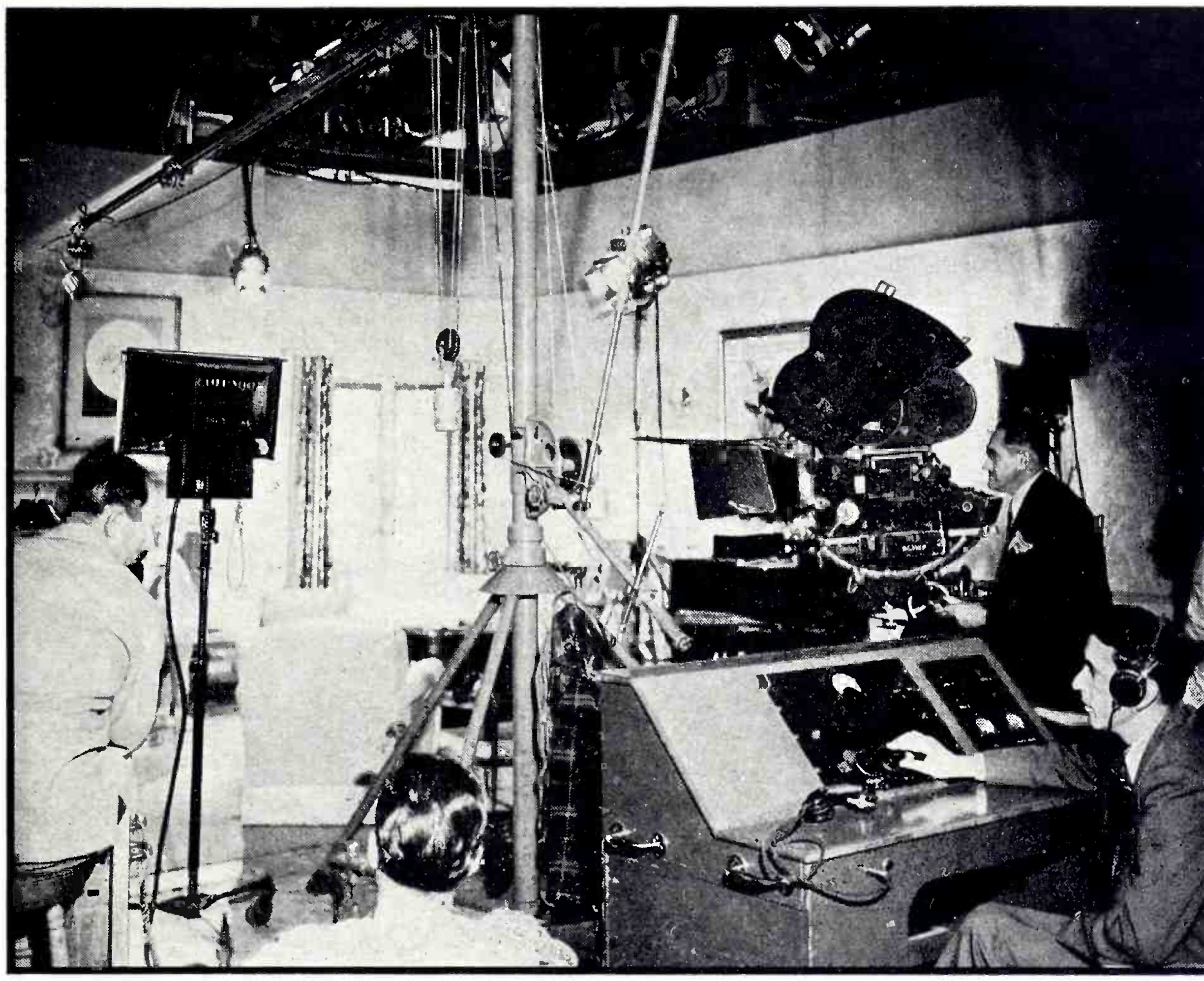
A phototube monitoring unit is often provided to check the operation of the recording equipment right up to the film. This is done by diverting a portion of the modulated light beam into a phototube, amplifying the phototube current and converting these currents into sound by either headphones or a loudspeaker. The sound so reproduced is practically indistinguishable from sound derived from electric currents which have not been transformed into modulated light and back to electric currents again. Any overloading or other source of distortion may be detected by comparing the sound from the direct and the phototube monitoring circuits.

In the early days of sound-on-film recording an electronic device in the form of a gas discharge tube was used extensively as a light modulator. These tubes have now been largely displaced in favor of mechanical modulators such as light valves and mirror galvanometers, due to a large extent to the difficulty in producing tubes giving out enough light to suitably expose sound-recording film. However, this type of modulator has a number of inherent advantages, such as simplicity and absence of resonance, which are not possessed by other modulators. Perhaps future developments in gaseous or electron discharge tubes will make it possible to once more enjoy these advantages together with an adequate light output.

Another interesting application of electronics to sound-on-film recording is the "negative playback ampli-

By C. R. KEITH

Electrical Research Products Division, Western Electric Company, Inc.



STUDIO—The "mixer man" at lower right is adjusting the output of the microphone to a value proper for operating recorders in this typical studio shot. The recorders are in air-conditioned rooms in another part of the building, the sound-carrying electrical currents being sent there by wires. The mike hangs on a boom supported by the mast

fier." It is easy to show that a negative variable density sound track contains certain distortions which are automatically compensated by the photographic process of printing and developing the positive print. In the usual studio procedure the negative is not used for reproducing sound but only for making prints from which the sound is reproduced. However, there are some circumstances, particularly in newsreel work, when it is desirable to reproduce sound directly from the negative. To make this possible with a minimum of distortion, an electronic circuit has been devised which produces the same kind of compensating distortion as is produced by the positive photographic process. A combination of feedback, non-linear vacuum tube characteristics, and d-c amplification is utilized in a very ingenious manner.

Motor Control by Electronics

Electronic circuits are also used for maintaining accurate speed control for motors driving either sound recording or reproducing equipment. This type of control is particularly applicable in areas having only d-c power, or where the a-c supply is not sufficiently well regulated to permit the use of synchronous motors.

Another electron tube application is the phototube densitometer. This instrument is used to measure the characteristics of films used for sound and picture recording, and is a most useful device to control picture quality. The densitometer is coming into use outside the motion picture industry.

One recent development is the "sprocket hole control track" which is used for automatically varying the gain of the reproducing system amplifier and also for connecting additional loudspeakers. As its name implies, a variable-width track is printed in the spaces between successive sprocket holes. A simple illuminating and scanning system is provided in the sound reproducer, including a phototube for producing corresponding electric currents which are used to control a variable-gain amplifier with the special characteristic that the change of gain is dependent only on the width of the track, and not on the intensity of the exciting lamp.

Another form of control track recording makes use of a very narrow track (5 mils wide) located in the black margin between the standard sound track and the picture. Frequency modulation is employed to increase the volume in the theater, reduce the noise for low sound levels, or for both purposes.

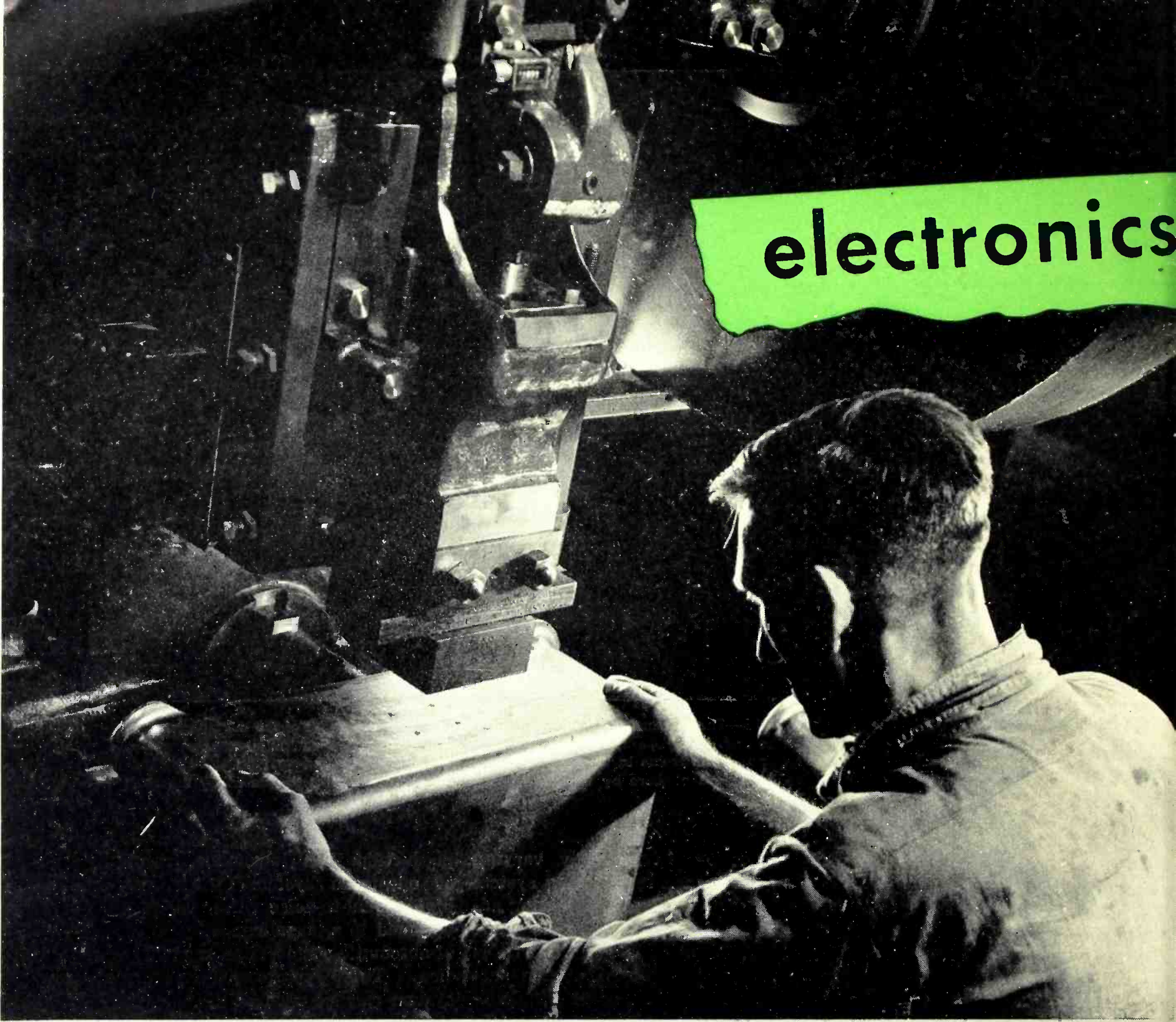
Three-dimensional Sound

Extensive use of electronic devices is found in recent equipment developed for stereophonic sound reproduction. An important feature of one such system is the very high signal-to-noise ratio, which is obtained to a large extent by means of automatic compression and expansion. This compression-expansion system may be used to increase the volume range, to reduce noise, or for both purposes.

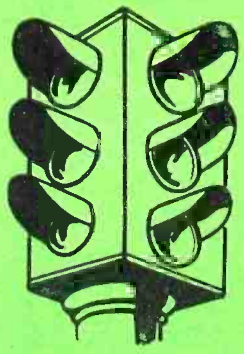
Further Simplification

Although great strides have been made in improving sound recording and reproduction in the last twenty years, still further improvements will undoubtedly be made as a result of electronic and other technological advances. One line of improvement may well be further simplification and reduction of cost of both recording and reproducing equipment. Stereophonic sound presents an alluring prospect, but there still remains further development in order to make the system suitable for use throughout the industry. Altogether there are still plenty of problems to the solution of which the electronics engineer will undoubtedly contribute in a large measure.

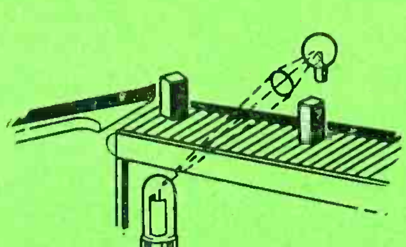
electronics



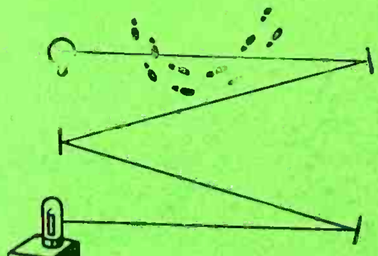
In industry, the electron tube is playing an increasingly important role in process control, safety of plant and personnel, and increasing production.



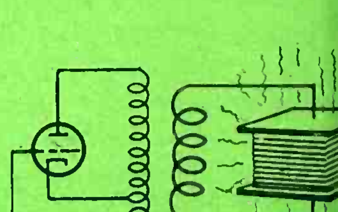
TRAFFIC



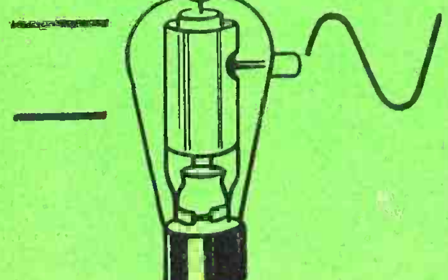
PRODUCTION



PROTECTION



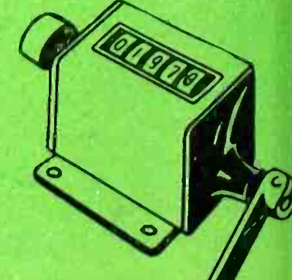
PROCESSING



POWER-CONVERSION

CONTROL

MAINTENANCE



COUNTING

—New Force in INDUSTRY

RESISTANCE WELDING speeded, improved by tube control

By G. W. GARMAN

Electronics Section, Industrial Dept.
General Electric Company

THE DEVELOPMENT of controls for resistance welding machines was one of the earliest achievements of electronic engineers in the industrial field. Present day interest in, and adoption of, electronics generally as a practical tool can be traced to a very large degree to the success of this application.

Resistance welding is one of a number of methods of fusing metals together. Others are brazing and soldering, arc welding, torch welding and the blacksmith's hot forging. Resistance welding consists of applying pressure by means of copper alloy electrodes to two or more pieces of metal and then heating the adjoining surfaces of the work to the fusion or melting temperature by allowing electric current of a definite magnitude to pass through the pieces for a definite length of time. When the current flow is stopped, with pressure still maintained, the melted metal "freezes," binding the pieces together as a single unit.

Although there are many forms of resistance welding, such as spot welding, projection welding, pulsation welding and seam welding, the basic method in all cases is the same. The nature of the weld depends upon such factors as electrode pressure, size and shape; type, thickness, and surface condition of metal to be welded; time of current flow, and, of utmost importance, the magnitude of this current. The last two factors can be controlled electronically, while the others are subject to mechanical control.

There are at the present time two basic methods of obtaining the necessary welding current. These are the a-c and the stored-energy methods.

A-C Resistance Welding

The actual welding current required to melt or fuse two pieces together depends upon the type of metal being welded and its thickness. When welding high-resistance metals such as stainless steel of thin gauge, only a few thousand amperes are required. When low-resistance materials such as aluminum alloys are welded, 20,000 to 60,000 amperes are required.

The simplest and oldest method of obtaining this current is by means of a step-down transformer (welding transformer), the primary of which is connected through an interrupting device to the plant electric power distribution system operating at 220, 440 or 550 volts. Even though a step-down transformer is used, the primary current may still be several thousand amperes. Prior to the introduction of electronic control, mechanical devices—such as magnetic, air-operated or synchronously driven motor-operated contactors and "pass-through" switches—were used to make and break this current.

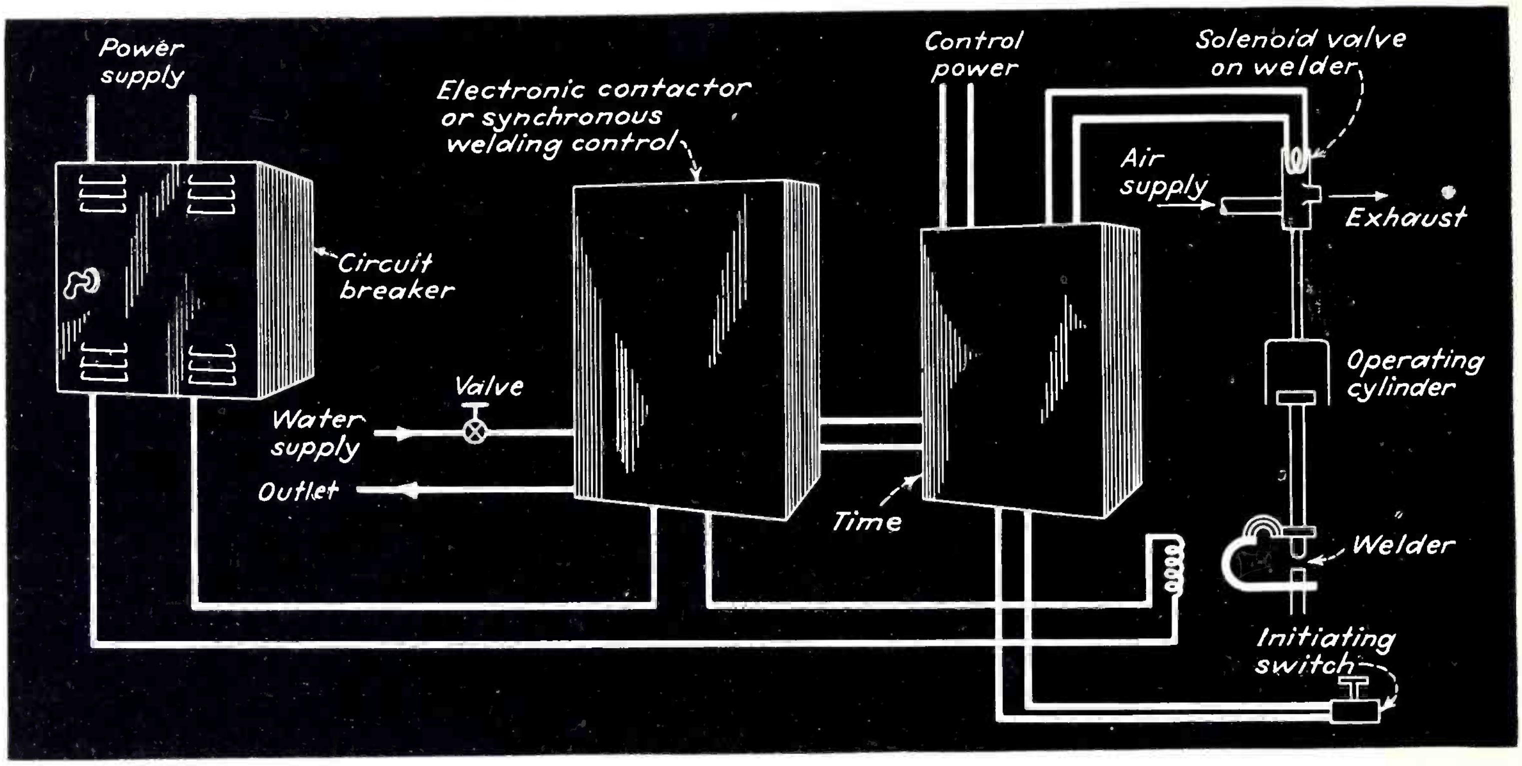
The problem of mechanically making and breaking such a current from 50 to 1200 times per minute without excessive maintenance is a real task. For uniform results, the welding circuit must be closed consistently not only for a definite length of time but also, to obtain consistent

BELLWETHER APPLICATION

One of the earliest large-scale uses of tubes in industry, resistance welding controls proved under actual field conditions that electronic equipment of proper design can "take it."

Even today, with electronic devices going into plants for many purposes, resistance welding controls account for a respectable percentage of all the tubes reaching industry.

Typical Welding Control Setup



Tubes perform many functions. Their work starts in the unit at the right, which controls other tubes in the contactor and power supply units. Operation may be fully automatic, permitting the welder to devote full time to insertion and removal of work

values of welding current, at a definite point on the a-c voltage wave. Electronic control assists materially in obtaining consistent results because it is without inertia and friction and can control precisely the start and finish of welding current. In addition, since electronic control has no moving parts or arcing contacts, maintenance time and expense are much less.

Engineers who have studied oscillograms of welding current when a standard magnetic welding contactor is used and when electronic control is used have noted that the primary current is several times normal when the magnetic contactor is used, thereby causing excessive voltage drop and additional heating in the distribution supply. This condition increases the probability of light flicker and interference with other equipment connected to the distribution system. Also, since the heat generated in the weld depends upon the square of the welding current, even a small variation in its value can cause an appreciable change in the heat generated, which, in turn, causes a variation in weld quality.

The importance of precise control in seam welding is great, as the bad effect of erratic closing of the welding circuit can, under certain conditions, become cumulative, thereby causing a still greater variation in line current, as well as weld quality. Welding current for a seam welding application can be controlled electronically with a high degree of precision.

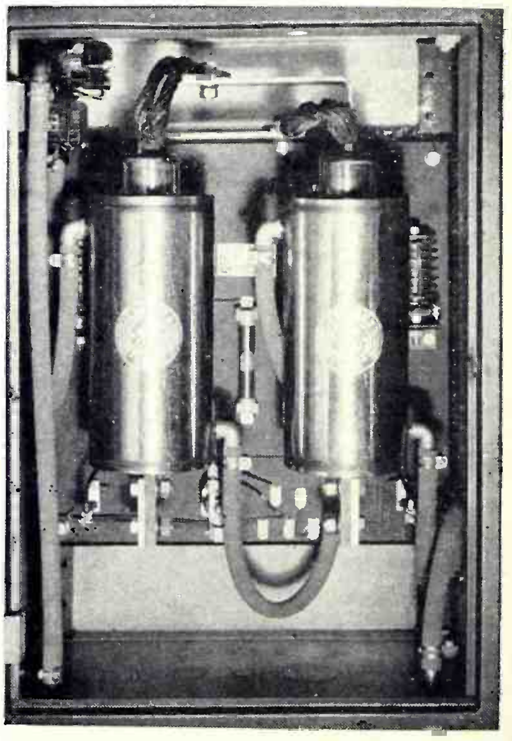
Many Industrial Advantages

To illustrate the advantages of precise electronic control in one typical plant; 21,000 refrigerator evaporators, containing 1,250,000 spot welds, more than 1,400,000 inches (22 miles) of gas-tight seam welding and 6,000,000 inches (94 miles) of intermittent seam welding, were welded without a single unit being rejected because of faulty welding.

The story of a-c electronic control could be ended at this point by merely stating that through its use production has been increased greatly and millions of dollars have been saved, but, like most developments, the story is never completed. For with each sucessful application of resistance welding new control problems arise.

To understand fully the contribution of electronic control to the metal fabricating industry, a brief sketch of the development of a-c electronic control may be of value.

With the general adoption of electronic control some 12 years ago, the only tubes available which were economically justified were the hot-cathode thyratrons. These had limited ratings up to 12½ amperes but could be operated as high as 6600 volts. With many applications re-

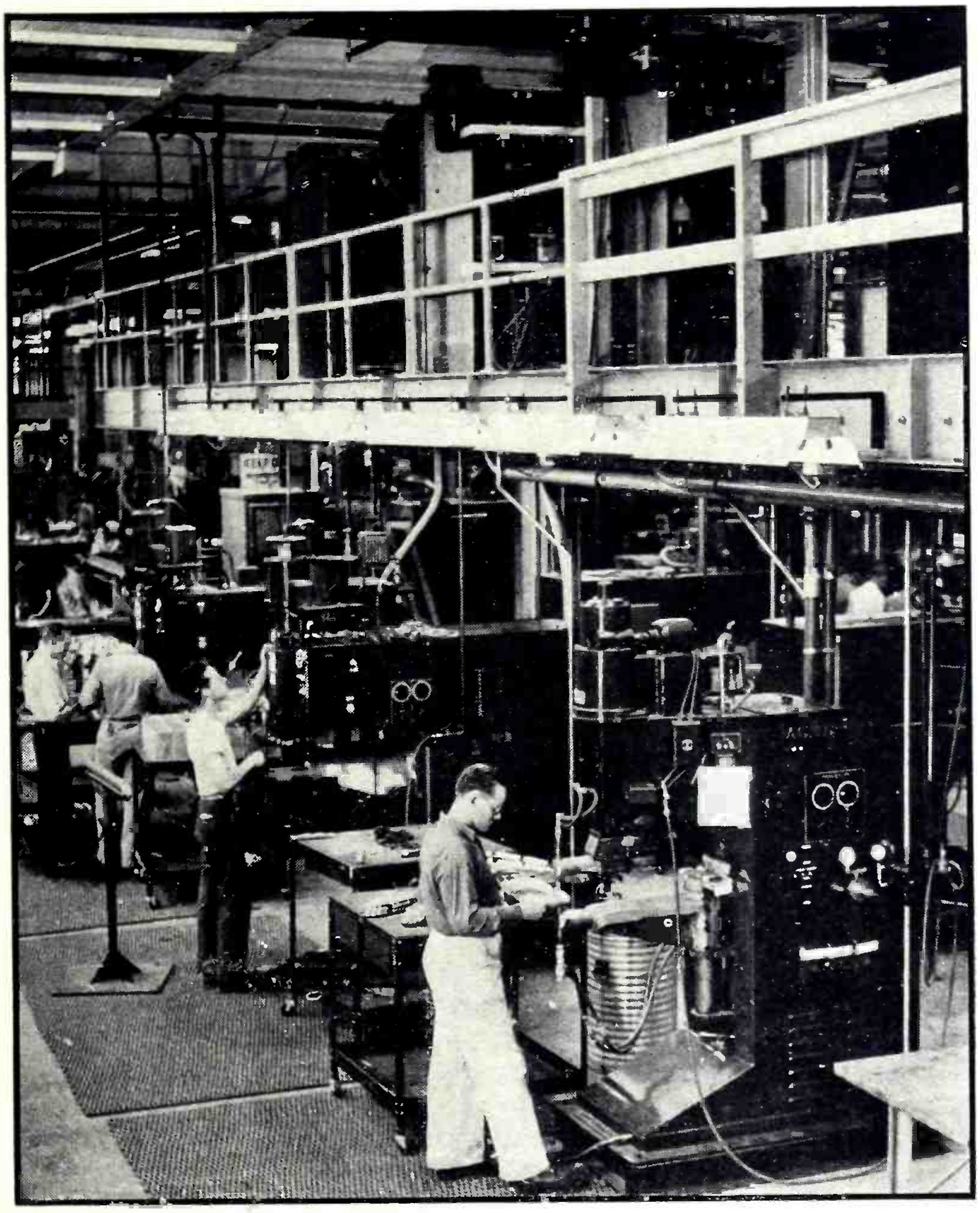


CONTACTOR—Two ignitron tubes take the place of bulky and complicated mechanical switches, opening a 9500 ampere, 230 volt circuit from 50 to 1200 times a minute without arcing quiring control of several hundred amperes, the logical procedure was to use a so-called "series transformer." The primary, or low-voltage winding of this transformer was connected in series with the primary of the welding transformer. When the thyratrons connected across the high-voltage winding were allowed to pass current, the transformer was effectively short circuited, allowing substantially full voltage to be impressed on the primary of the welding transformer. With the thyratrons shut off or prevented from passing current, the impedance of the primary winding was sufficient to allow only a small voltage to be impressed on the welding transformer. Even though this equipment was relatively expensive and bulky, and was limited to the control of a welding load of about 350 kva maximum with a single pair of tubes, or 700 kva with two pairs of tubes, it was used extensively, particularly for seam welding of gasoline tanks, refrigerators, and similar products.

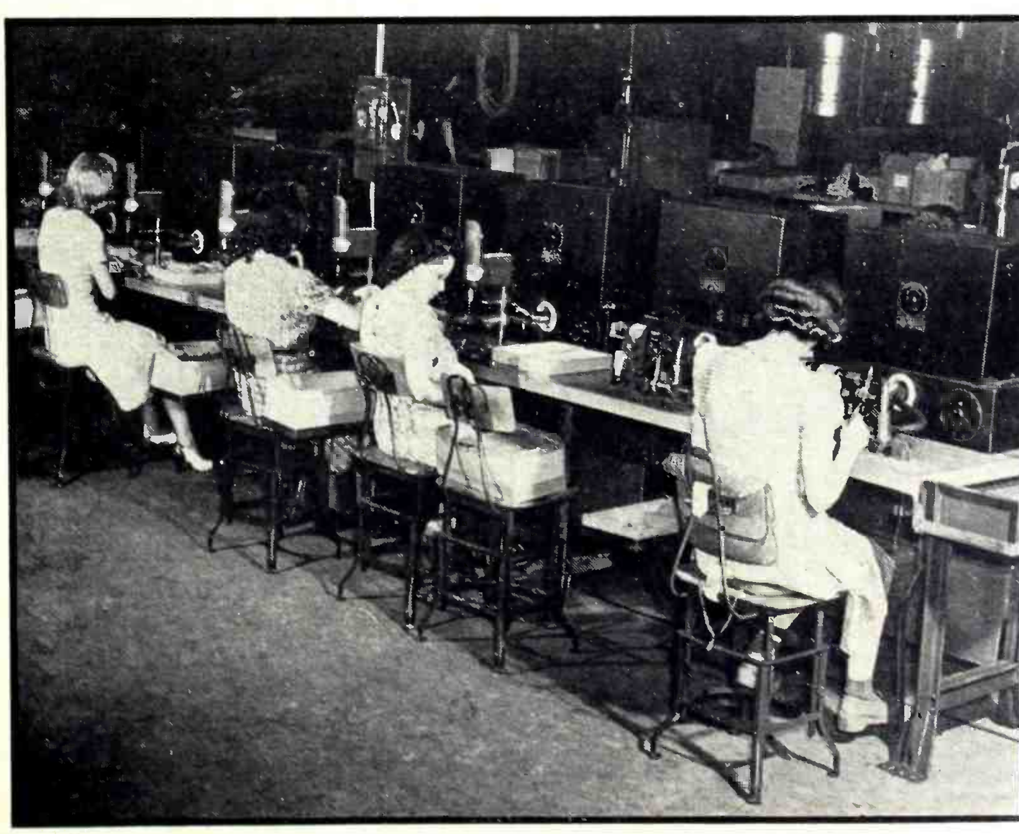
It was, however, this type of control combined with an electronic timing circuit that demonstrated the full advantages of controlling welding current precisely and proved that a resistance welding machine with the proper type of control was a precision machine tool. Without electronic control the resistance welding machine manufacturers were handicapped. For, no matter how well they designed their machines, both the quality of the weld and the field of application were limited.

With the development of the sealed-off water-cooled ignitron tube, the limitation of price and size of electronic control was removed. In addition, while the previous control using a single pair of tubes was limited to 350 kva, the water-cooled tubes could control for short periods of time approximately 2,000 kva. Furthermore, even without the precise timing and control feature, two of these tubes could be connected as a single-pole electronic switch or contactor. Such a contactor had the advantages of long life, low maintenance and silent operation. Prior to the war, hundreds of these contactors were installed in the automobile industry. A survey indicated

(*Continued on page* 210)



INDUSTRIAL INSTALLATION—A-c resistance welding equipment, complete with modern electronic controls, in use in a large plant



TUBE PLANT—Resistance welding controls are widely used by the electronic industry itself, as well as by other industries for which it builds such controls. Here thyratron tube control panels facilitate welding of radio tube structures

PROTECTION
by Electronic

Important in peacetime, the safeguarding of commercial premises and industrial plants against burglary, vandalism, fire, smoke and water damage is even more so during war, when acts of sabotage may be as destructive as loss on the actual fighting fronts

IN the field of protection, electronics is assuming an important role in guarding industrial plants and other properties against intrusion, burglary and various acts that might lead to sabotage. The systems used for this purpose are of two types: photoelectric, in which the detecting medium is a beam of invisible light; and body capacity, which depends upon the change produced when a person or other object enters an electric field.*

Much of the pioneering in these types of sytems has been done by the so called "central station" protective companies, firms which, during the past ten years, have installed and operated in connection with their central station protection services thousands of photoelectric alarm systems for both indoor and outdoor protection. Up to the beginning of the war such companies installed body capacity alarms chiefly for the protection of safes and metal cabinets, but with the demand for increased protection for war plants these systems also have been developed for the protection of open areas, both indoors and out.

The photoelectric system, usually called the "invisible ray" alarm, was originally employed as an indoor burglary trap, an alarm being caused when an intruder intercepted the invisible beam of light. This system supplemented conventional protection of screens, foils and contacts. The demand quickly arose, however, for its use outdoors over comparatively long distances, and systems soon were developed to meet these requirements. One of the earliest outdoor installations was for the protection of a waterfront stretch of nearly 3000 feet over the water to guard against instrusion from the sea. This required mounting the projecting and receiving devices on tidal floats and the use of specially designed equipment throughout. The long-distance systems developed later were a modification of this system.

The development of photoelectric protection systems naturally began with attempts to adapt standard electric eye devices ordinarily used for opening doors, counting persons and objects, etc., but these did not prove satisfactory to meet the exacting requirements involved. Consequently, it was necessary to develop special equipment capable of long range operation and involving features designed to insure reliable operation with infrared light and under varying conditions. These systems now have a high degree of sensitivity, are thoroughly stable, will operate on reduced voltage, and the devices are constructed so that they can be easily mounted and adjusted in any location.

Several photoelectric systems have been approved by Underwriters'

CENTRAL STATION—Men in background watch "drops" remotely operated when trouble occurs on distant protected prem-

BIG BUSINESS

It is estimated that there are at least 30,000 so-called "central station" installations in the United States, maintained and policed by organizations specializing in such service.

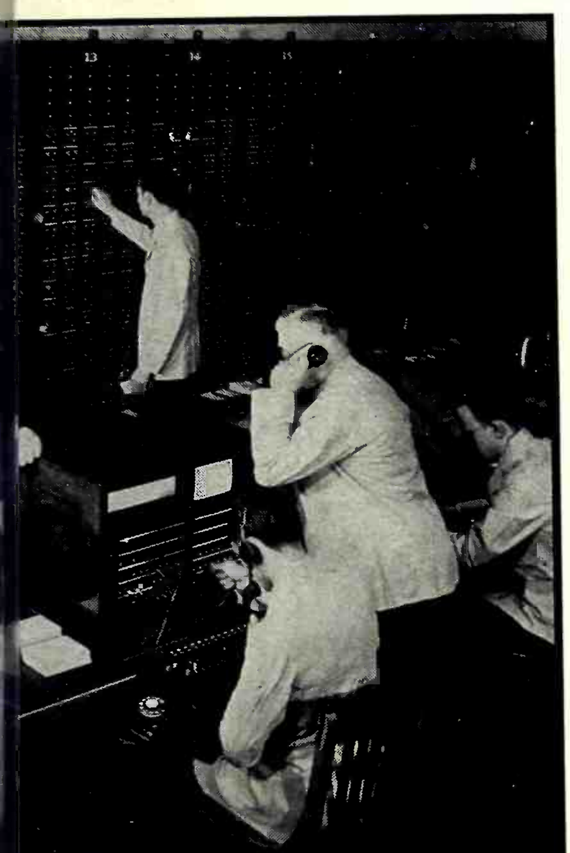
In addition, an untold number of protective installations have been made by individual business firms purchasing equipment outright and doing their own policing.

* Editor's Note. Recently a third method has been announced. This utilizes a Rochelle-salt type of vibration detection unit affixed to the fence surrounding a plant. Vibrations of the wire generate a voltage which is utilized to sound an alarm. No details of this method are available as yet.

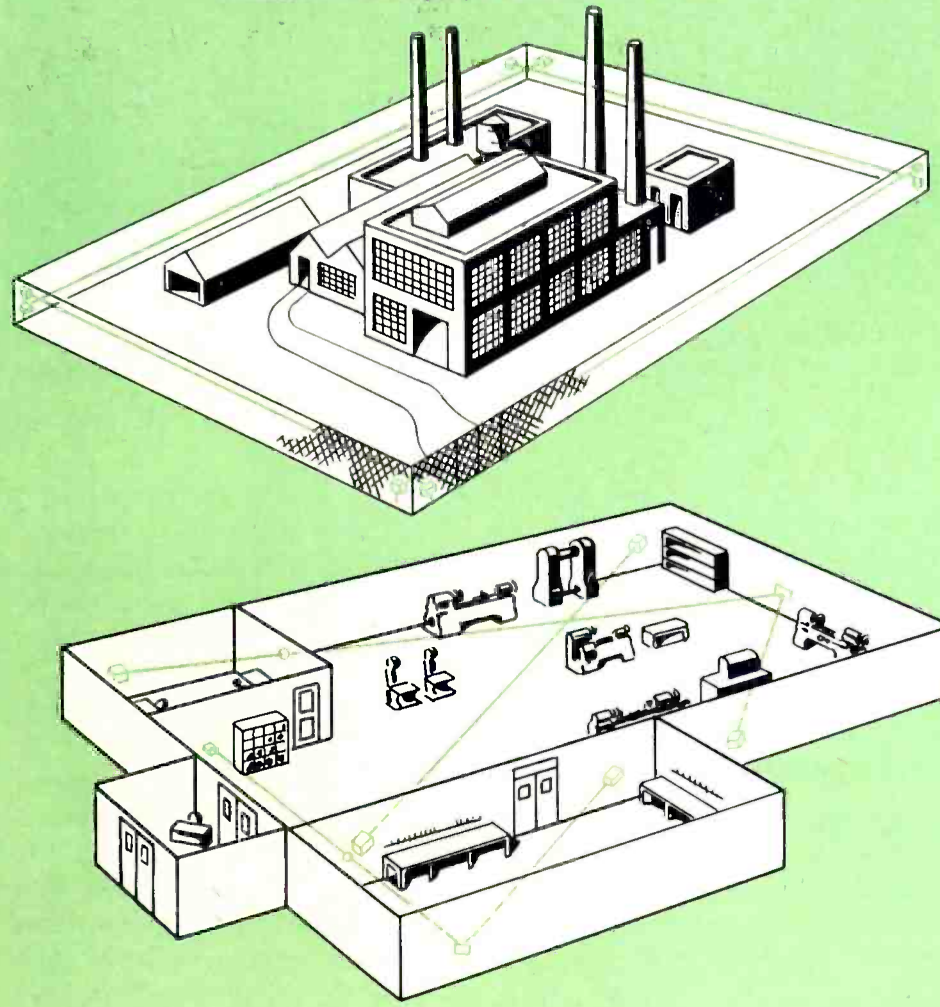
OF PROPERTY

Methods

By PAUL M. FARMER,
Chief Engineer
American District Telegraph Co.



ises, pass data to dispatchers in foreground. Special police speed to the scene and local police or firemen are called



THEY SHALL NOT PASS

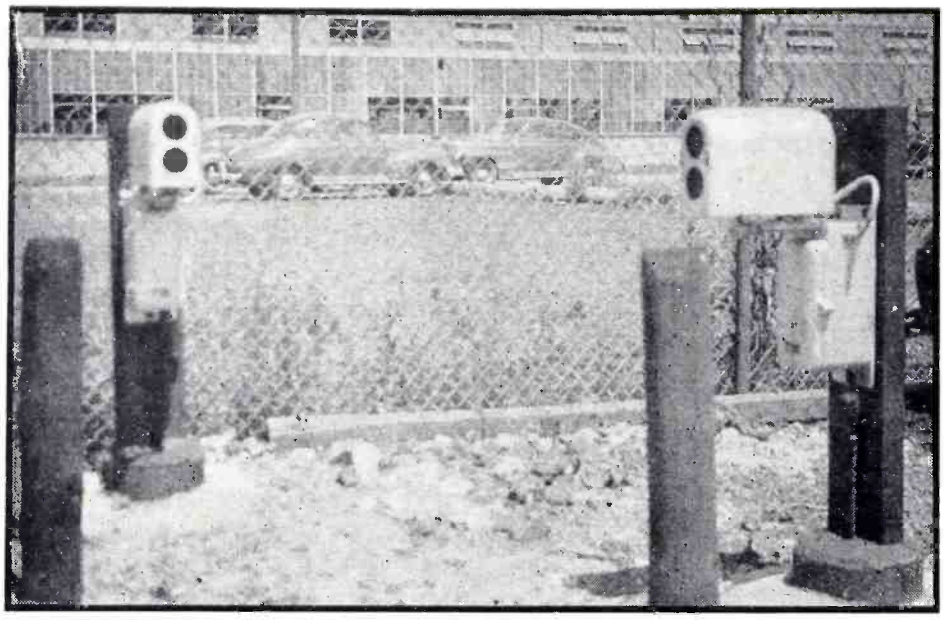
OUTDOORS—Invisible light-beam and phototube devices, capacity alarms utilizing radio waves and sensitive controls which transmit a warning signal when disturbed by vibration constitute barriers that are hard to defeat

INDOORS—Criss-crossed patterns of light catch intruders who may succeed in evading electrical devices guarding doors, windows and even walls and ceilings. Safes and vaults may be further protected by supplemental body-capacity and sound operated alarms

Laboratories for protection of inaccessible openings, ceilings, floors and party walls, eliminating the need for other types of protection usually difficult or expensive to install. To obtain certification of the alarm system for reduced insurance rates the Underwriters require that a network of invisible rays be reflected back and forth inside the premises so as to subdivide floor space into at least five approximately equal areas.

The maximum length of beams for indoor systems is about 150 feet in a straight line from light source to receiver. When mirrors are used to reflect the beam back and forth across a room the beam length is reduced by approximately 50 percent for each mirror used. This is a practical rather than a theoretical limitation, based upon considerable operating experience. The indoor system may be used also for short distances out-of-doors, in which case the light source and receiving units are equipped with protective hoods to shield the lenses from the weather and to reduce extraneous light.

The protection of outdoor areas ordinarily requires a photoelectric system capable of projecting a much longer beam than indoor systems. Such systems usually are installed for boundary protection, particularly as a secondary line of defense inside of wire fences or other types of physical barriers, to detect and report the presence of intruders. The equipment for such systems is necessarily of a different character than that used indoors. The light source and receiving units are completely weatherproof and ruggedly constructed to withstand outdoor conditions. The beam, which generally has more power than the indoor system, in conjunction with its receiving device, is effective over distances up to 500 feet even under adverse conditions such as rain, snow, sleet and fog. Two



HOT CORNER—Saboteurs successfully scaling the fence in the background still have to face invisible light beams emanating from the two photoelectric alarm devices criss-crossing the premises inside

light bulbs, each capable of operating the system independently, are sometimes provided for safety. The beam is large enough to avoid interruptions by small birds and animals, bits of flying paper and leaves, or other small objects.

Use of Photoelectric Systems Outdors

The important feature of this outdoor system, however, is the use of a modulated light beam to whose frequency the receiver is tuned. By this method of operation the receiving equipment is very sensitive, which makes it possible to operate over long distances. Furthermore, the receiving unit will respond only to the light projected from the light source, and no other light that might be applied accidentally or maliciously will prevent the system from operating. The system is also designed so that momentary power failures will not cause alarms.

Photoelectric systems also can be used for fire detection, but such systems have not been developed extensively because of relative equipment costs and the wide use of exceptionally effective automatic fire detecting systems of other types, particularly those operating on the rate-of-temperature-rise principle. Photoelectric devices, however, are used extensively for fire and smoke detection in air duct systems, particularly large air conditioning installations, where fires are likely to start in filters or in combustible material drawn into the systems. There are many cases on record in which small fires in air duct systems have caused exceptionally heavy damage by smoke and hot gases being circulated through the air ducts to other parts of the building. To detect such fires quickly, photoelectric devices are installed which project a light beam across the interior of the duct. This beam is reflected back to a receiver, controlling devices which automatically close dampers, shut off fans, and sound warnings before any damage can be done.

Capacity-Operated Protective Systems

Electronic alarm systems of the body capacity type have come into extensive use in recent years for the protection of safes and metal cabinets, superseding the former method of inclosing them in electrically lined wooden cabinets which had to be especially built. With one electronic method, now in common use, a unit containing a vacuum tube oscillator is connected to the safe which is insulated from the ground. The safe and the ground form part of the electrical system and when the electrostatic capacity between these two elements is increased by a person or object approaching the safe, the balance of the system is upset and through the action of amplifying devices an alarm results.

This same principle has been applied in the last two years to the protection of outdoor areas such as property boundaries by connecting a similar unit containing a vacuum tube oscillator to field or "antenna" wires situated where the protection is desired and at the appropriate height above the ground. Since the electronic unit may be adjusted to detect the approach of a person to within a few feet of the antenna, protection is effective up to a height of several feet above the ground. On level ground the wires attached to insulators are supported on steel or wooden posts properly spaced to prevent sway. Closer spacing may be required over rolling ground. A single unit can provide protection for four or five hundred lineal feet of boundary. Any number of units can be operated without interference. Alarm signals of this type are received at a control center, usually by means of indicating target drops which show the particular unit that has been operated.

These electronic systems as applied to the protection of war industries are proving invaluable in supplementing watchman and guard forces, often providing a considerably higher degree of protection with less manpower. In many smaller plants and in certain buildings of large plants, these systems when combined with other automatic protection often are used to supplant watchmen entirely. This is desirable only when the systems can be connected to a central station where guards are constantly on duty to investigate and maintain continuous electrical supervision of the protection systems.

What the Future Holds

The foregoing outlines only briefly how electronics is being applied today in the field of industrial protection. Now, without going too far out on a limb, we will endeavor to take a look into the future.

It is generally admitted that prognostications may assume dangerous proportions and to attempt to foretell the future of protection services is perhaps no exception. Over the last 70 years burglar alarm systems have undergone tremendous development, and fire alarm and other electrical supervisory systems have kept pace. Therefore, it would be expected that with the coming of

(*Continued on page* 218)

INDUCTION HEATING

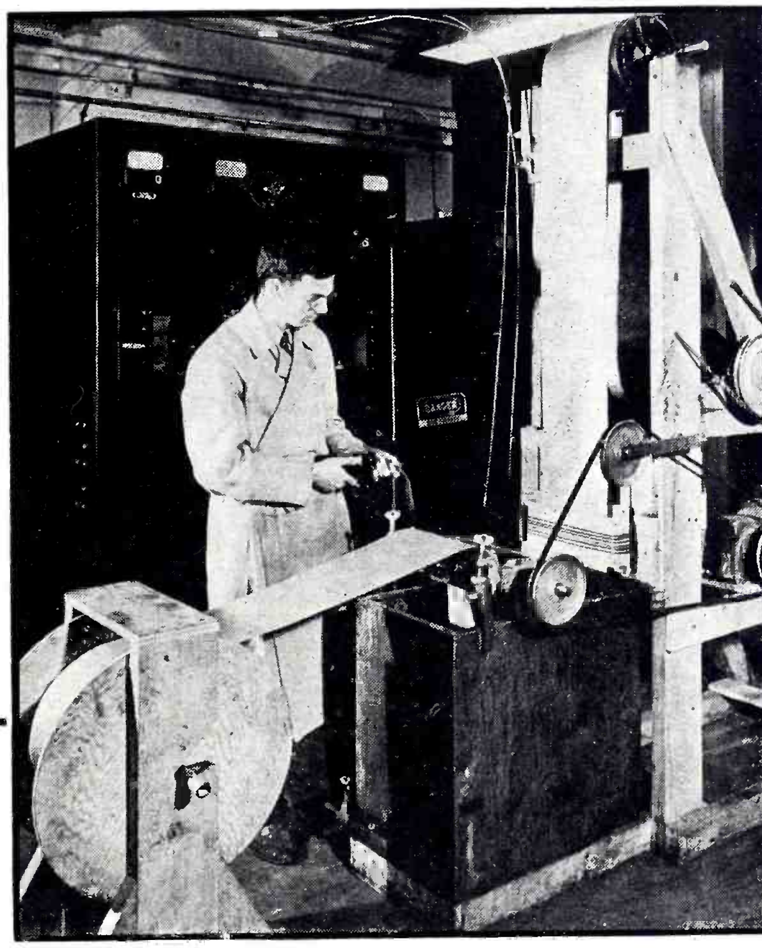
Comes of Age

Until recently best known among laymen for its therapeutic uses, induction heating has long been used in the manufacture of vacuum tubes. Now the principle is expanding rapidly into the general field of industry, accomplishing jobs which can be done in no other way

By G. W. PENNY

and J. A. HUTCHESON

Westinghouse Electric & Mfg. Co.

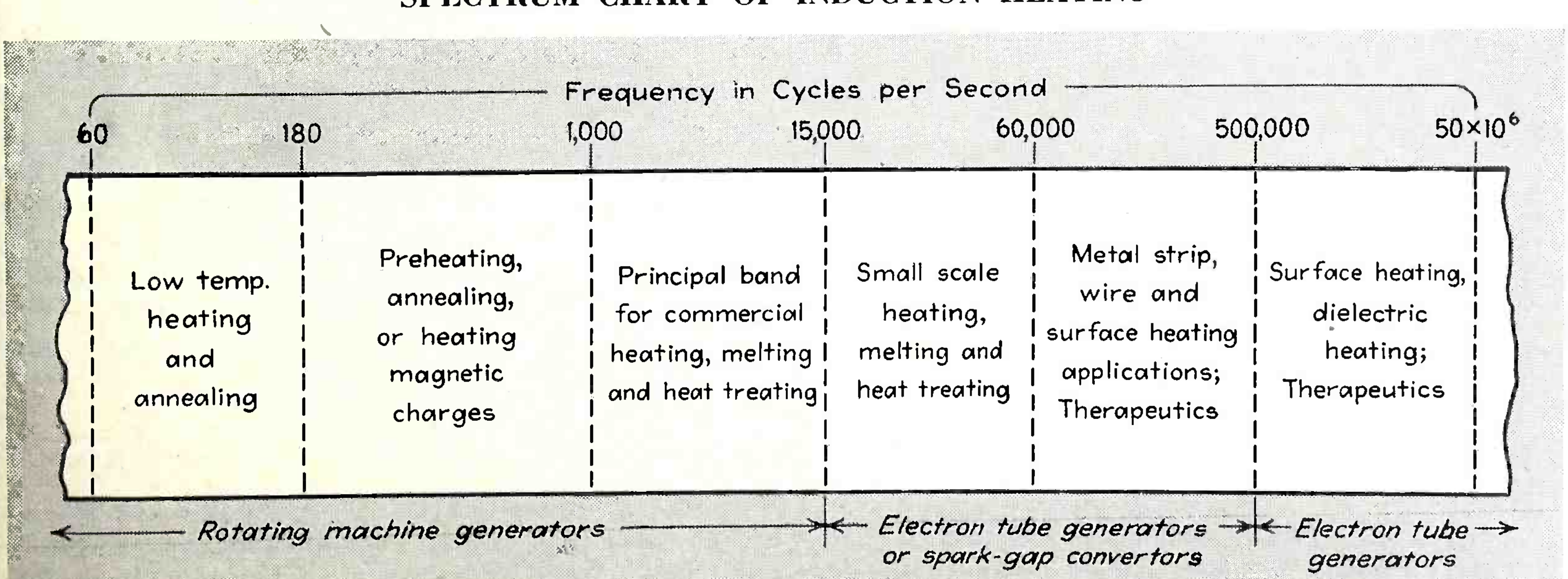


PLATING STEEL—The amount of tin required in the manufacture of cans may be reduced two thirds by electroplating sheet steel instead of dipping it in hot tin but the resulting finish is rough. A Westinghouse induction heating unit similar to this experimental electronic model runs the temperature of plated sheet up to 450 deg. F. causing the tin to flow and become smooth

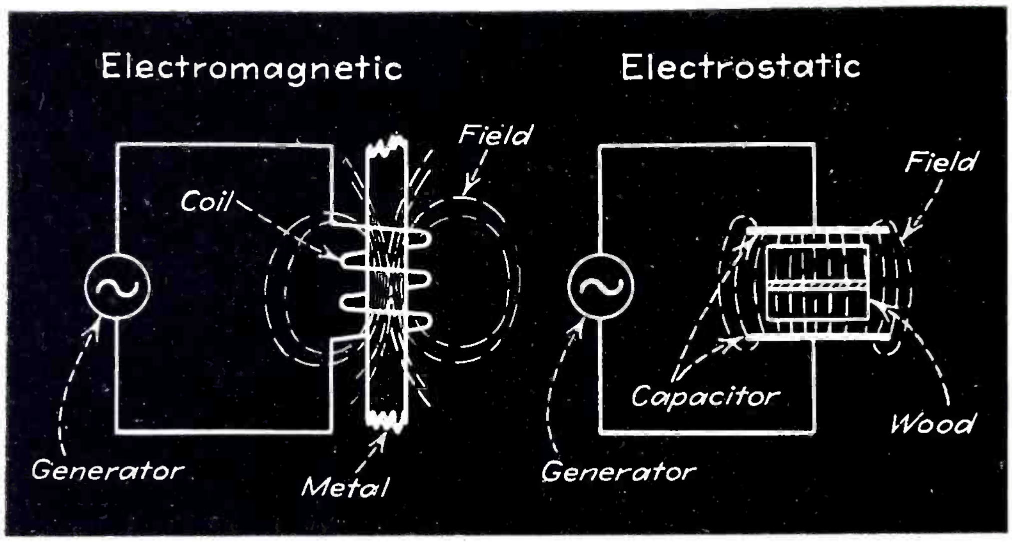
THE term "induction heating" has been applied to the process whereby any type of material is heated by the action of an electric or magnetic field in which the material is placed. For purposes of discussion, it seems logical to divide the subject into two categories, the first being that in which the heat in the material results from the action of an electromagnetic field and the second being that in which heat is produced in the material by the action of an electrostatic field.

The choice of the means of heating is usually determined by the characteristics of the material involved. If the material is a good conductor, such as the various metals, then it usually will be found that the electromagnetic field gives the best results. In an application of this type the object to be heated

SPECTRUM CHART OF INDUCTION HEATING



How Power Is Applied



Any material may be heated by placing it within an a-c electric field, inducing a voltage and causing sufficient current to flow. The field may be that surrounding a coil and this method of applying power is generally used where the material to be heated has relatively high conductivity. Or it may be the field existing between the plates of a capacitor, this method of applying power generally being most convenient where the material to be heated has relatively low conductivity

is placed in a coil of wire through which a heavy current is passing. The object therefore, is threaded by the magnetic lines of force produced by the current flowing in the coil and the alternation of the direction of these lines of force at a high rate induces a voltage in the material to be heated which, in turn, causes current to flow in the material. Presence of this current flowing through the resistance of the material produces a power loss which appears as heat in the material.

One of the earliest applications of this particular form of induction heating was made in the vacuum tube industry. In the manufacture of vacuum tubes it is necessary to heat up the elements within the tube in order to drive out any gas which may be occluded in them. This must be done while the tube is being evacuated, consequently it is not possible to accomplish this by external application of heat. The electromagnetic induction heating process was decided upon and has proved satisfactory for many years.

Other Types of Applications

Many other applications have been made of this particular type of induction heating. Some of these applications are currently in commercial use while others are still experimental. The following types of applications are typical:

(a) Heating vacuum tube elements.

(b) Heating crankshaft surfaces for surface hardening.

(c) Heating gears to provide surface hardening for the teeth.

(d) Heating tin-plated sheet steel to re-flow the tin.

(e) Heating rods prior to forging operations.

Applications of Electrostatic Heating

The electrostatic heating of materials has been, perhaps, more commonly known than the electromagnetic heating. It has been used for a number of years in demonstrations which have been shown to many thousands of people and which have aroused considerable popular interest. These demonstrations include popping corn and cooking the lowly hot dog by heat induced by electrostatic means. This process of getting heat in the material is usually applied to substances which are relatively poor conductors and which might more properly be classified as insulators. Such materials as wood, plastics, etc., come in this latter category.

The typical electrostatic induction heating apparatus employs a large capacitor in its load circuit which is made of two or more plates placed on either side of the material to be heated. The apparatus usually operates at a frequency higher than that used in the electromagnetic type of induction heating equipment.

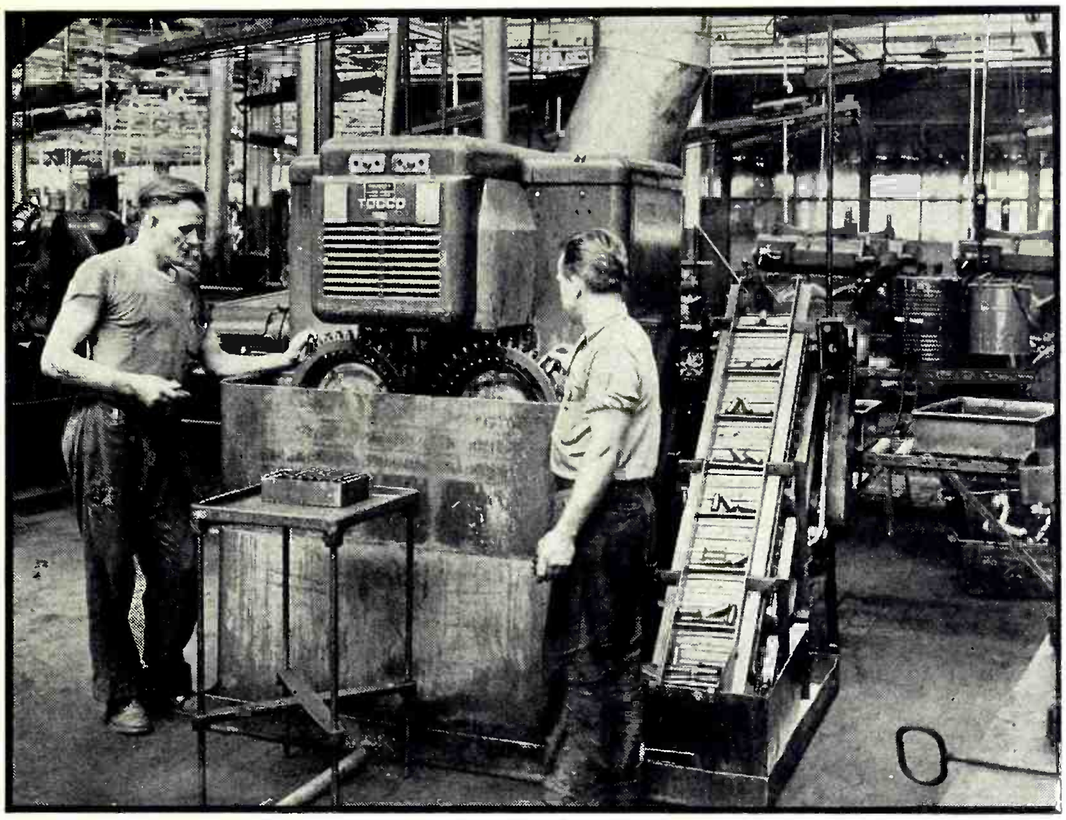
The application of the electrostatic type of induction heating equipment has been more varied than the electromagnetic type. There are applications of the type where heat is produced in materials such as plastics for the purpose of melting them. In other applications the heat is generated to hasten the drying of the material, such as wood or certain types of plastics. One example of this type is found in the application wherein a glue used to fasten two large surfaces is heated and dried by electrostatic induction heating. This results in considerable saving of time. Another class of application is made in certain cases where small insects or larva which are present in a host material are killed by passing them through a high frequency electric field. In this case it seems that death is brought about by heat generated in the insect itself. Still another type of application is that wherein heat is produced in a material for the purpose of changing the characteristics of it. Roasting peanuts is a good example of this type.

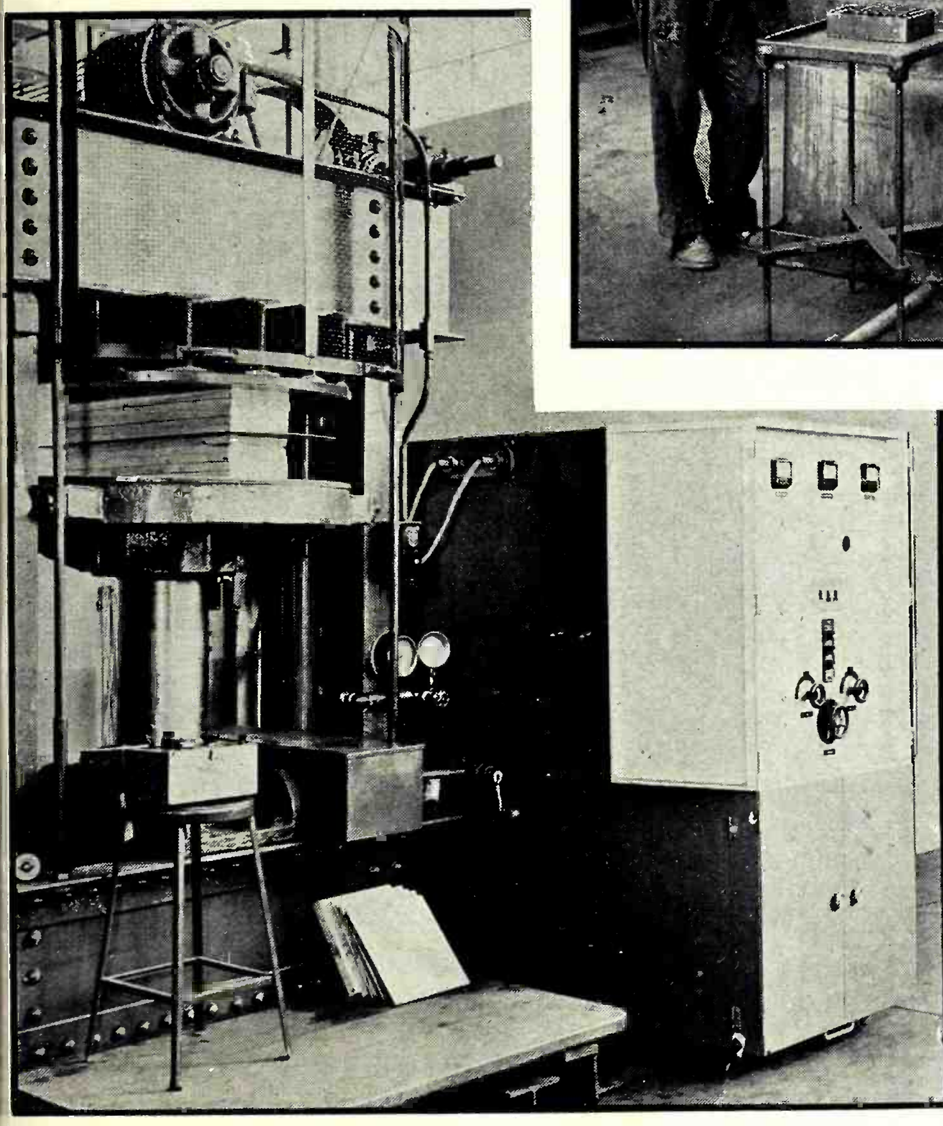
One type of induction heating which may be either electromagnetic or electrostatic in character is the fairly well known "radio therapy" equipment. The problems involved in this medical apparatus are well known and have been dealt with in other papers, and therefore will not be described further here.

The main characteristic of induction heating rests in the fact that the heat desired is produced directly in the place it is needed. This feature works advantageously in applications of the type where the material to be heated is not accessible, such as the elements of a vacuum tube. It is also advantageous in applications where otherwise heat has to be transmitted through other material.

Induction Heating Apparatus

The apparatus used for producing this radio-frequency power for use in heating by induction is comparatively simple. Fundamentally, it comprises a rectifier to convert commercial frequency power into direct-current power and an oscillator to convert the direct-current power into the desired radio-frequency power. The primary considerations in the design of this equipment are maintenance of continuity of operation and simplicity of operation to provide satisfactory service in the hands of inexperienced operating personnel. The frequencies used vary from about 15 kilocycles to 50 megacycles. This range does not impose any new problems to the designer. The power level is usually high, being in the order of hundreds of kilowatts. In this connection it is interesting to note that the total power used for radio-frequency induction heating today is probably in the order of 10,000 kw. (Editor's Note — Total installed power in broadcast stations in the U. S. is about 4,000 kw.) A single installation employing 3,600 kw is in the process of construction as this paper is being written.

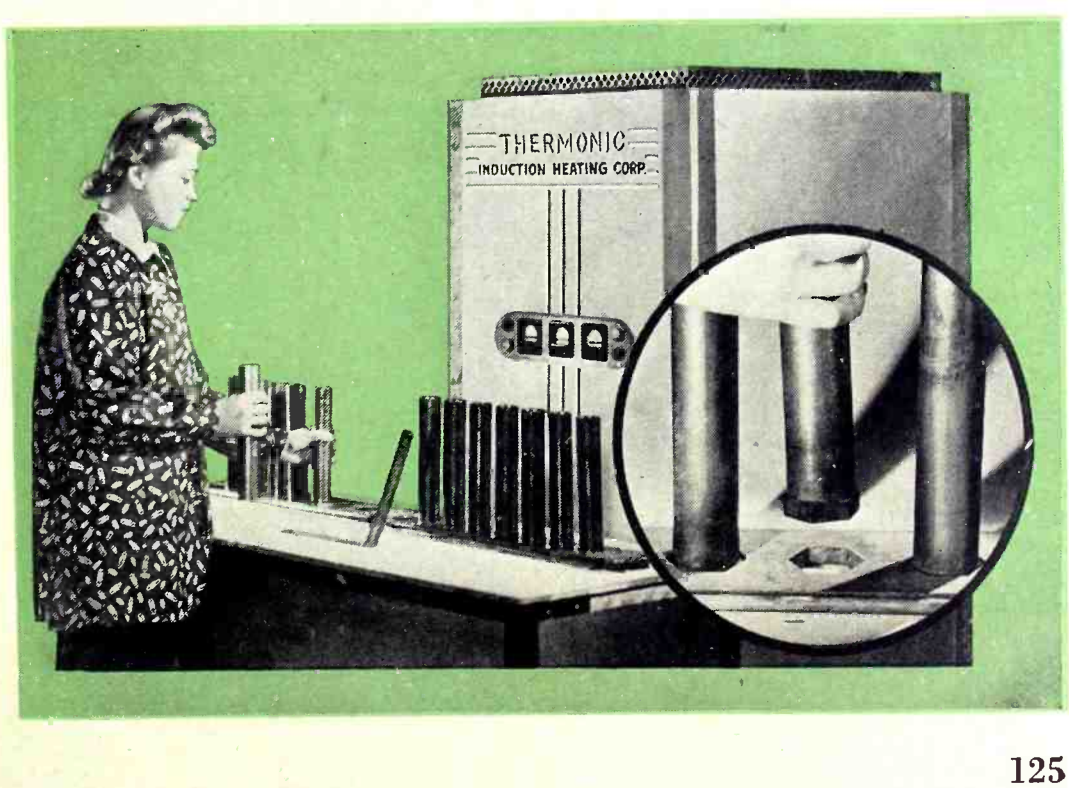




HARDENING METAL—(Above) This "Tocco" rotating machine type of generator turns out 3000-cycle power used to heat metal parts to 1500 deg. F, handling 70,000 per day. Not all induction heating apparatus employs tubes but continuation of the trend toward higher frequencies brings more and more of them into use

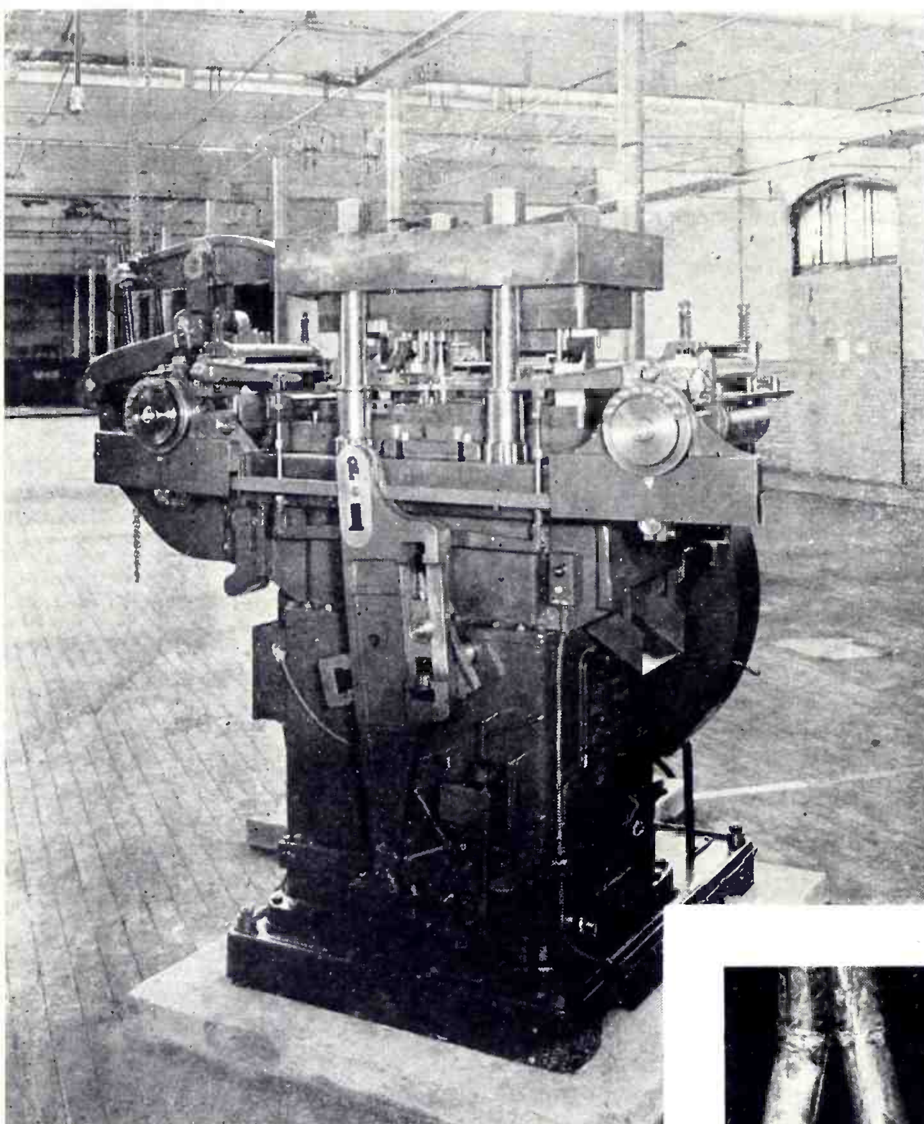
BONDING PLYWOOD—(Left) This medium-size, tube-type industrial heating unit built by the Girdler Corp. delivers 7 kw of high frequency power and is shown operating in conjunction with a developmental press in a plywood manufacturer's laboratory. Similar units turning out 600 kw or more have been built by the same company and are in use

BRAZING BOMBS—(Below) Here an Induction Heating Corp. electronic unit brazes the nose assemblies of seven 4-lb. incendiary bombs at once, single-turn power applicator coils raising the temperature to 1150 deg. F in 70 seconds



PRODUCTION CONTROLS aid the War Program

By using high-speed electronic devices to inspect parts of all kinds as they leave production lines, manufacturers of components are saving themselves and assemblers much time and material. Electronic gear is also helping to lengthen the life of many machines



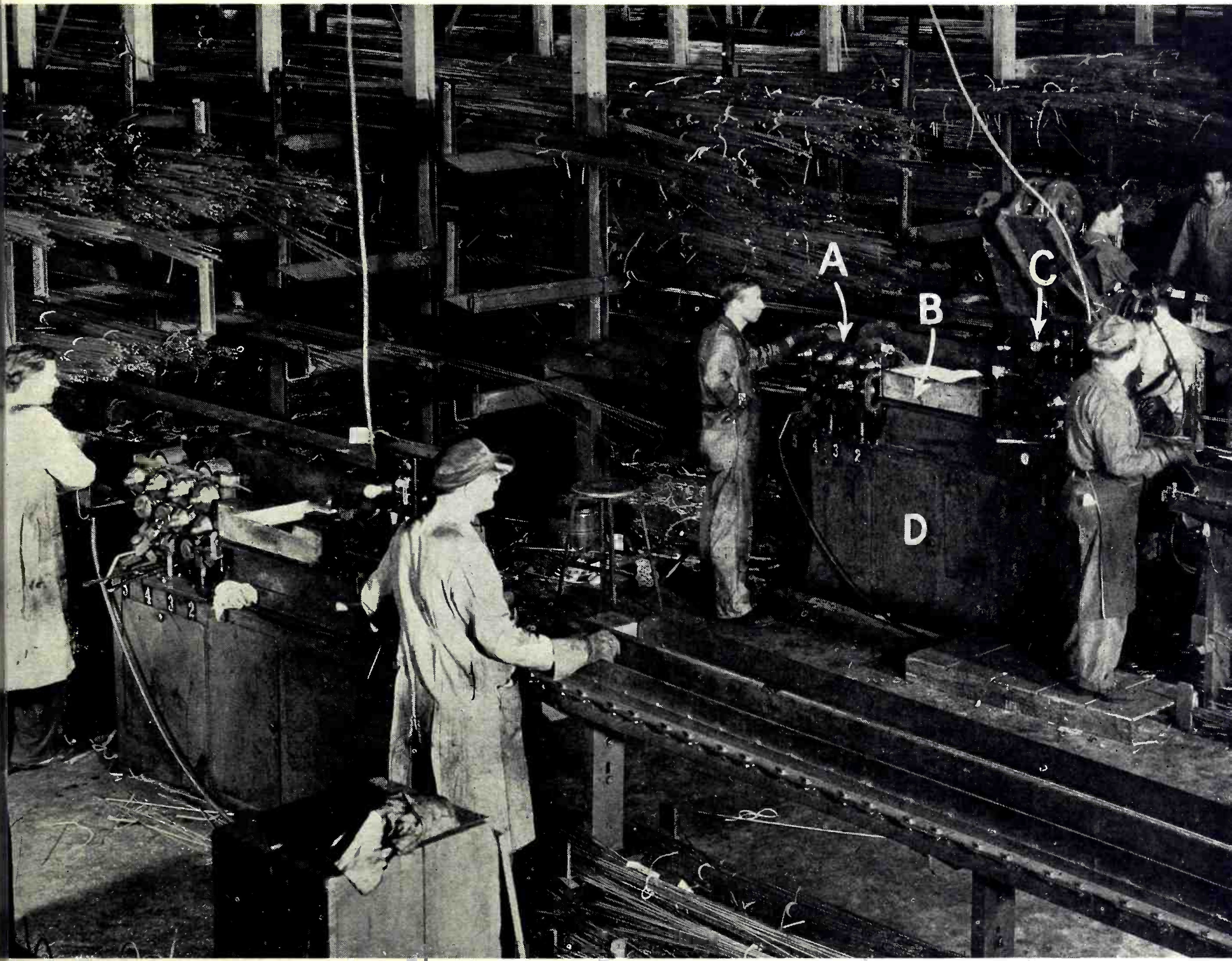
By **RALPH A. POWERS**

Bundy Tubing Company

ELECTRONIC EQUIPMENT is obviously playing an important part in the war production program. It is speeding up communications between government agencies and plants, between primary contractors and sub-contractors and between departments in individual factories. It is protecting plants against fire, explosion and burglary and, particularly, against deliberate acts of sabotage. It is safeguarding the arms and legs of workers operating machines under "forced draught." It is providing automatic control so that machines of many varieties may

PROTECTION — High-speed progressive punching machine of the type discussed by the author. Phototubes are used to make certain that metal strip fed to such machines is uniform to prevent breakage of dies

PROCESSING—Tubing is here fed into 240 kc induction heating apparatus which anneals the tips and facilitates later operations. The hood over the hairpin coil which applies power is used to carry away gases



INSPECTION—Two electronic flaw detectors at work at Bundy Tubing Co. automatically marking steel tubing at the rate of 300 feet per minute. A—Marking rollers operated by tube equipment. B—Magnetic unit with three balanced pickup coils. C—Pilot lamp assembly to indicate operation of equipment. D—Location of amplifiers and other electronic equipment

achieve a maximum rate of production with a minimum of human attention.

Electronic equipment is doing at least two other vital jobs in industry and these are our specific concern here. It is checking the quality of manufactured parts destined for use in critical gear as these parts leave production lines and it is protecting the precious machinery which turns parts out. Examples are too numerous even to list but we can describe a few applications and so indicate the general trend.

Detecting Tube Flaws

With the ever increasing use of brazed or welded tubing for gasoline lines, oil tubes and control lines, such tubing must be rigidly inspected for flaws in the brazing or welding operation as well as for flaws in the metallic structure itself. Voids between laps, in the case of multi-lapped steel tubing, must also be detected and rejected.

Electronic flaw detectors have been developed to accomplish rapid and automatic inspection of tubing. Tubing passes into a straightening device, then through "saturation" and "pickup" coils and out the other end of the test machine at the rate of 300 feet or more per minute. In the event a flaw is detected by electronic equipment located in the base of the machine an air-cylinder operates a crimping device which automatically marks the tubing at the location of the flaw.

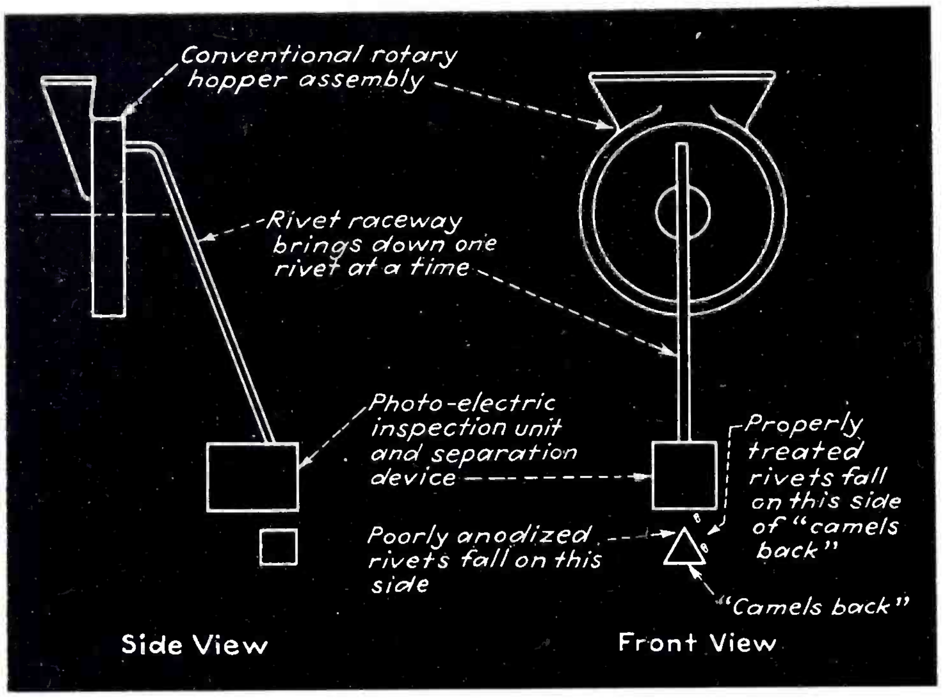
This same general type of high frequency, or magnetic, detection of flaws is being considered for steel bar stock used in automatic fabrication of other critical metal parts which must be made as flawless as possible.

Rivet Inspection

Recently, the problem of high-speed inspection of rivets came up in an important manufacturing plant. Thousands of rivets had to be inspected to see if they were properly "anodized". Electronics solved this problem.

After anodizing, the rivets are put through a dying process. Those that have been properly anodized change color to a dark green, while those that have received insufficient anodizing appear grayish in color or

HIGH-SPEED ELECTRONIC RIVET INSPECTOR



Poorly anodized rivets reflect less light from a lamp to a phototube than properly finished rivets and the resulting difference in phototube amplifier current operates a switch. The switch actuates an electromagnetic hammer, or a valve controlling an air-jet, in such a way that defective rivets are flicked or blown to one side as they leave the raceway

merely appear to be lacquered a transparent, slightly yellowish, color.

Following the general principle of photoelectric bean-sorting and rocksalt sorting, the difference in reflected light between rivets that have been properly anodized and those that have not been properly anodized is sufficient to permit detection and automatic sorting.

One of the major problems was to handle the large number of rivets per hour. This required a suitable means of hopper-feeding rivets so each individual rivet could be "scanned", or looked at, by a phototube and its associated amplifying equipment. The standard procedure is to use conventional rivet-hoppers of either the rotating type or the vibrating type, so that rivets fall in line and pass down a common raceway to automatic riveting machines. Photoelectric detection apparatus is installed at the end of this raceway.

Various types of ejection mechanisms can be used. These include high-speed solenoid air valves to blow the rivets to be rejected out of the way and high-speed hammers of the dynamic type, with suitable equipment for damping oscillations.

Protection of Dies

Where parts are stamped out of metal strips by high-speed presses, dies are frequently damaged due to irregularities in strip width and thickness and, particularly, non-uniformity of the metal with regard to hardness. Where fabrication of the metal strip involves lamination or welding prior to the performance of the stamping operation breakage of dies is particularly troublesome.

Such troubles are now minimized by "scanning" the width and thickness of metal strips by means of light-beam and phototube units as the strips pass to the press between guide rollers, the press being automatically stopped where material width or thickness is apt to cause die breakage. Unusually hard spots in metal strips caused by bad welds generally show up as black specks in the metal and the difference in the amount of light reflected from such specks and adjacent metal is readily detected by means of light-beam and phototube apparatus, again permitting the press to be automatically stopped before such hard spots reach the dies.

In certain industrial applications of high-speed die presses four or five separate light-beam and phototube units are used in the manner discussed above, all of these units being connected to a common vacuum tube amplifier in such a manner that almost any abnormal metal strip characteristic causes the press to be stopped before the metal reaches the dies. Similar safeguards are also included in some instances to prevent operation of the press in the event that pieces of metal fail to reject properly from either the male or female member of the die.

Induction Heating Control

When vacuum tube oscillators are used either for annealing materials or for continuous brazing, electronic time delays systems frequently control cyclic functions of the complete machine. Tube time delays may, for example, be arranged so that water cooling can be automatically turned on several minutes before heating starts. Water may also be left on for a definite period of time after the equipment has been turned off at the end of an operating cycle.

When annealing at high frequencies the ends of small pieces of monel or standard steel tubing such as that used for gasoline engine radiators, induction heating is incorporated within an automatic machine. Electronic time delays control the sequence of the machine, which forces short lengths of steel tubes through the induction heater and coils and, after required heating time, directly into a swedging operation which makes hex sections on the ends of the round tubes. Electronic time delays are used to insure that the gas in the hydrogen chamber has been turned on prior to starting of the process described and are also used to be sure that the tubing cannot be started from the rolling machines through the induction heater until preceding work has been cleared.

INDUSTRIAL APPLICATIONS

Involving Electronic Detection

By **ABRAHAM EDELMAN** *Photobell Corporation*

BALANCE — Westinghouse trues up electric motor rotors by running them in this electromagnetic unbalance detection machine using a vacuum tube amplifier

MANY of the most useful applications of electron tubes to industrial problems involve the simple fact that all such tubes can be made to act as *detectors* of the presence or absence of an object or of some characteristic of an object, or of certain physical changes in the object. For example the "electric eye"—popular term for the phototube—is a detector of light. A beam of light "detected" by a phototube is converted into an electric current. The ordinary tube as used in millions of home radio sets acts as a detector of electrical quantities, such as voltage, current power, etc. The Geiger-Müller tube, for example, is a detector for cosmic rays but has been put to numerous mundane uses. Its principle of operation differs markedly from that of either the phototube or the radio tube (which is essentially an amplifier)—but all three are electron tubes; and all three find use in industry.

It is but a step from *detection* of some physical change in an object or material to the *control* of the physical characteristics of that object or body. Thus in the recital to follow, of several uses of the phenomenon of detection, certain adaptations could make the detection system also act as a controlling system.

The Tube as a Detector

The ordinary radio tube requires that the device or characteristic to be detected produce a voltage change at the input to the tube. Therefore, there usually must be some sort of conversion device between the stimulus and the input to the tube. As a simple and most useful example, a microphone can be placed in the vault of a bank. This microphone is a device which converts sounds into voltages. Any intrusion into the vault, or even any intrusion on its surroundings may produce a noise which the microphone translates into a voltage which is amplified to any desired degree by an electron tube amplifier.

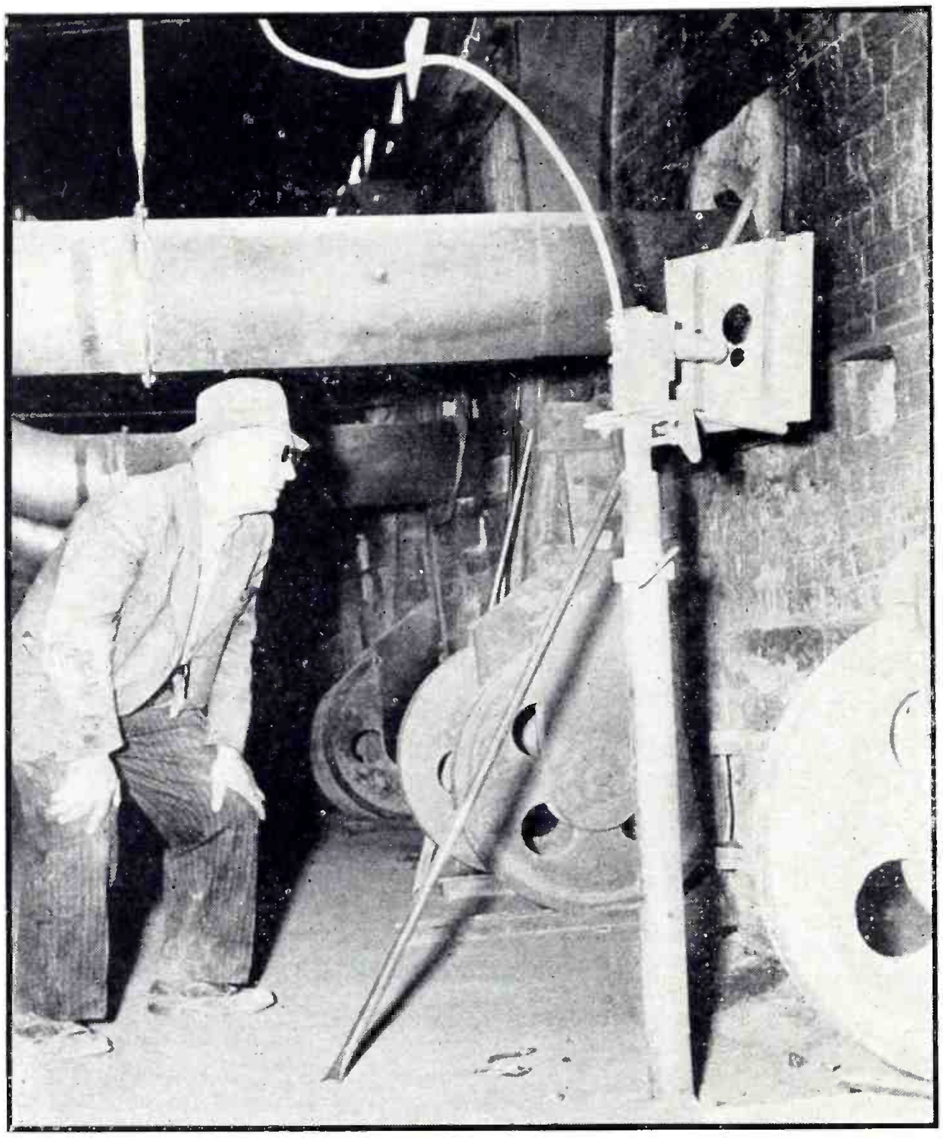
Another interesting application of the microphone-amplifier combination is its use to test the soundness of castings and forgings. The work to be tested is struck with a hammer and caused to vibrate audibly. A microphone picks up the sound, amplifies it and filters out harmonic frequencies so that the base frequency may be compared with a standard tone. Experiment has shown that a defective part will not vibrate the same as a good part and this furnishes a suitable basis for comparison.

Another electronic method for detecting soundness of work is frequently used for checking the perfection of seam welds. The weld is caused to pass directly under a coil through which high-frequency current is passing. This generates eddy currents in the welded parts, through the welded seam. As the seam passes under the coil, the eddy currents remain sensibly uniform until an unwelded portion is reached, whereupon the eddy currents are reduced because of the high resistance or partly open circuit encountered. When eddy current is reduced, a bridge circuit unbalances and an indicator or alarm operates.

The very fact that a tube will pick up radio programs out of the air indicates an interesting application. Broken insulators on power lines create sparks; these sparks act as miniature radio transmitters; a radio receiver in the vicinity will pick up these spark noises and by proper orientation of the antenna indicate the location of the broken insulator or other source of leakage of power.

Metal Detection

Electron tubes are widely used to detect metal. An early use was in prisons or other places where it was



TEMPERATURE—G-E phototube holder and optical system, trained into cement kiln for temperature control at Nazareth Portland Cement Company

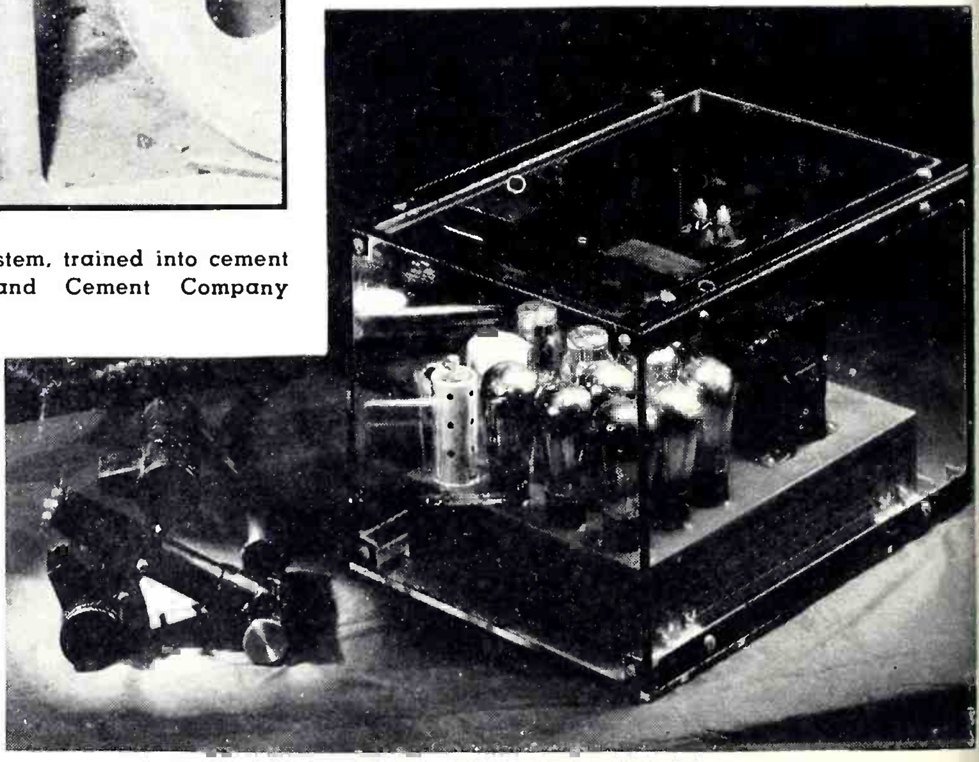
are all complete, it is easy to find these stripes by looking for them along the cut edges of the piled up cards.

In most or all of these cases where a tube is used to detect presence of objects unseen, or changes in the characteristics of a material, the tube translates the voltage stimulus placed upon it into a current or power change. This change in an electrical current may be indicated on a current-reading meter, or it may be used to supply power to operate a relay. The relay may turn on a light, ring a gong or perform any other desired function.

Capacity Relays

A combination of tubes and simple electrical or mechanical parts in proper fashion produces what is termed a "capacity relay." The electrical capacitance between two metallic objects insulated from each other, or between one such object and the ground, will change when the objects are approached by any person or object. This change in capacitance can be converted, by the amplifier tube, into an audible or visual alarm.

The application to a jeweler's showcase is obvious. Similarly capacity relays have been employed to open electrically-operated doors in locations at which phototubes could not operate; and to start a powder



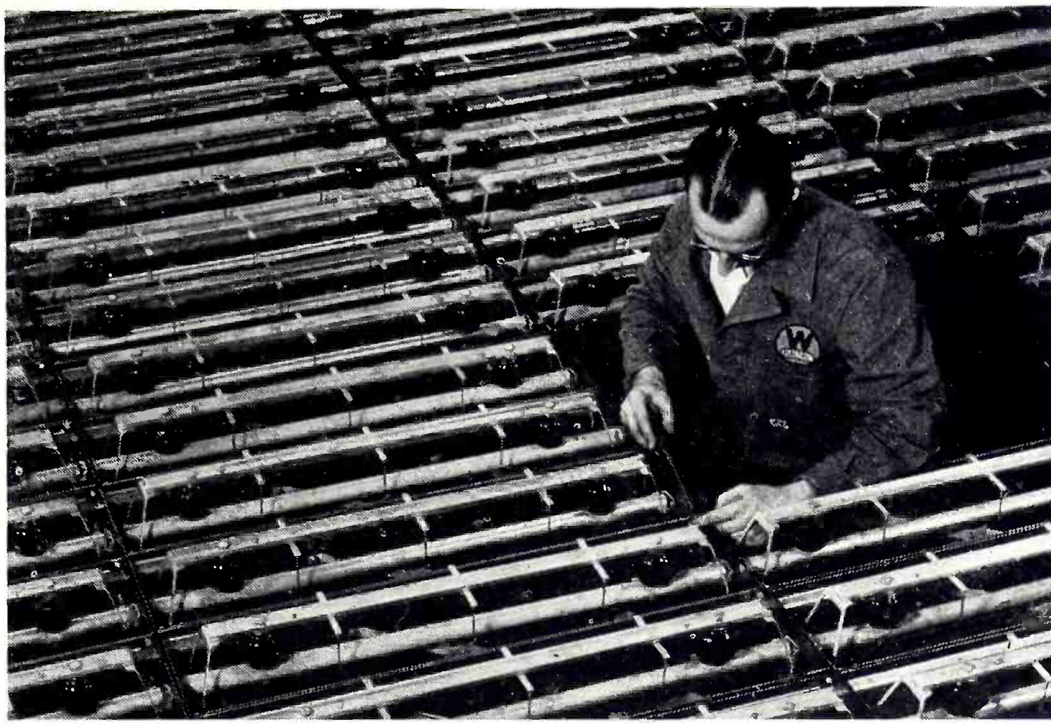
COLOR—Rock salt sorting device utilizing a phototube detector and a vacuum tube amplifier. Rapidly distinguishes variations in color, or size, or both

undesirable for any metal to be transported across a doorway. Any metal hidden on a person traversing the doorway can be detected without his knowledge or consent by simple electronic methods. The metal detector widely publicised because of its employment to locate shrapnel in the bodies of sneak attack victims at Pearl Harbor is another example. Somewhat similar devices have been utilized for locating metal underground, such as water pipes, or mineral wealth, or buried treasure. Similarly, metal detectors are employed to discover unwanted metal in furs and skins, rubber, paper and other materials handled in bulk.

In the manufacture of paper for employment as punched cards in tabulating machines it is important that there be no imbedded metal particles in the paper, because such particles will act in the same fashion as a punched hole, conduct electricity through the paper and so furnish a spurious operation. Metal particles enter the paper mash during its manufacture, often coming from the metal beaters which are used. To combat this difficulty, the paper is passed through a machine in which metal brushes rub against the paper. Although the paper may be travelling at speeds up to 400 feet per minute, a particle of metal capable of passing a micro-coulomb of electricity operates an amplifier connected to the metal brush; this energizes a relay and operates an inking device which makes a long ink stripe on the paper starting at the metal particle and extending for several feet. Later, when the cards

falling into a metal-foil lined paper bag when the bag has come into position under a spout from which the powder pours. A capacity relay performs a unique service by filling glasses properly. Two metal plates forming the capacitance are placed outside the glass in a machine intended to dispense milk at a school. A pump drives the milk into the glass, between the two plates, at a constant high speed until the capacitance between the two plates has increased to a value which operates a relay to stop the flow of milk. In addition to being absolutely sanitary, this method is faster than the previous methods, in which the milk was caused to seek its own level by a syphon system.

Instead of using capacitance, the electric field existing between two coils carrying an electric current may be utilized as the detecting agent. If the two coils are insulated from each other and made to form a part of an amplifier or oscillator circuit, any metallic object interposed between the coils will change the tube current and will operate a relay.



DUST—Electrostatic precipitators designed to rid air of dust and dirt use electronic principles, are more efficient than mechanical filters

High-speed Counters

Any of the methods outlined briefly above can be made to count objects by the simple expedient of using an electromagnetic counting device instead of a relay in the output of an electronic amplifier. Each time a tube gets an impulse on its input, the output current change will operate the counter.

Electron tubes are useful in all these applications for several reasons. For example, a tube requires practically no energy from the stimulus to make it work. Thus a tube will operate from sources of stimuli in which extremely little power exists. Yet, interposed between such a source of stimulus and a power relay, the tube acts as a power amplifier, increasing the original power to the point at which it will operate a relay.

Another reason why the tube is so important is the fact that it requires practically no time in which to operate. This is because the electrons traversing the tube have so little mass they can be accelerated to very high speeds in extremely short spaces of time.

For example, the usual mechanical counting machine will operate several hundreds of times a minute successfully. Electronic counters, on the other hand, will readily respond to half a million or more counts per minute. An interesting system has been developed for causing such an electronic circuit to operate a standard slow-operating counting unit. This consists of a circle of tubes so interconnected that the impulses to be counted reach all of them symmetrically. At any one impulse, only one of these tubes responds; and its response is such that it primes the next tube in line so that the latter will respond to the next impulse. Thus, each succeeding impulse causes the response to occur in another tube within the ring of tubes. There may be any number of tubes in a ring; for convenience, assume that there are ten. Then any one tube in the ring will operate from one tenth of the total number of pulses. The tenth tube is also connected to a second ring of ten tubes in such fashion that it furnishes the impulses to this entire ring. As a result, each tube in the second ring operates from one pulse in each hundred. A relay in the output of the final tube, therefore, operates on every hundredth impulse, and must operate only one hundredth as fast as if it actually recorded each and every impulse. It is just as accurate, however, as if each individual impulse caused the final counter to operate.

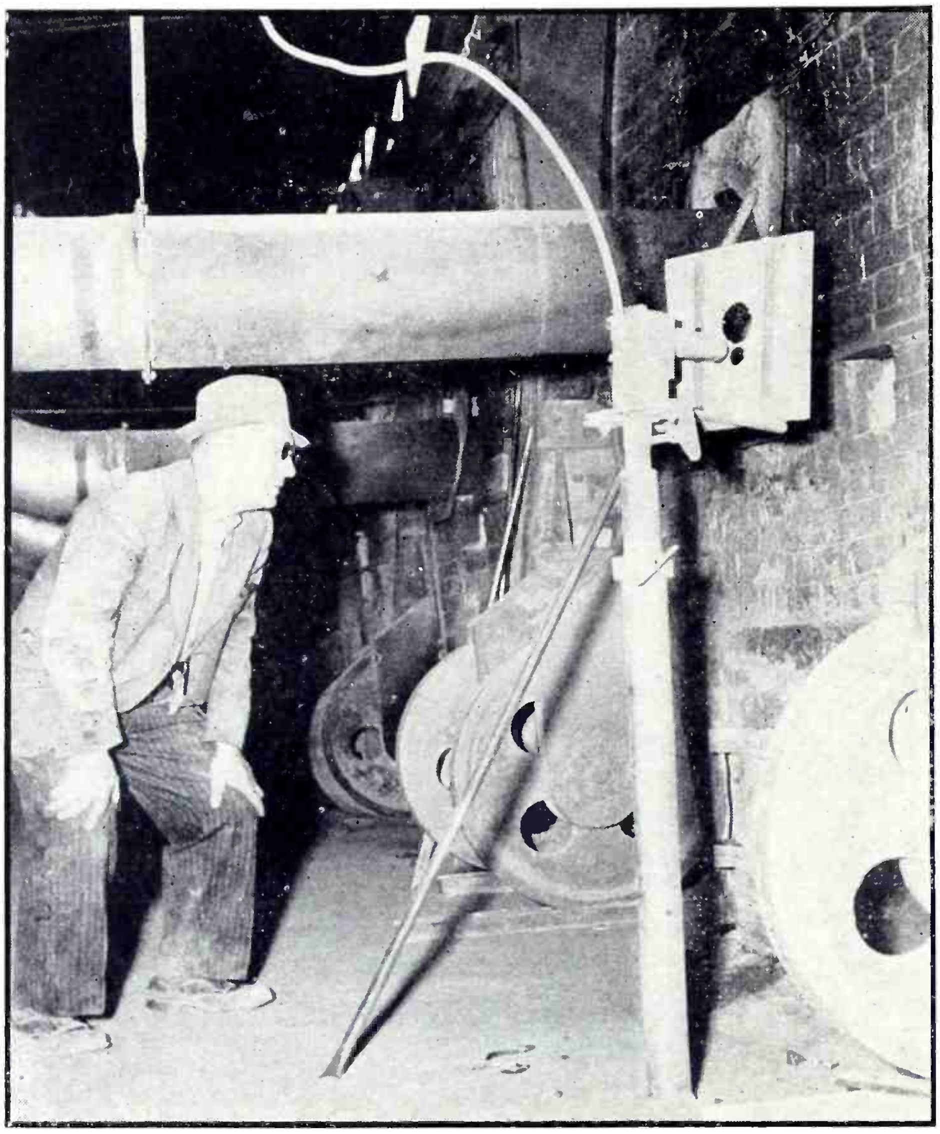
The high speed of operation of amplifier tubes has provided the means for an effective *precedance relay*, which can tell which of two events happened first, even though the time interval between the two events may be very short.

Phototube Detection Systems

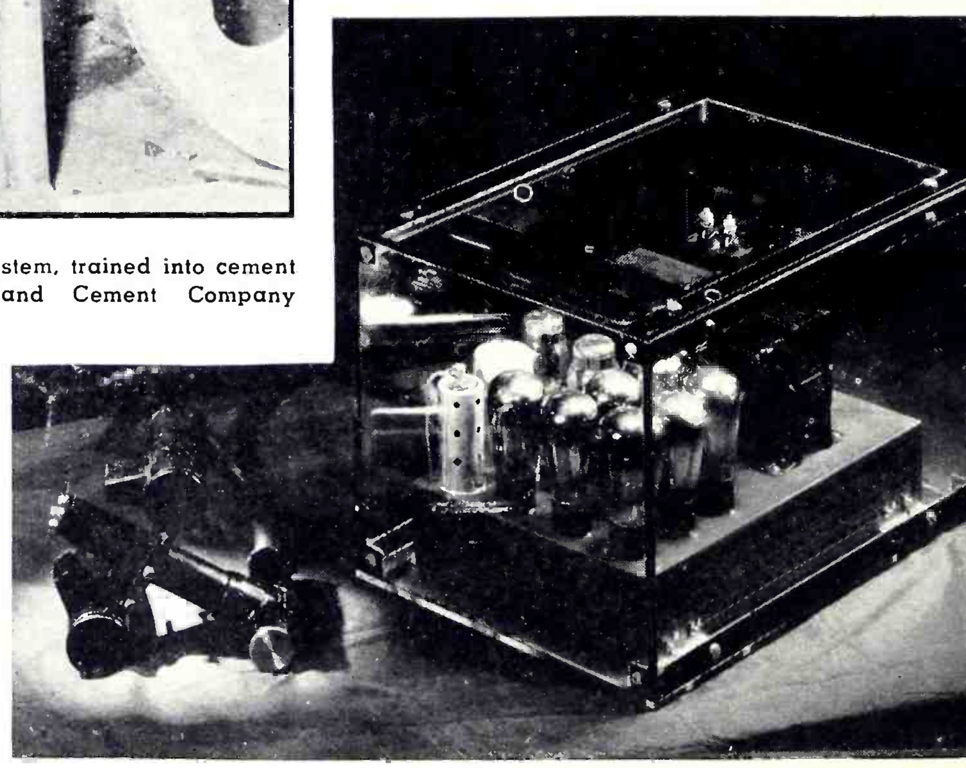
Since a beam of light shining into a phototube causes the latter to produce an electric current, which can be amplified in the types of tubes just described, it is only natural that detection or counting systems have been devised which utilize the flexibility of a light beam. All that is necessary is to shine the beam of light, invisible or visible, across the path along which the objects to be counted are passing. Each time the object eclipses the beam of light, the electric current from the phototube is interrupted, this change in current is amplified by the following tubes and caused to operate a relay or counting machine.

Phototubes can be used with colored filters so that they are responsive to certain colors and not to others. Then objects having the two colors, one for which the tube is sensitive and one for which the tube does not respond, may be separated or counted separately by a phototube-amplifier system.

Since the electric current generated by the phototube is in direct proportion to the amount of light shining on the tube, the phototube



TEMPERATURE—G-E phototube holder and optical system, trained into cement kiln for temperature control at Nazareth Portland Cement Company



COLOR—Rock salt sorting device utilizing a phototube detector and a vacuum tube amplifier. Rapidly distinguishes variations in color, or size, or both

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In most or all of these cases where a tube is used to detect presence of objects unseen, or changes in the characteristics of a material, the tube translates the voltage stimulus placed upon it into a current or power change. This change in an electrical current may be indicated on a current-reading meter, or it may be used to supply power to operate a relay. The relay may turn on a light, ring a gong or perform any other desired function.

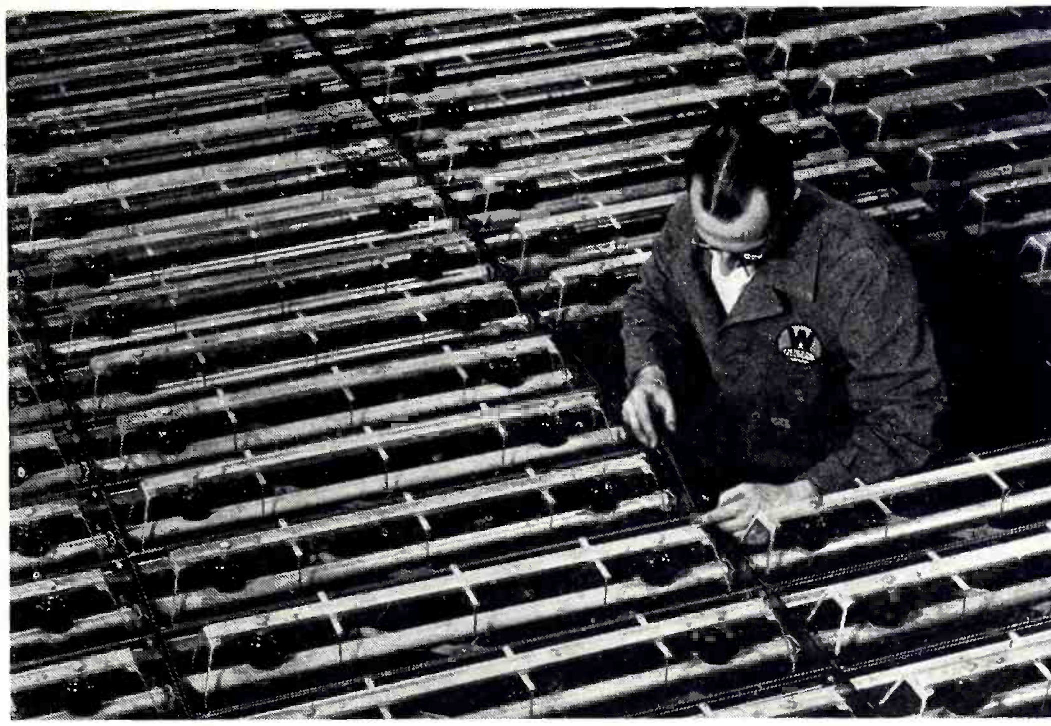
Capacity Relays

A combination of tubes and simple electrical or mechanical parts in proper fashion produces what is termed a "capacity relay." The electrical capacitance between two metallic objects insulated from each other, or between one such object and the ground, will change when the objects are approached by any person or object. This change in capacitance can be converted, by the amplifier tube, into an audible or visual alarm.

The application to a jeweler's showcase is obvious. Similarly capacity relays have been employed to open electrically-operated doors in locations at which phototubes could not operate; and to start a powder

falling into a metal-foil lined paper bag when the bag has come into position under a spout from which the powder pours. A capacity relay performs a unique service by filling glasses properly. Two metal plates forming the capacitance are placed outside the glass in a machine intended to dispense milk at a school. A pump drives the milk into the glass, between the two plates, at a constant high speed until the capacitance between the two plates has increased to a value which operates a relay to stop the flow of milk. In addition to being absolutely sanitary, this method is faster than the previous methods, in which the milk was caused to seek its own level by a syphon system.

Instead of using capacitance, the electric field existing between two coils carrying an electric current may be utilized as the detecting agent. If the two coils are insulated from each other and made to form a part of an amplifier or oscillator circuit, any metallic object interposed between the coils will change the tube current and will operate a relay.



DUST—Electrostatic precipitators designed to rid air of dust and dirt use electronic principles, are more efficient than mechanical filters

High-speed Counters

Any of the methods outlined briefly above can be made to count objects by the simple expedient of using an electromagnetic counting device instead of a relay in the output of an electronic amplifier. Each time a tube gets an impulse on its input, the output current change will operate the counter.

Electron tubes are useful in all these applications for several reasons. For example, a tube requires practically no energy from the stimulus to make it work. Thus a tube will operate from sources of stimuli in which extremely little power exists. Yet, interposed between such a source of stimulus and a power relay, the tube acts as a power amplifier, increasing the original power to the point at which it will operate a relay.

Another reason why the tube is so important is the fact that it requires practically no time in which to operate. This is because the electrons traversing the tube have so little mass they can be accelerated to very high speeds in extremely short spaces of time.

For example, the usual mechanical counting machine will operate several hundreds of times a minute successfully. Electronic counters, on the other hand, will readily respond to half a million or more counts per minute. An interesting system has been developed for causing such an electronic circuit to operate a standard slow-operating counting unit. This consists of a circle of tubes so interconnected that the impulses to be counted reach all of them symmetrically. At any one impulse, only one of these tubes responds; and its response is such that it primes the next tube in line so that the latter will respond to the next impulse. Thus, each succeeding impulse causes the response to occur in another tube within the ring of tubes. There may be any number of tubes in a ring; for convenience, assume that there are ten. Then any one tube in the ring will operate from one tenth of the total number of pulses. The tenth tube is also connected to a second ring of ten tubes in such fashion that it furnishes the impulses to this entire ring. As a result, each tube in the second ring operates from one pulse in each hundred. A relay in the output of the final tube, therefore, operates on every hundredth impulse, and must operate only one hundredth as fast as if it actually recorded each and every impulse. It is just as accurate, however, as if each individual impulse caused the final counter to operate.

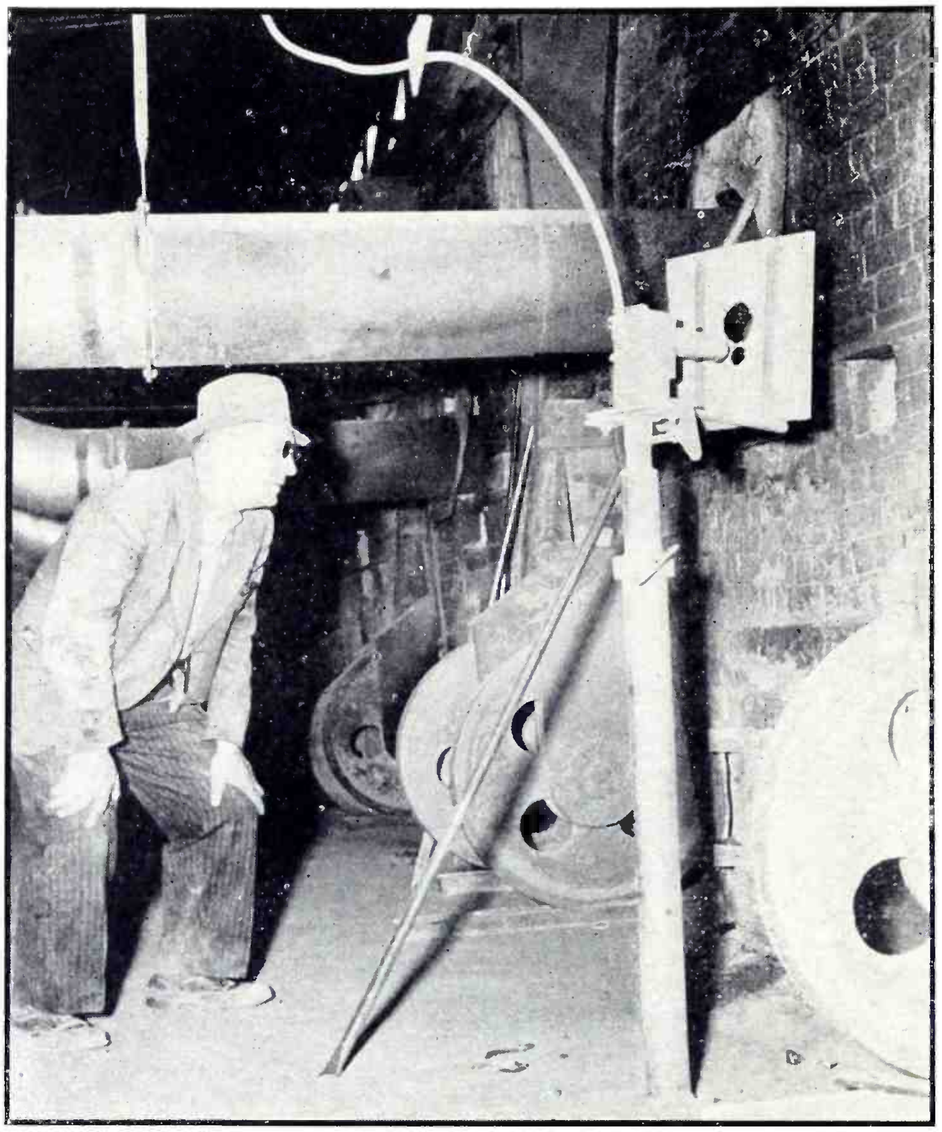
The high speed of operation of amplifier tubes has provided the means for an effective *precedance relay*, which can tell which of two events happened first, even though the time interval between the two events may be very short.

Phototube Detection Systems

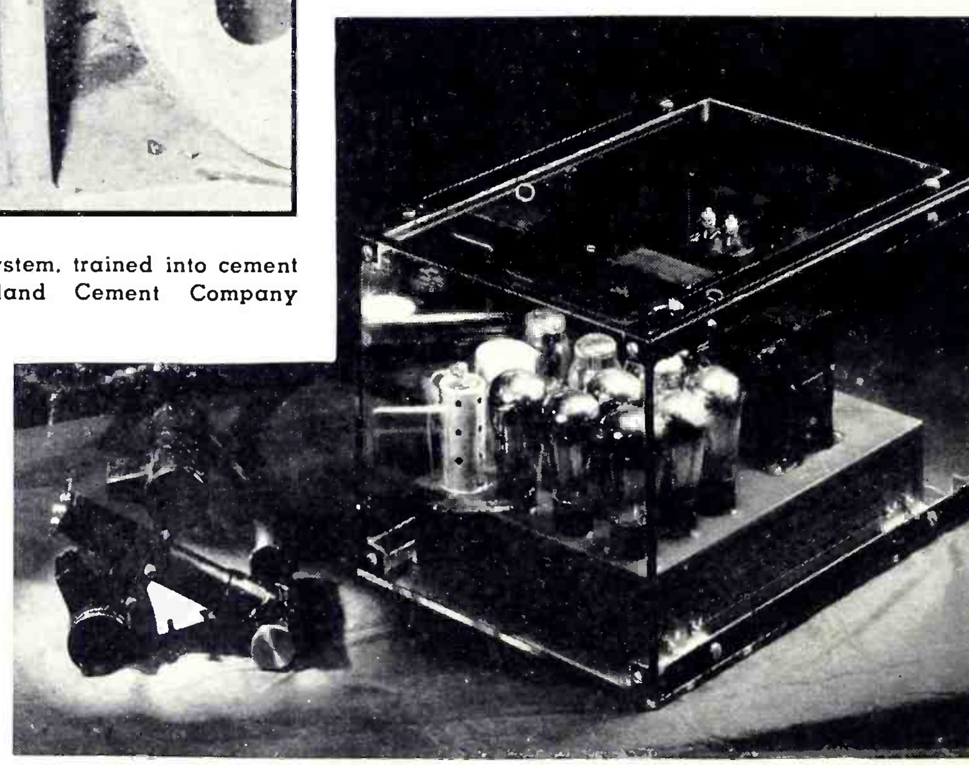
Since a beam of light shining into a phototube causes the latter to produce an electric current, which can be amplified in the types of tubes just described, it is only natural that detection or counting systems have been devised which utilize the flexibility of a light beam. All that is necessary is to shine the beam of light, invisible or visible, across the path along which the objects to be counted are passing. Each time the object eclipses the beam of light, the electric current from the phototube is interrupted, this change in current is amplified by the following tubes and caused to operate a relay or counting machine.

Phototubes can be used with colored filters so that they are responsive to certain colors and not to others. Then objects having the two colors, one for which the tube is sensitive and one for which the tube does not respond, may be separated or counted separately by a phototube-amplifier system.

Since the electric current generated by the phototube is in direct proportion to the amount of light shining on the tube, the phototube



TEMPERATURE—G-E phototube holder and optical system, trained into cement kiln for temperature control at Nazareth Portland Cement Company



COLOR—Rock salt sorting device utilizing a phototube detector and a vacuum tube amplifier. Rapidly distinguishes variations in color, or size, or both

undesirable for any metal to be transported across a doorway. Any metal hidden on a person traversing the doorway can be detected without his knowledge or consent by simple electronic methods. The metal detector widely publicised because of its employment to locate shrapnel in the bodies of sneak attack victims at Pearl Harbor is another example. Somewhat similar devices have been utilized for locating metal underground, such as water pipes, or mineral wealth, or buried treasure. Similarly, metal detectors are employed to discover unwanted metal in furs and skins, rubber, paper and other materials handled in bulk.

In the manufacture of paper for employment as punched cards in tabulating machines it is important that there be no imbedded metal particles in the paper, because such particles will act in the same fashion as a punched hole, conduct electricity through the paper and so furnish a spurious operation. Metal particles enter the paper mash during its manufacture, often coming from the metal beaters which are used. To combat this difficulty, the paper is passed through a machine in which metal brushes rub against the paper. Although the paper may be travelling at speeds up to 400 feet per minute, a particle of metal capable of passing a micro-coulomb of electricity operates an amplifier connected to the metal brush; this energizes a relay and operates an inking device which makes a long ink stripe on the paper starting at the metal particle and extending for several feet. Later, when the cards are all complete, it is easy to find these stripes by looking for them along the cut edges of the piled up cards.

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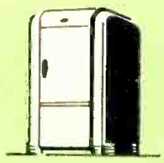
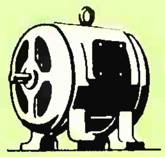
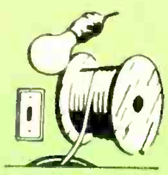
Electronic Equipment used by

THREE MAJOR INDUSTRIES*

ELECTRICAL MANUFACTURING







COMMUNICATIONS

Radio receivers
Intercommunication systems

CONTROL and PROCESSING

Welding timers
Temperature controllers
Flame controls
Smoke detectors
Electronic switches
Vacuum tube relays
Induction bombarders
Balancing machines
Bactericidal lamps

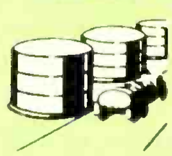
MEASUREMENT

Cathode ray oscilloscopes
Vacuum tube voltmeters
Signal generators
R-C oscillators
Beat frequency oscillators
Square wave generators
Tuning fork drivers
Wave analyzers
Sound meters
Stroboscopic devices
Capacitance bridges
Megohm bridges
Vacuum tube electrometers
Time gauges
Integrating flux meters
Electron microscopes

MISCELLANEOUS

Vacuum tube amplifiers
Constant voltage power supplies
Mercury vapor rectifiers

PETROLEUM FIELD



COMMUNICATIONS

Radio receivers
Radio transmitters
Ship to shore equipment
Land line repeaters
Public address equipment

CONTROL and PROCESSING

Electronic timers
Vacuum tube relays
D-C motor speed controls
Temperature controls
Welding controls
Specialized locating equipment
Specialized well-shooting equipment
Sonic fluid level indicators
Seismograph recording equipment

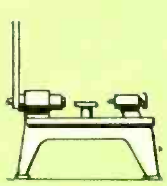
MEASUREMENT

Cathode ray oscilloscopes
Stroboscopic devices
Vacuum tube voltmeters
Recording type impedance meters
Recording type low potential meters
Signal generators

MISCELLANEOUS

Amplifiers
Rectifiers
Geophones

MACHINERY MAKERS



COMMUNICATIONS

Radio receivers
Carrier current relays
Carrier current telemetering
Public address systems
Intercommunication systems
Sound recording equipment

CONTROL and PROCESSING

Welding timers
Alternator controls
Temperature controls
Electronic switches
Vacuum tube time delays
Photoelectric relays
Conveyor controls
Induction heating equipment

MEASUREMENT

Bearing noise testers
Mechanical movement recorders
Densitometers
Score testing devices
Cathode ray oscilloscopes
Vacuum tube voltmeters
Sine wave oscillators
R-C oscillators
Beat frequency oscillators
Megohm bridges
A-C bridges
Recording microammeters
Sound level meters
Wave analyzers
Stroboscopic devices
Surface analyzers

MISCELLANEOUS

Audio amplifiers
Electronic voltage regulators
Rectifiers

* Partial list from an editorial survey of typical companies

can be used as a measure of the amount or intensity of light impressed upon the tube. Many thousands of light-measuring instruments and photographic exposure meters in use furnish sufficient evidence of the success of this type of instrument.

Photoelectric devices are most frequently used where *seeing* has been the essential task; and at the moment there are more of these routine jobs being taken over by electronic devices than the casual reader would imagine. Photoelectric equipment is now being used to count cartons, to route them according to size or shape or color or weight, for inspecting them to see if proper labels have been affixed, for synchronizing the flow of work between machines; and in literally thousands of similar tasks.

Detection Extended to Control

Since electron tubes can be made to detect presence or absence of objects or changes in the characteristics of materials, and will operate an alarm when certain undesired changes occur, it is only a simple inventive step to realize that the alarm can be made to perform a more useful task than merely to inform an operator that something has gone wrong. Instead of the audible or visual alarm, one may use a valve which turns on or off water, or steam, or a flow of any material or one may perform practically any other *control* function desired. These systems may be made self-monitoring so that when something goes wrong with the system, no damage occurs.

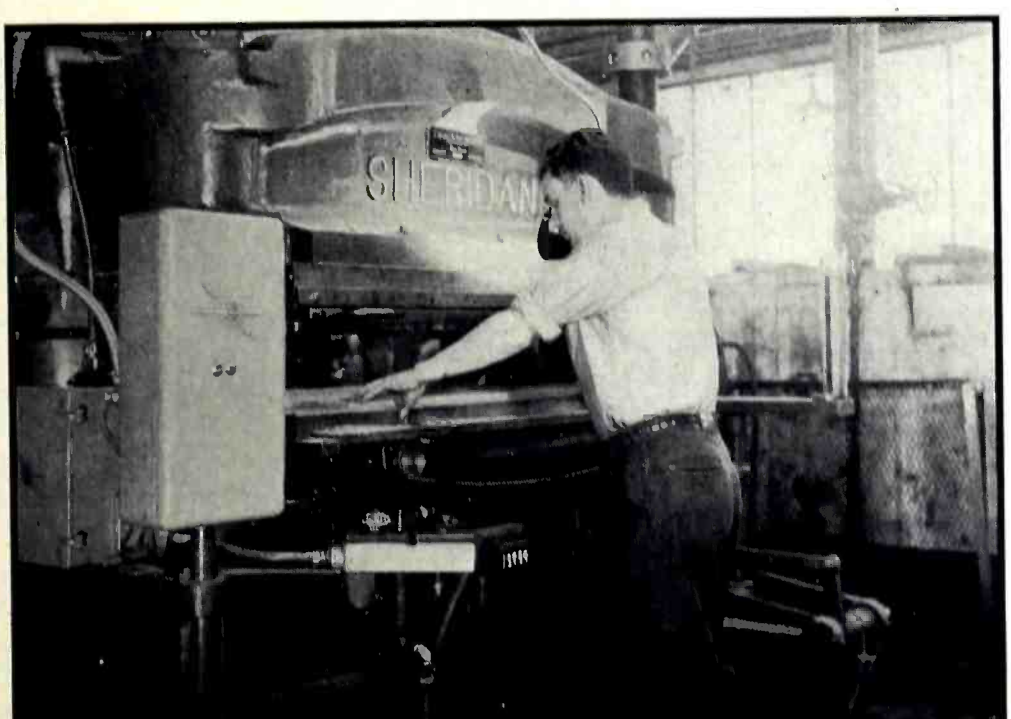
Detection devices are frequently capable of replacing personnel; and in times of labor shortage as at present, their value may not be measured in terms of money alone. There are many jobs being done electronically and automatically today that were formerly accomplished less efficiently by manpower, as some of the following examples will show. The trend today is toward fully automatic machines where previously it was toward machines with operators to feed something here, adjust something there. It is no uncommon sight inside a progressive factory to find assorted machines working away unattended, at tasks that personnel could do only with experience and attention of a high order. The electronic robots of our present-day factories are enormously increasing the war effort, without fatigue or wage.

An entire class of such devices may be described by furnishing an example. A factory employs a large, complicated machine to manufacture very large size bags by cutting the paper from a roll, folding it up, and gluing it together. Various causes make the paper jam up in the machine occasionally; sometimes the paper is imperfect, at other times the humidity is to blame. An operator is required to watch each section of the machine, and instantly to press a stop button when something goes wrong. If the operator is not fast enough, then the bags wrap themselves around parts of the machine, and cause considerable damage. To correct this situation, photoelectric devices have been installed to replace the watchers. They shut off the power instantly if the bag does not show up during its allotted time at the right place between certain rollers, and sound an alarm so that no time need be lost for the difficulty to be corrected and the machine restarted.

The layman is familiar with the photoelectric door operator, which causes the door at a railroad station, hotel, showroom, restaurant, etc., to open as someone approaches it. This apparently personal attention is usually obtained through the agency of three photoelectric devices and their associated equipment. A beam of light is intercepted as a person approaches the door, and this causes the door to open. Some people may stop in the doorway or walk slowly, and therefore a second beam of light is provided in such position as to be intercepted during the entire time that the person is passing through. Finally, a third beam of light is provided so that it will be intercepted when the person has fully passed through the door, and is departing. This initiates a closing operation for the door. Many design details have been improved in these doors through the years of experiment with them, so that today they are quiet in operation, free from operating troubles to a large extent, and are not a hazard to the pedestrian in any sense.

The layman probably does not know that there are far more doors of this type employed to save time and money than there are for luxurious atmosphere. Restaurants were among the first to recognize that waitresses could use them to great advantage in passing between kitchen and dining room. Today, the noise and odors of the kitchen are kept out of the dining room while

(*Continued on page* 220)



DETECTOR—Here an Electronic Control Corporation device using phototubes prevents operation of an embossing press if the operator's arms are in danger

POWER COMPANY Uses of Electronic Equipment

Tubes probably find a wider variety of applications in the electric utility field than in any other. Virtually every function they can perform is utilized in one way or another. Data concerning this particular industry is, therefore, especially informative

THE electron tube has been accepted with enthusiasm by the electric power industry. Things are done in power systems through the use of tubes which were formerly impossible or at least inefficiently accomplished by other means.

The demands placed upon the field of electronics by the power industry are extremely varied and cover a wide range of power handling requirements. There are many applications for sensitive and weak current devices on the one extreme while on the other extreme we find mercury arc rectifiers and frequency converters handling thousands of kilowatts. The weak current devices are represented by photoelectric controls, synchroscopes, relays, communication equipment, amplifiers and many other specialized designs. The medium power class of equipment is along the line of automatic battery chargers, voltage regulators and exciters and governor controls for the large power station generators. In the heavy power bracket falls the controlled mercury arc rectifiers and also frequency changers for converting large amounts of power from one frequency to another for more efficient use of the power on electric traction systems. The grid controlled rectifier is rapidly replacing rotary converter equipment in many phases of the power field. The ease of voltage control and the speed of response to the control is superior to rotary machine operation. Those of us who have been most closely associated with the low power applications of tubes have a tendency to overlook the fact that these high power tubes are true electronic devices and are fundamentally the same as the small and popular types. It is true that the large tank-type mercury arc rectifiers do not resemble the familiar form and appearance of the regular tube, yet many of the design difficulties were overcome in the small types, thus making the large ones successful. The success and reliability of operation provided by the smaller types of tubes have been the incentive for the wide adoption of tubes, both large and small.

TYPICAL APPLICATIONS *

WEAK CURRENT

- Radio transmitters
- Radio receivers
- Carrier-current transmitters
- Carrier-current receivers
- Carrier-current relays
- Carrier-current switching equipment
- Telemetering of voltage
- Telemetering of current
- Telemetering of wattage
- Telemetering of pressure
- Telemetering of temperature
- Telemetering of water level
- Telemetering of frequency
- Location of cable faults
- Location of pipe faults
- Control of phase-angle
- Control of loads
- Alarms for over-voltage
- Checking of wattmeters
- Protection of property . . . .

MEDIUM CURRENT

- Charging batteries
- Testing cable
- Testing insulation
- Testing rubber gloves
- Regulating voltage, current
- Exciting generators
- Eliminating smoke . . . .

HEAVY CURRENT

- Mercury-arc rectification
- Frequency conversion
- Electrolytic processing
- D-c transmission . . . .

*Partial list.

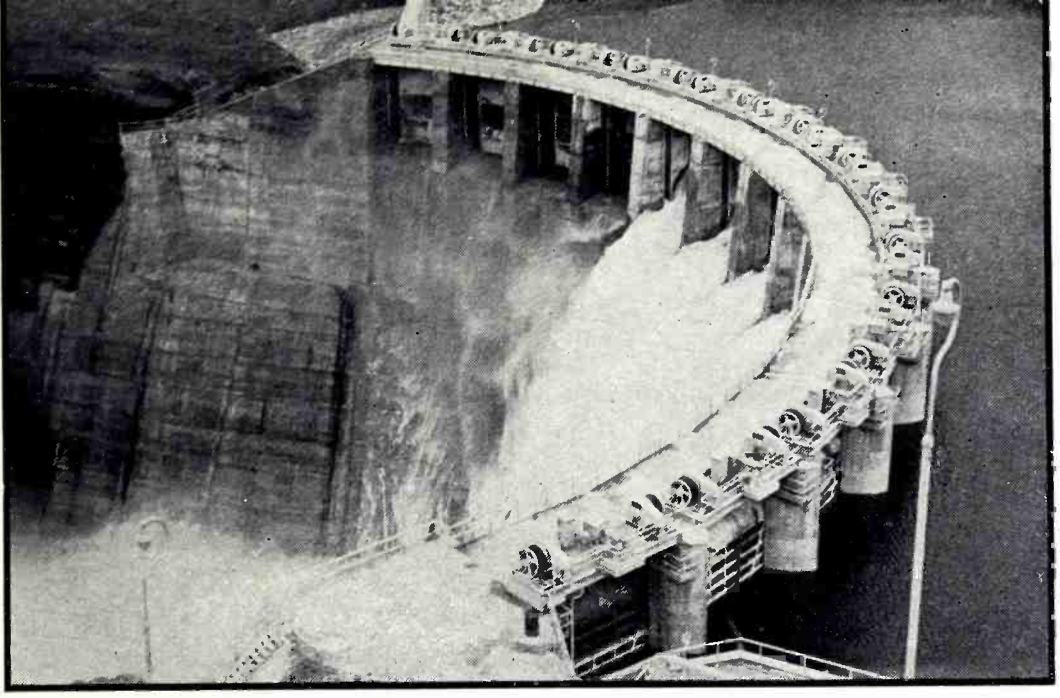
Factors Affecting the Adoption of Tubes

The general acceptance of electronics in power systems has been impeded because in power work the old equipment has, in most cases, been doing a good job for many years and would be expensive to modernize. With machinery which has been designed to work with the electronic control circuits the full advantages are obtained from the new circuits, and the original installation is made with the goal of maximum over-all efficiency in mind. However, since much of the equipment in use today was installed before the electron tube was considered to be useful in power systems, the process of adapting this older equipment to new control circuits becomes more difficult. There have been some installations on the old machinery to help make up for the shortcomings under the steadily rising standards of operation. These additions which have resulted in more accurate frequency control, closer and faster voltage regulation and other advantages obtained through the use of automatic controls and telemetering, are possible only by employing the sensitive and inertialess electron tube.

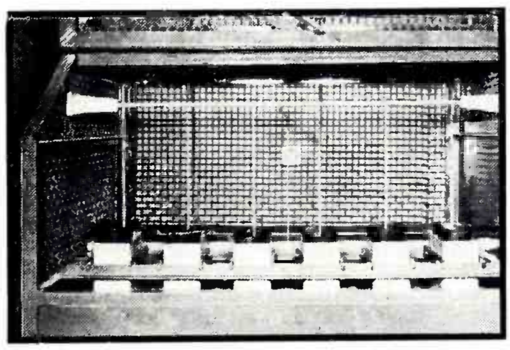
Another factor which slowed up the acceptance of tubes by power systems has been the natural and justified reluctance of power engineers to the use of the new equipment. The tube has had to prove that it is out of the gadget stage and is now in a position to take over responsible applications without danger of fail-

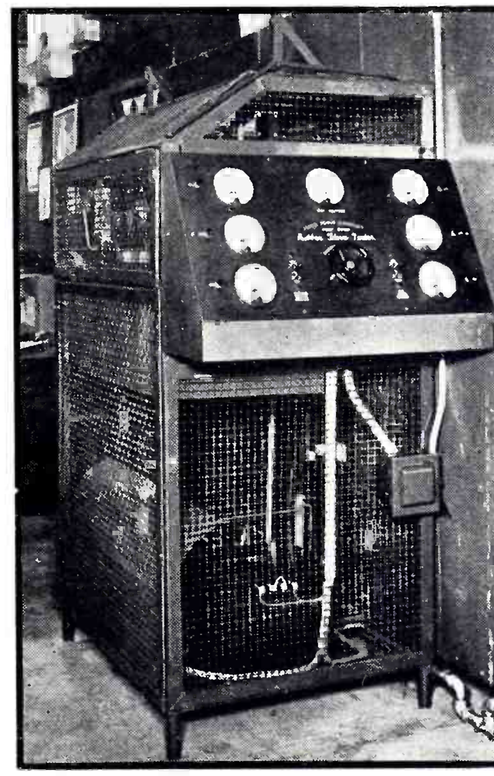
By W. H. BLANKMEYER

The Montana Power Company



CONTROL—Electronic governors open and close gates at this power dam





SAFETY—Rubber glove tester designed by Leonard W. Walker of the Idaho Power Company. 15,000 d-c. volts is applied in series with a milliameter and when leakage exceeds a safe value the gloves are discarded. Contact is made by filling gloves with water and then partially submerging them in water, chains lowered into the water within each glove constituting one connection and the tanks the other connection. Six gloves may be tested at once

ure or of excessive maintenance. With regard to the maintenance factor, experience has shown that the maintenance of electronic equipment is usually less than other types of equipment doing the same job. Also it is easier to avoid future trouble in electronic equipment through periodic testing than by inspection of regular old style equipment.

A third factor which slowed the development of the field was the tube licensing situation. The tube patents were so interlocked that it was impossible for any one manufacturer to build tubes and equipment for power system use without infringing on several other patents. Consequently, development was almost at a standstill until the exchange of several patents cleared up this difficulty to every one's satisfaction.

Development of Electronic Applications

In the early days of electric power generation and distribution it was not practical to transmit power over great distances. The generating plants had to be located at or near the load center and a sufficient number of plants provided in the densely populated areas so that the power need not be transmitted far.

The operation of such plants as compared with present day problems was comparatively simple. It was not necessary to employ complicated protective relay systems, communication networks, telemetering and numerous other modern devices to maintain the required standards of customer service. This ease of operation was partly due to the fact that there were but few industrial loads so that a short power outage was not a serious occurrence. However, during the time of these early systems a need was felt for many of the modern developments.

The development of the long distance high voltage alternating current transmission line changed the entire picture of the power system. The electric power could be generated at the source of water power or near a conveniently available fuel supply. This major developmnt complicated the power system enormously. For example, it became necessary to have some form of communication system to carry load dispatching orders, line clearances to facilitate repairs and for routine business conversations.

The telephone and telegraph lines provided the only communication along these early day transmission lines. The telephone conductors were generally supported on the same pole or structure as the power conductors. The result of this practice was that the tight coupling with the power circuit caused such a high noise voltage to be induced in the telephone circuit that it was usually impractical to maintain high standards of transmission. This noise and the high long-line attenuation can now be overcome by the use of high level audio transmission using special amplifiers and repeaters, or by employing carrier current.

Another power system complication resulting from the change to long transmission lines was the need of adequate equipment protection in the form of automatic switching. Long transmission lines are extremely vulnerable to lightning, sleet, wind, floods, etc.

When a phase to phase or phase to ground flash-over occurs on a high voltage line a serious disturbance occurs which must be cleared very quickly to prevent damage to the associated equipment and to prevent a general shut-down. This automatic clearing is accomplished or aided economically and efficiently by the use of a carrier signal.

In the event of a disruption of the power line it usually means that the telephone line is also put out of service, since they are both mounted on the same structures. To alleviate this difficulty it is now common practice to provide lines over which both

(*Continued on page* 169)

GEOPHYSICS . . .

Scientific Exploration for OIL

SHOT—Reflection seismograph setup; rig for drilling 50 to 100-foot holes; shooting-truck for controlling and transmitting instant of explosion; recording truck. This shot was taken a few seconds after the explosion of the dynamite

The geophysicist has had to draw freely from the electronic art in developing the various prospecting methods used in the search for the subsurface geological anomalies with which oil and gas deposits are often associated. Beginning with the use of electronics in refraction seismograph amplifiers for increasing the effect of the feeble seismic impulse resulting from the distant dynamite explosion and in radio equipment for transmitting and recording the instant of this explosion, the geophysicist has come to accept the vacuum tube as a standard part of his equipment. The successful application of electronics in field instruments has overcome the natural distrust of things that are new and untried. At the present time, electronics is applied successfully to instruments used in all the geophysical exploration methods, such as seismic, thermal, magnetic, electrical and gravitational. For more detailed discussion of the methods than can be given here, the reader is referred to the *Journal of Geophysics* and to the excellent texts referred to in the bibliography.

How Electronics Aids Geophysicists

Modern gravity meters capable of measuring the earth's gravitational field to within one part in ten million employ electronic equipment in both the temperature-control apparatus and the gravity-sensitive and indicating elements. Instruments of this type can be operated both on land and in moderately deep water.

Electrical measurements made at the surface of the earth for investigating the various electrical properties of the upper strata often call for electronic equipment for increasing the sensitivity of the measuring instruments. These instruments are used in making measurements of the natural earth potential, polarization effects, radio field strength, and others. Use is made of direct, alternating, and transient currents for these investigations. An advantage of alternating and transient currents is that quite small potentials can be readily detected and measured by means of high-gain electronic amplifiers and rugged indicating instruments.

The application of electronic equipment in the magnetic method makes possible the construction of sturdy magnetometers of the inductor type for determining the variation in the strength of the earth's magnetic field. Magnetometers of this type can be operated both on land and under water and thus magnetic surveys over varying terrain can be readily accomplished.

When remote control is applied to geophysical instruments, it can be seen at once that some form of electronics can be applied to any present-day method. However, since electronic equipment made its appearance in the geophysical field through the seismic method of exploration and since it remains a very impor-

By DERRY H. GARDNER

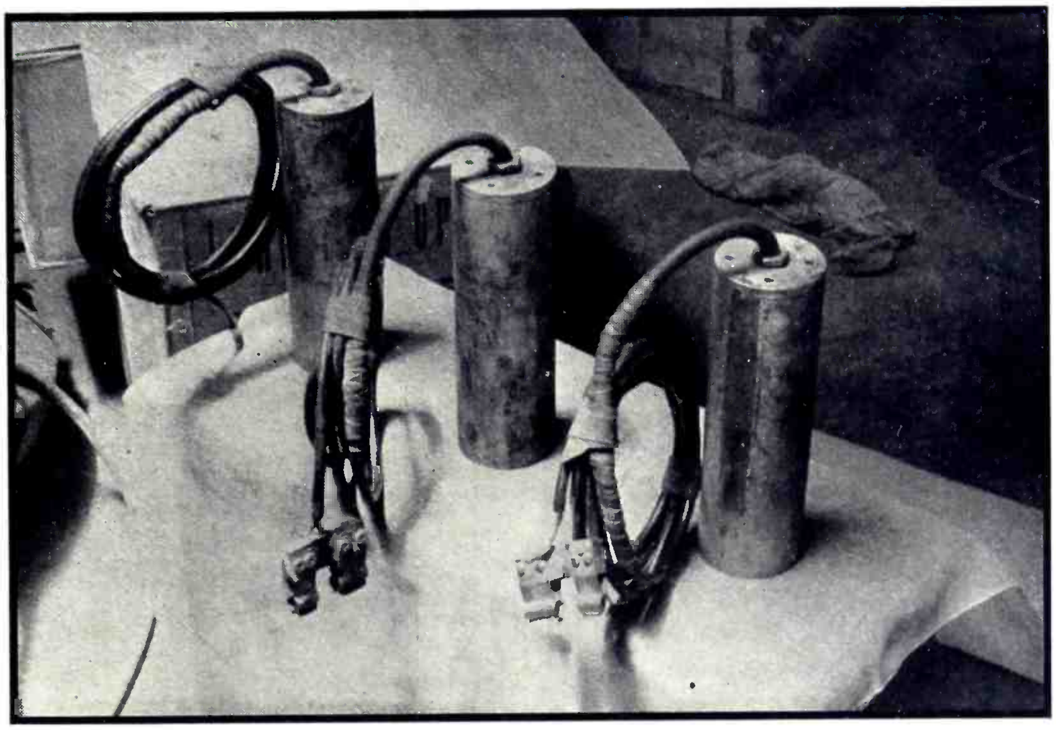
Geophysical Research Department
Humble Oil and Refining Co.

In the search for oil and gas-bearing ore, electronics plays an important part not only in aiding in the location of the hunted material but in getting it out of the ground and refining it. Tubes are especially important in connection with the reflection seismograph method of exploration

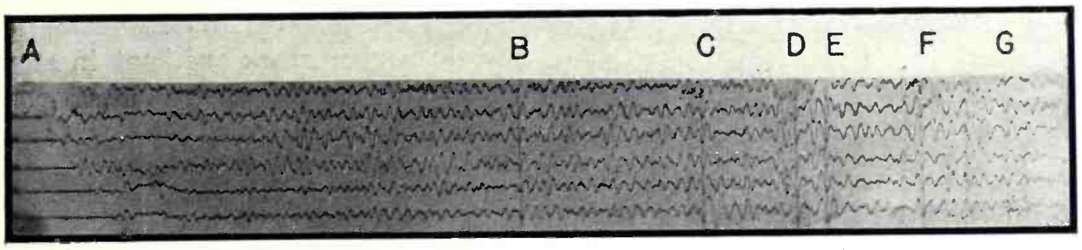
tant part of today's seismic apparatus, extended discussion will be confined to the role being played by electronic equipment in the reflection seismograph method of oil exploration.

Application to Reflection Methods

For the past ten years, the reflection seismograph method of geophysical exploration has proved to be outstanding in locating petroleum-bearing structures. By means of seismic pick-ups, high-gain amplifiers, and photographically recording galvanometers of the multi-element type, the seismic effects produced by controlled dynamite explosions are recorded and analyzed. The underlying mode of operation of the reflection seismograph is quite similar to that of the sonic depth finder except that in the reflection seismograph method many channels having separate seismic pick-ups, electronic amplifiers and recording units are used. As in the case of the sonic depth finder, the depths to the reflecting strata are determined from the velocities of propagation and the total time required for the seismic vibrations to travel from the point of the explosion to the reflecting interfaces and back to the seismic detectors located at the surface of the earth. The point of explosion, referred to as the shot point, is commonly located from 50 to 100 feet below the earth's surface.



PICKUP—Seismic pickup of the variable-reluctance type. At a frequency of 45 cps and a ground movement amplitude of one millionth inch, this device will deliver approximately one-half millivolt to the grid of the first amplifier, through the appropriate transformer



SEISMOGRAM—Characteristic record obtained by exploding dynamite underground, detecting reflected and refracted waves at points around the "shot hole"

When the seismic waves arrive at the earth's surface, their acoustic energy is converted to electrical energy by means of seismic pick-ups. This energy is then passed to high-gain amplifiers, automatically adjusted to a given level, and the undesired components filtered out, and then passed to recording galvanometers where the photographically recorded seismogram is made. Timing marks at intervals of 0.01 seconds and the instant of explosion of the dynamite charge are recorded on this seismogram, together with the seismic refracted and reflected waves.

When such a seismogram is made with a large number of seismic pickups placed on the surface of the earth in line with the shot point at intervals of around 200 feet, it is possible to differentiate between the direct, the refracted and the reflected waves, because of the difference in their apparent velocity of propagation. The difference in the arrival time at the nearest and farthest pickup from the shot point is usually much greater for the refracted waves than for the reflected waves. Often the reflected waves from the deeper strata arrive almost simultaneously at all seismic pickups on a 1,000-foot spread, whereas the difference in the arrival times of the refracted wave over this spread is

(*Continued on page* 226)

MOTOR CONTROL...

Where speed must be varied within fairly wide limits d-c motors are ideal. Electronic accessories permit such motors to be operated from a-c power lines and at the same time provide a flexibility of control which can be accomplished by no other means

By S. D. FENDLEY

Electronics Sect., Industrial Control Div., General Electric Company

ALTHOUGH the relative simplicity and low cost of the a-c induction motor have made it the most universally used type, it is recognized that for applications where adjustment of speed is desirable, the d-c motor still has no equal. Since industry has largely adopted the use of a-c power, however, it has meant that to use the d-c motor, a special d-c power supply must be provided; this has not always been economical or feasible.

Electron tubes are inherently rectifiers and it was inevitable that they would be used to supply power for d-c motors where such motors were desirable. The rectifier supplied the necessary link between the a-c power supply and the d-c motor.

Its Past

The use of electronic tubes for controlling d-c motors dates back more than a decade. One of the earliest applications was in connection with an automatic lighting control system installed about 1929. In this application, thyratron tubes were used to supply both the field and armature of a small motor to control its speed over a range of approximately 36:1. Following this, numerous electronic speed control equipments were supplied for motors of various sizes and for many different applications.

The principal function of most of the original electronic motor controls was to control the speed of the motor. Other requirements—such as starting and accelerating—were largely provided through the use of various combinations of conventional control devices. There are in service a relatively large number of this type of electronic motor speed controls, and there are still many applications in industry today for their use.

In general, these equipments consist of an adjustable-voltage rectifier using thyratron tubes to supply direct current for the field and armature of the motor. By varying the output voltage of the tubes, the speed of the motor can be changed. Some type of feedback system is employed to do this and it may be of either the mechanical or electrical type.

A typical application employing the use of the mechanical feedback arrangement is that of holding essentially constant tension in the reeling of wire as it comes from the wire drawing machine. By arranging a loop of the wire so that it operates the movable core of a reactor, it is possible to slow down the speed of the reel motor in proportion to the increase in the size of the reel diameter. Essentially constant tension is thus maintained without the use of slip clutches or other similar devices.

The electrical feedback arrangement employs the use of a pilot generator and provides a practical method of holding the speed of one machine at some fixed relation to the speed of another. A typical example may be found in the rubber industry where two conveyors handling a plastic rubber stock are kept in step with each other so that the material will not be distorted in passing from one to the other.

Even though these first motor controls did only the one job of controlling or holding the speed of a motor, they did a job which could not be done so well with conventional apparatus and each installation served to build confidence in the use of tubes for motor service and had a large bearing upon the continued development and use of such equipment.

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This drive consists of an anode

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2—Wide speed ranges are possible without the use of gears, belts, or pulleys.

3—Low speed can be provided at full torque and close speed regulation can be maintained even though the load varies from no-load to full-load.

4—The electronic control does not introduce unwanted vibration in a machine, since it has no high-speed rotating or moving parts.

5—Machines equipped with electronic motor control can be moved as readily as when conventional a-c electrical equipment is used.

6—Complete control of the motor, including speed adjustment, is accomplished from a single small push-button station.

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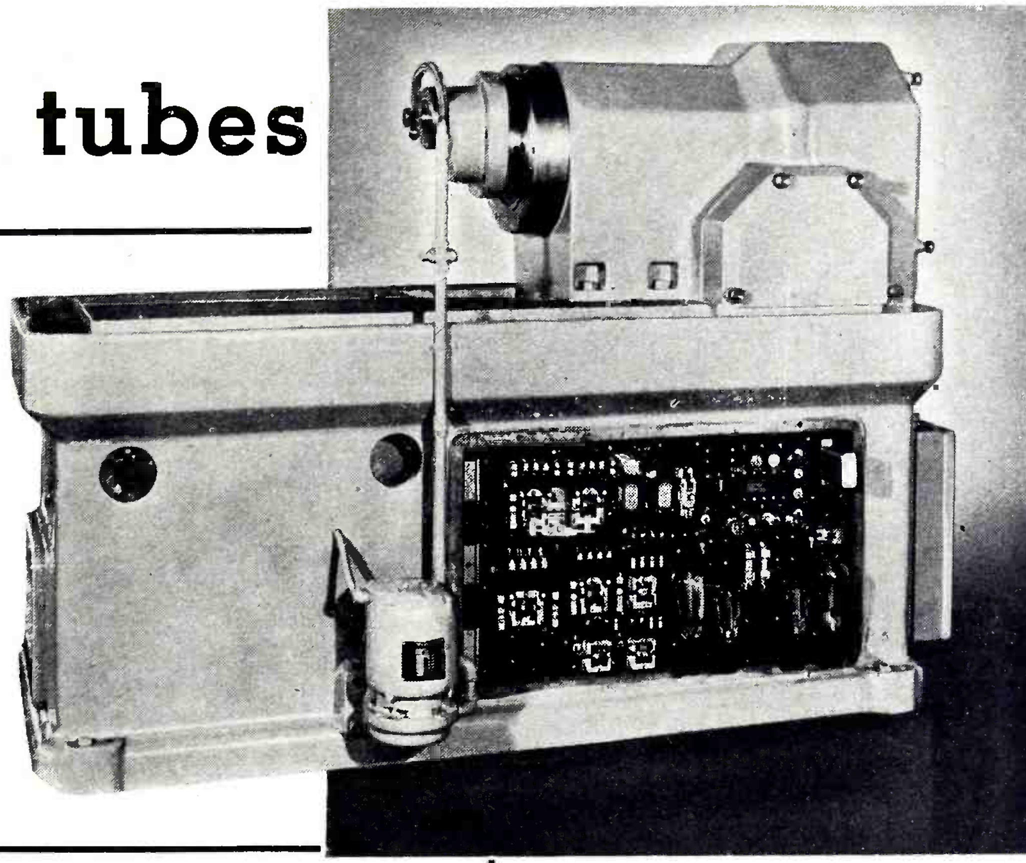

SPECIAL—Electronic motor control applied to planetary milling machine. The control feeds the cutter into work at a pre-selected speed, automatically switches to another speed for feed-around, rapid-reverses the feed motor at the end of the operation and, finally, shuts off the motor

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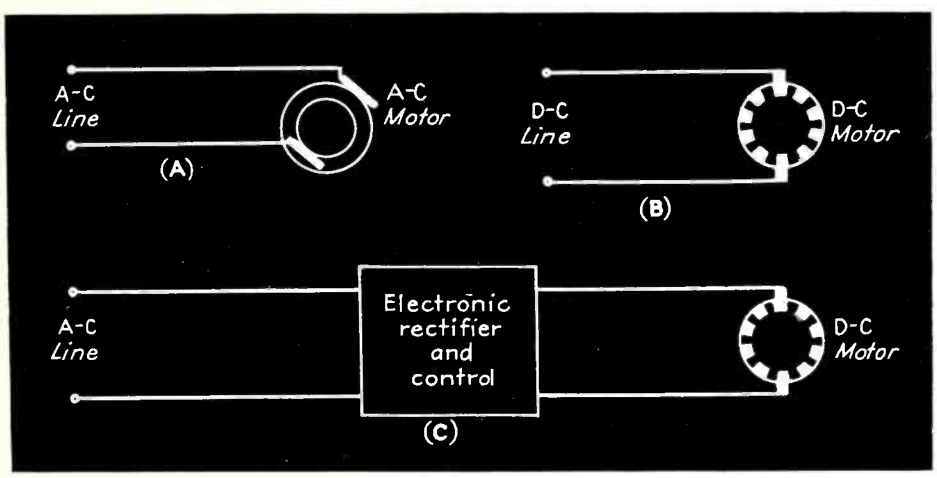
The desired operating speed can be preset and when the start button is pressed, the motor will be smoothly accelerated up to a speed corresponding with the setting of a speed-controlling potentiometer. The motor will always be started with full field regardless of whether the potentiometer is set for operation below base speed by armature voltage control or above base speed in the field weakening range.

Have Your Cake and Eat It Too



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A wide speed range is obtainable. The range theoretically may be anything from a value approaching zero up to the maximum for which the motor is designed to operate by field weakening. The practical limits are determined largely by the heating and stability of the motor.

By providing closely regulated armature voltage and automatic compensation for *IR* drop, this system holds the motor speed constant within close limits independent of load and ordinary line-voltage variations.

Because of the outstanding characteristics of this new control system, it has been applied in a number of interesting applications. Most of the drives have thus far been used on machine tools although they have been applied also for such applications as propeller governor testing, automatic welding machines and magneto testing.

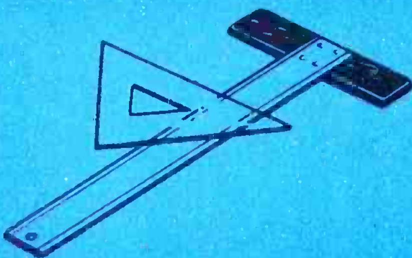
Among the machine tools to which drives have been successfully applied are grinders, milling machines, lathes and thread millers. Such advantages as increased production, longer tool life, simplification of design and a greater variety of work that can be done, have been reported by users. On a grinder headstock, the wide speed range and constant torque characteristics at low speed make it possible to provide the right speed for every type of grind so that better work can be turned out. On a milling machine, a simple mechanical arrangement for controlling the speed-adjusting potentiometer in combination with a template and follower mechanism has made it possible to maintain constant cutting speed which again has resulted in better work.

Its Future

The electric drive i.e., motor and associated control, probably has been the greatest single factor contributing to the great progress made in the development of modern production machines. The a-c motor and its control will continue to be used

(*Continued on page* 234)

electronic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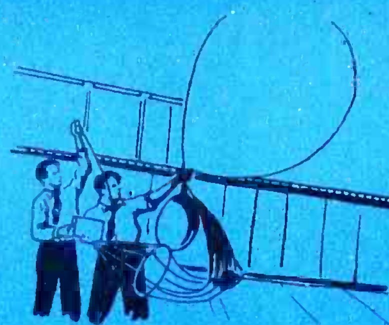
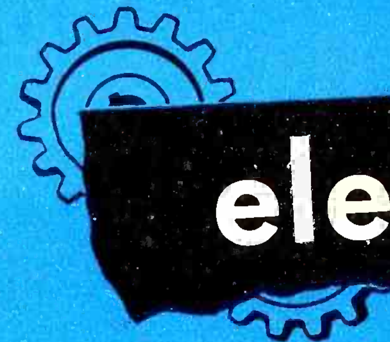
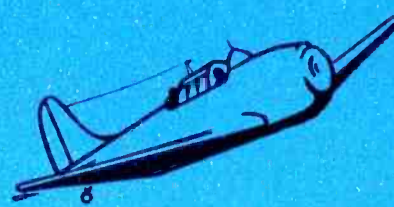

METEOROLOGY


MECHANICS


ELECTRICITY


MEDICINE


CRYSTALLOGRAPHY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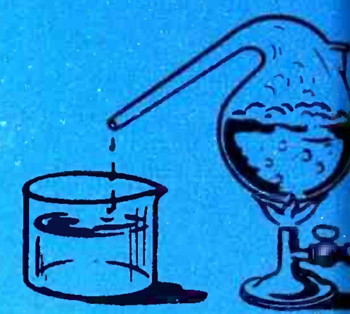
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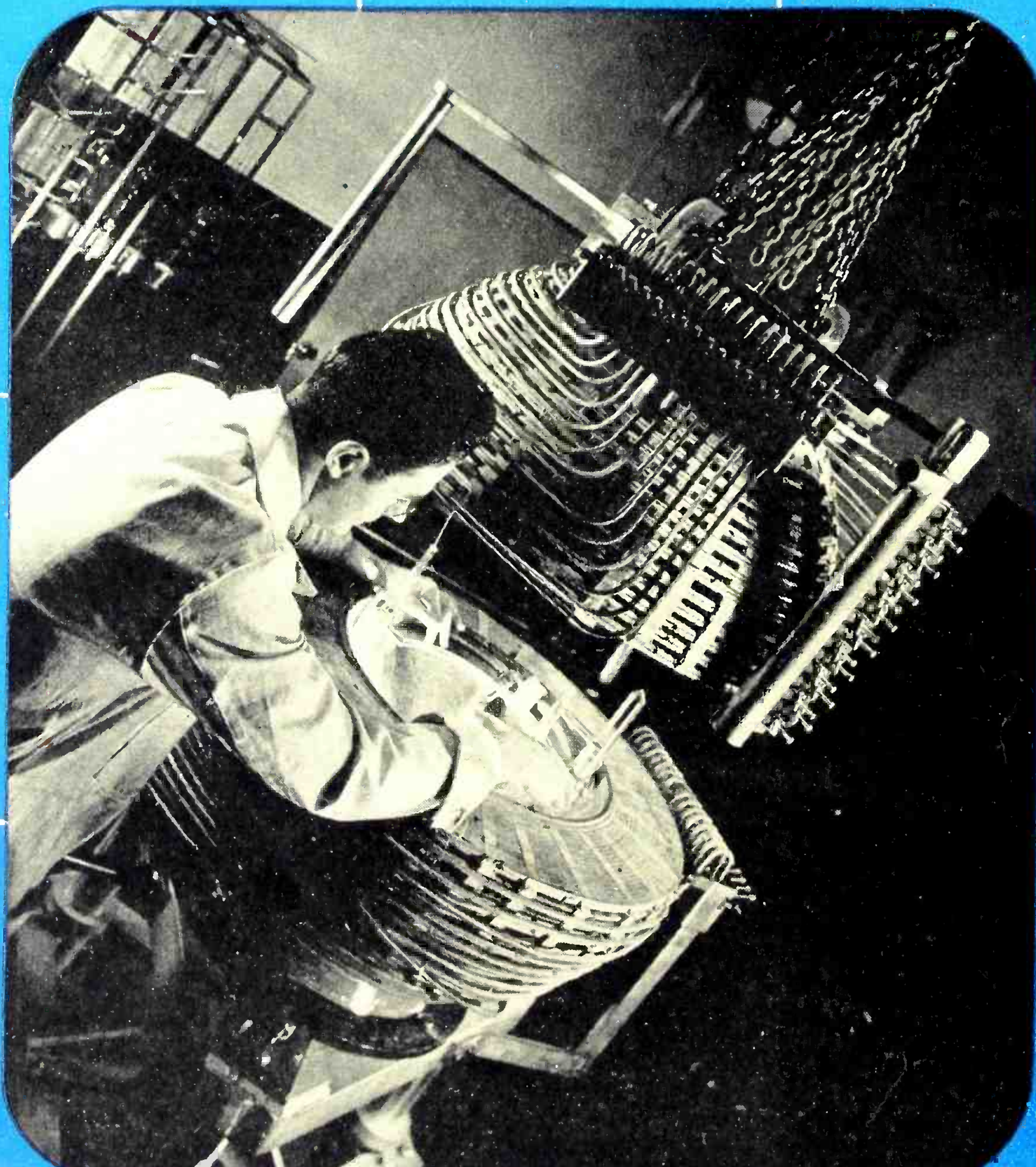
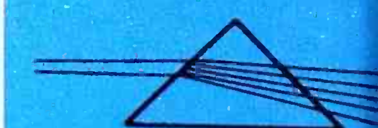
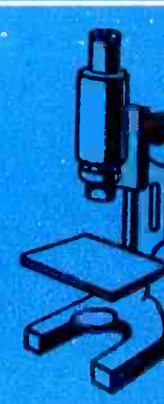

Medieval alchemists have their modern counterpart in physicists whose researches have enabled one element to be converted into another


PHYSICS


MEASUREMENT


BIOLOGY

— Aid to RESEARCH

MEASUREMENT . . .

basis of all science

By GORDON THOMPSON
Chief Engineer
Electrical Testing Laboratories, Inc.

ELECTRONICS has brought to the everyday measurement of all kinds of physical, electrical and chemical quantities a precision and facility that were thought possible, fifty years ago, only in the national physical laboratories or, with the expenditure of much money and labor, in some special project. Today a factory worker will measure the diameter of a piston or check the frequency of a quartz crystal oscillator with a precision of a few parts in a million as readily as his grandfather measured the width of the new door he was fitting into the old front-door frame. Precision and facility—ease and accuracy—are all brought by electronic tubes.

To describe the thousands of devices and methods for measurements in use today employing electronic tubes would require volumes. As just indicated, every branch of physical, electrical and chemical measurements has been vitalized and carried to hitherto unattainable, to almost incredible, precision and facility. Even to provide a catalog, a mere listing, of applications would exceed by several times the space limits allotted to this review.

Consider first the basic elements of this physical universe, length, mass and time.

Lengths and thicknesses are measured today with pointer-indicating gauges whose scales can be read several feet away to fractions of a ten-thousandth of an inch. (Remember, the "micron" is only four hundred-thousandths of an inch). This precision may be achieved with an electromagnetic structure of which the inductance changes with the position of the measuring spindle, or the spindle may move condenser plates; in either case, electronic tubes amplify the resulting change and deliver the result to an indicating instrument. Even the simple, and basic, machinist's micrometer finds its precision multiplied several fold by using a radio tube to detect contact in place of the sensitive touch of the operator. Various arrangements of "go-and-no-go" gauges with electronic tube indicators permit the gauging of hundreds of parts per hour by one operator as they move past him (or her) down the production line. The electron microscope has made possible the measurement of lengths too short to be amenable to perception by light waves. At the other extreme of length we have the determination of longitudinal distances on the earth's surface (primarily a time determination,) reaching new exactness by the radio, and the estimation of stellar distances extended to new fields because of the electronic tube.

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The uncertainty principle teaches that the ultimate limit of smallness that can be observed is reached when the quantity to be measured is smaller than the disturbance caused by the application of the measuring means.

Electronic devices allow us to approach this ideal limit by supplying us with the lightest known measuring agents, electrons and photons.

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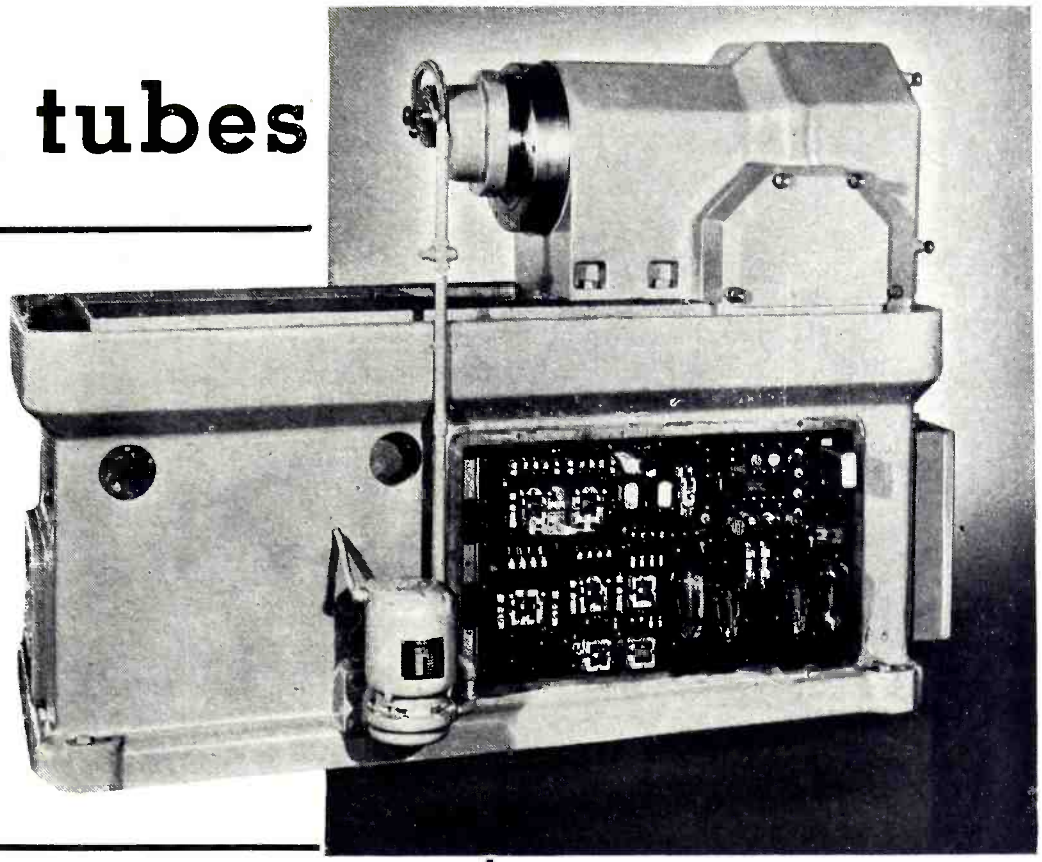

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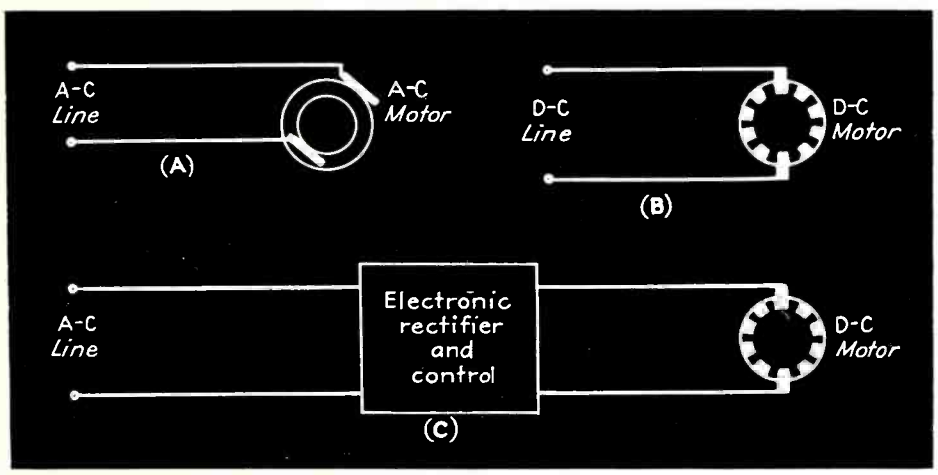

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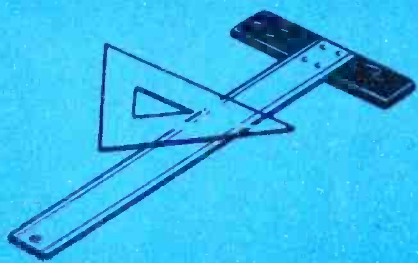
(*Continued on page* 234)

electronics



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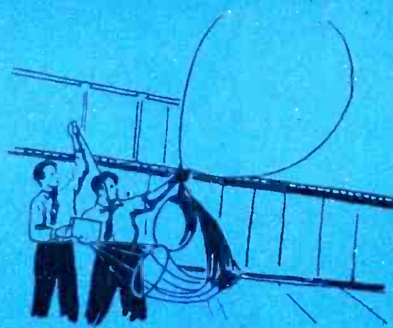
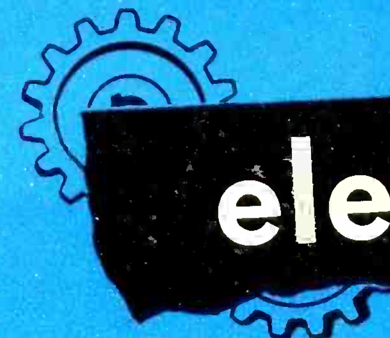


METEOROLOGY



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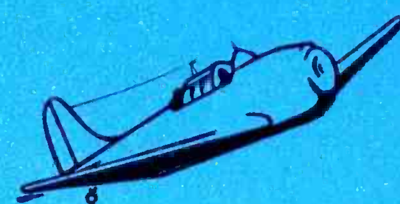
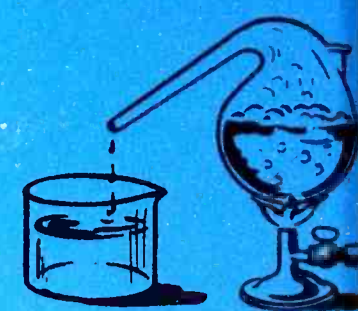
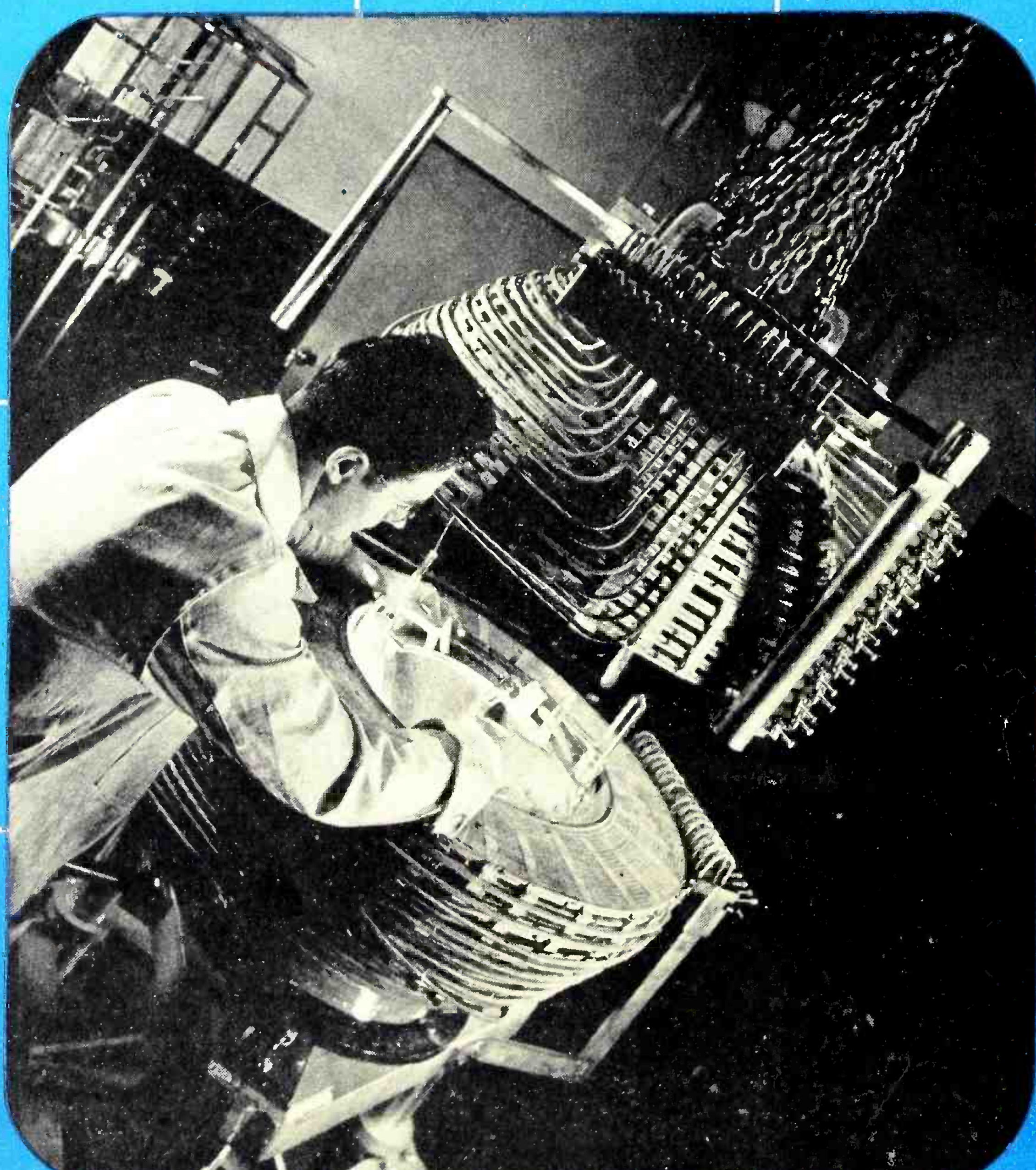


AERONAUTICS



CHEMISTRY



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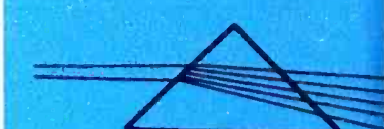
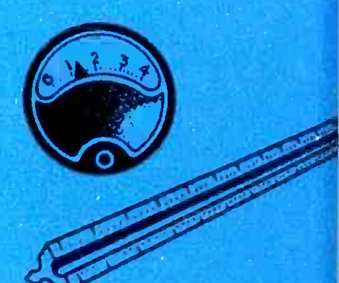
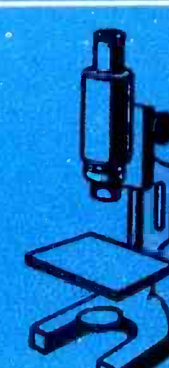


PHYSICS



MEASUREMENT



BIOLOGY

— Aid to RESEARCH

MEASUREMENT . . .

basis of all science

By GORDON THOMPSON

Chief Engineer
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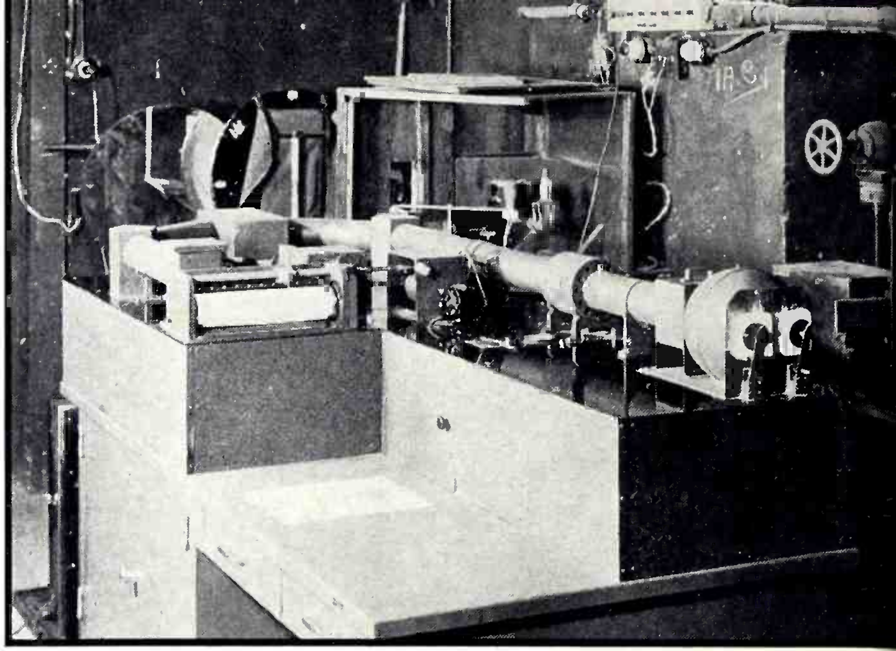
UHF—Measuring equipment in double-shielded room at the Electrical Testing Laboratories. Left—radio receiver; center foreground—Schering bridge; center at rear—radio frequency signal generator; right—quartz-insulated standard air capacitor



SPECTROPHOTOMETER—This is the celebrated instrument devised by Dr. A. C. Hardy, MIT, for measuring transmission or reflection factors of materials at any and all wavelengths in the visible spectrum. It uses four types of electron tube

great variety of electronic devices that have been created for length and time measurements. But the continuous weighing of loaded conveyors has been greatly improved with the application of amplifiers, and electronic tube accessories for scales and balances have increased sensitivity and eased the tension of the observer's concentration. One such arrangement yields audible signals so that an operator does not need to look at the scale beam to know that it is level. The mass spectrometer gives trajectories to electrons indicative of their masses and is a powerful tool for the separation of isotropes.

Time. In the field of time measurements the electronic tube has probably made its greatest contribution. The variable frequency tuned circuit, sustained by the electronic tube, is a powerful measuring tool. Controlled by the piezo-electric voltage of a quartz bar, such circuits have yielded time values accurate day after day to better than one part in a million, a precision that the finest astronomical clocks could maintain for only relatively short periods. The electron tube and the resultant high-precision time standard not only makes correct time available as a commercial product but furnishes standard concert pitch to orchestras everywhere. The cathode-ray oscillograph records phenomena which may occur "but once in a lifetime" and which may transpire in a few millionths of a second. With a variable-frequency sweep circuit such an oscilloscope can hunt out the frequency of an unknown voltage and exhibit the contours of its wave shape.

Measurement of Other Physical Quantities

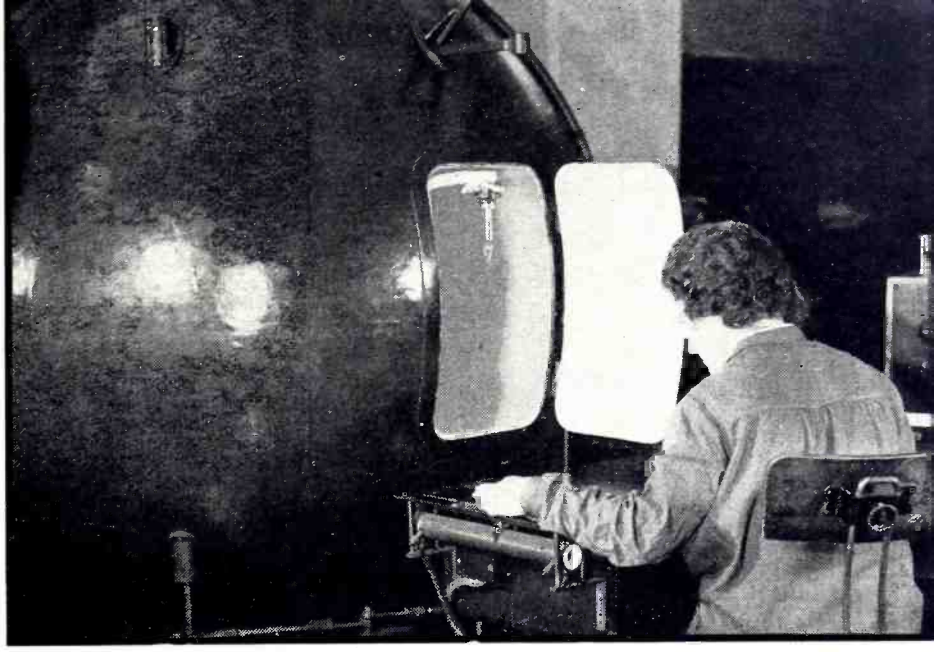
The measurement of *temperature* and especially the control of temperature finds new facility and precision because of the electronic tube. The familiar basic devices—expanding metals and liquids, thermocouples, resistance thermometers—work now through electronic amplifiers so that indicators and recorders can carry more sensitive scales, or the temperature of a space, of a surface or a kettle of liquid may be maintained with smaller drifting. The measurement of *moisture* and humidity in rooms, chambers, foods, lumber, soil, and so on, is a related field for which ingenious devices and arrangements utilizing electronic tubes are available.

An oscillating tube circuit of which the frequency can be varied at will may excite a flashing light (stroboscope) which illuminates a rotating machine; the frequency of the light which "stops" rotation measures the machine's *speed*. And since the measuring device has no mechanical contact with the rotating object it may measure the speed of the smallest-powered machine without altering the speed under observation. Obviously this rapidly flashing light may be used for high-speed photography which has become a powerful measuring aid in the study of high-speed operations. Of course, when the frequency is held slightly off synchronism the motion of even a high-speed mechanism may be studied closely. Unbalanced vibrations in high-speed machines, down to hundred-thousandths of an inch, may be measured and corrected. Or with various types of pick-up mechanisms, coils, condensers, microphones and the like, the nature of the vibration may be analyzed and the guilty source detected. The accelerometer used to determine effective *weight* during the evolutions of an aeroplane trial flight, for example, is available solely because of the development of electronic tubes.

The *sound* level meter and associated analyzing equipment which utilize electronic tubes may perform a service similar to that of the "vibrometer" through the medium of the noise emitted by a rotating or vibrating mechanism, or may evaluate the effectiveness of devices and materials placed to minimize the noise penetrating to spaces which should be quiet.

The measurement of the *power* transmitted by a shaft has always been an alluring subject to the physicist; when the shaft itself can be calibrated as a torque-meter, electronic devices can step up and furnish a power scale. Electric resistance strain gauges now take their place beside electromagnetic and

INSTRUMENTS—Typical commercially available devices in use at ETL. Sound level meter, stroboscopic tachometer, cathode-ray oscilloscope, vacuum tube voltmeter, amplifier for power frequencies, susceptance-variation circuit, bridge and wavemeters



PHOTOMETRY—Sphere in which light is evaluated by a phototube which "sees" like the human eye by means of accurately adjusted chromatic filters. Phototubes give greater accuracy than the human eye; they do not suffer from fatigue

mechanical strain gauges for measuring shaft distortion as well as the more familiar function of measuring distortion under static stress, and for all of them the electronic tube amplifier is a willing and able servant. Engine indicators now make use of the piezo-electric effect of crystals and with suitable electronic tube amplifiers deliver linear responses without the use of elaborate linkages. Study of engine performance are readily made.

Measurement of Electrical Quantities

Electric *voltages* can be measured with electronic tubes with precision up to frequencies of the order of millions per second and with the withdrawal of negligible power from the circuit measured. The vacuum-tube voltmeter may measure the peak voltage of a fluorescent lamp or of a proof-voltage testing circuit or of the surge from the starting of an oil-burner mechanism. Chemical reactions may generate voltages with certain electrodes and although the accompanying energy is too minute to be detected by other means, the electronic tube voltmeter or potentiometer serves the purpose. The hydrogen ion concentration (pH) method of determining acidity or alkalinity and the measurement of electrolytic conductivity are of this nature. The measurement of *electric current* in terms of the voltage drop across a known resistance traversed by the current to be measured is a procedure familiar to every electrical technician. With electronic tubes the minuteness of the current which can be measured in this way is so great that negative decimal exponents must be used to avoid the string of ciphers otherwise needed to express the value.

Invariably a method of control can be used as a method of measurement and vice versa. The mercury-vapor "valve" (thyratron) with the phase of its grid voltage altered by the quantity to be controlled has found hundreds of applications. For example, the voltage of a generator may be held constant to one part in a thousand while its load fluctuates over a wide range, because such a tube or group of tubes acts instantly to readjust the exciter field current to the new value required by the load. Motor speed may be controlled.

Wheatstone's "bridge" network for the comparison of electric resistances was the basis for the *alternating-current bridges* proposed by Wien, Maxwell, Anderson and others years ago. The a-c bridges and other balanced circuits now used to measure resistance, inductance, capacitance, power factor, loss angle and so on, over the whole frequency spectrum, are numbered by the hundreds. For practically all of these electronic detectors and amplifiers are used. At frequencies of the order of megacycles, a good radio-broadcast receiver using perhaps 10 or more electronic tubes replaces Wheatstone's simple coil and magnetic needle type of galvanometer.

Measurement of Illumination

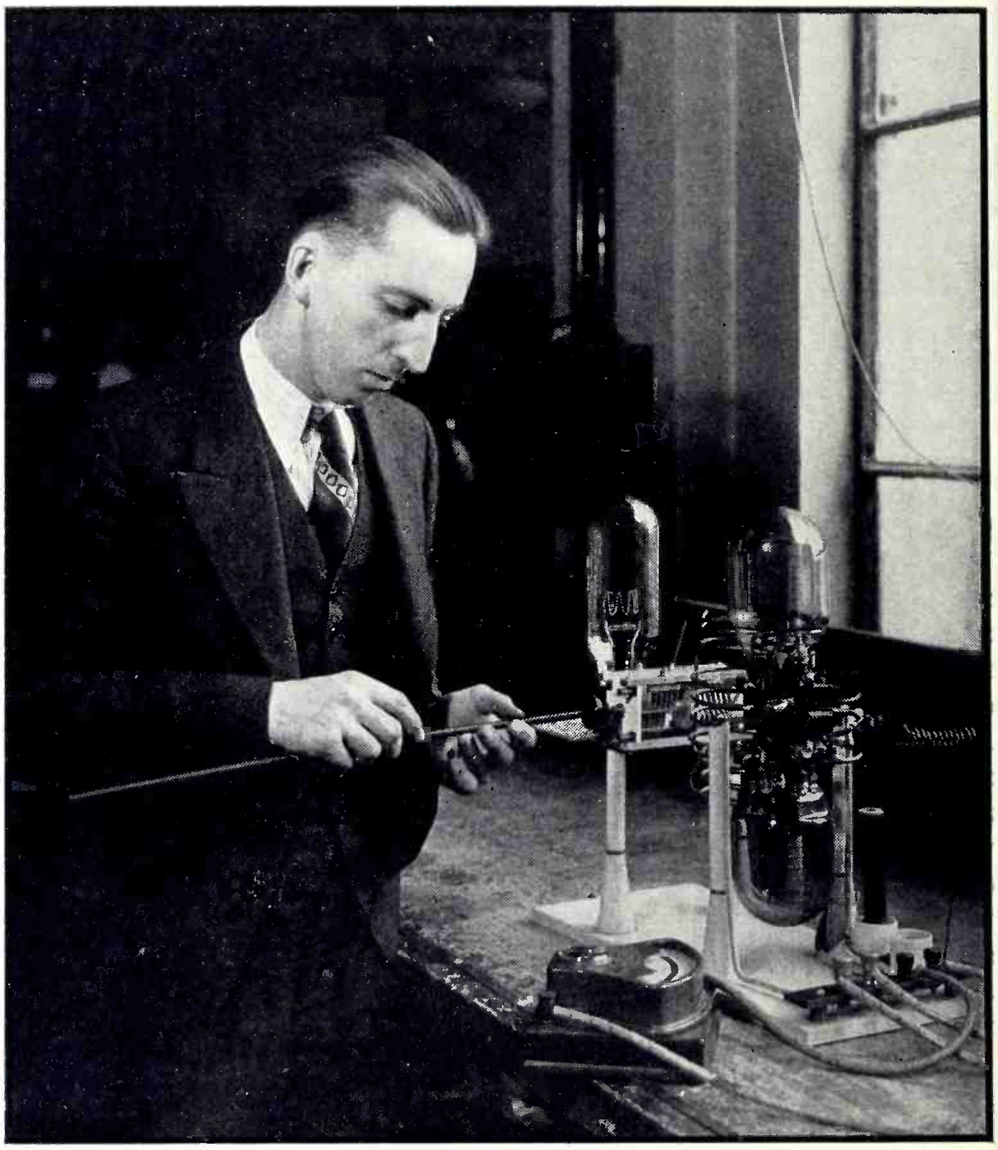
The photo tube and the photoelectric barrier-layer cell are close cousins to the electronic tube. And the electronic tube amplifier is ready with a linear magnifier for their feeble currents to aid in measurements of *light and illumination*; here again there is a notable gain in precision as compared with the ocular method of comparison involving brightness equalization and color-matching. In some instruments a variety of electronic tubes are combined to produce a measuring device; for example, the Hardy spectrophotometer utilizes a caesium phototube, a rectifier tube, several amplifier tubes and grid-controlled mercury-vapor tubes for recording automatically the result of a photometric measurement with monochromatic light at wavelengths throughout the visible spectrum. A similar tool is the microphotometer for evaluating spectrograms and distribution patterns of radiant energy.

In step with present-day life, measurements have become so complicated an activity that a specialist must usually be called in to make repairs and adjustments when the measuring tool "goes wrong." Nevertheless, the facility and accuracy made available by the application of electronic devices have been so positive and so economical that continuously expanding development and use are confidently expected. Thus electronics aids research.

MEDICAL

Several electronic tools are now available to the practicing and the research physician — x-rays, the electrocardiograph, high-frequency therapy, the "electric knife". The physiologist and the biologist as well are learning how to use electron tubes

By W. E. GILSON, M.D.
Department of Physiology
University of Wisconsin



THERAPY—New high frequency tube (WL-461) which will permit doctors to obtain higher power at higher frequencies for high-frequency therapy

CONTRIBUTIONS OF ELECTRONICS TO MEDICINE

1856—Discovery of potentials produced on surface of heart during contraction.

1875—Caton showed presence of brain potentials.

1887—Waller demonstrated that cardiac potentials could be obtained from two parts of the body with the heart between them.

1890—d'Arsonval experiments on biological effects of high frequency currents.

1895—Roentgen discovered x-rays.

1898—X-rays applied to biological sciences.

1903—Einthoven described string galvanometer.

1913—Einthoven electrocardiographic apparatus widely used in U. S. A.

1913—Coolidge produced the hot-cathode x-ray tube.

1924—Hans Berger recorded and analyzed brain potentials.

1925—Beginning of use of vacuum tube oscillators for high frequency therapy.

1928—Beginning of use of electronic amplification for clinical electrocardiography.

1828–1943—Multitudinous applications of principles enumerated above.

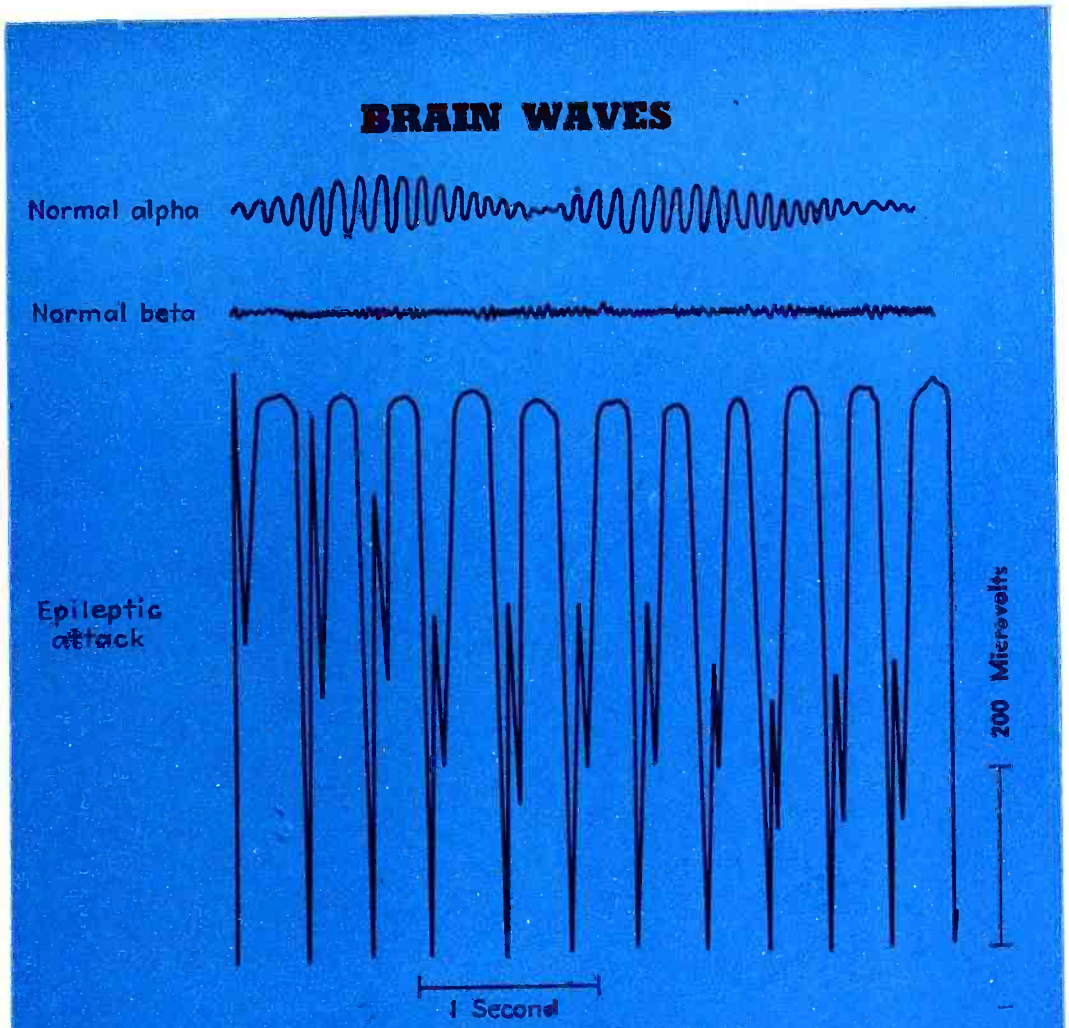
As in other fields, the last decade has seen a remarkably increased use of electronics in both clinical medicine and fundamental research. In general, the electronic device is developed for research and later given a wider application in medical practice.

As would be expected, electronics is applied far more generally in research, because of the number of special problems which are encountered and because of the relative complexity of some of the devices used. It usually requires several years before an electronic device has been simplified sufficiently so that it can be put in the hands of a physi-

SCIENCE

joins hands with electronics

cian who is not trained in the use of vacuum tube circuits. Each of the large companies making such equipment has a number of servicemen trained to make repairs when a breakdown occurs. Most of them carry a pair of pliers and a screwdriver and the necessary knowledge to enable them to locate and remedy the trouble. Others carry a pair of pliers and a screwdriver.



A typical series of patterns obtained by means of an electroencephalograph, an electronic instrument which measures the electrical potentials generated in the brain

X-rays Were First Electronic Application in Medicine

The Roentgen ray machine was the first electronic device to be used in practical medicine. As is well known, the penetrating power of the rays was first observed by Roentgen in 1895 while experimenting with a Crookes tube. He realized the value of his discovery, and both clinical and technical development proceeded rapidly.

The first tubes used clinically were gas filled, with a cold cathode. Following his development of a method of producing ductile tungsten, W. D. Coolidge in 1913 produced the first hot-cathode tube. Such tubes are almost universally used at present, the high voltage applied to their plates being full-wave rectified a.c. The anode of the tube is strongly positive with respect to the cathode and attracts electrons to it with a high velocity. These electrons strike its tungsten surface and produce a molecular agitation which results in the formation of x-rays. In the Coolidge tube the strength of the rays can be controlled by varying the cathode temperature, and the hardness of the rays can be varied by changing the anode voltage. With higher voltages the penetrating power is greatly increased.

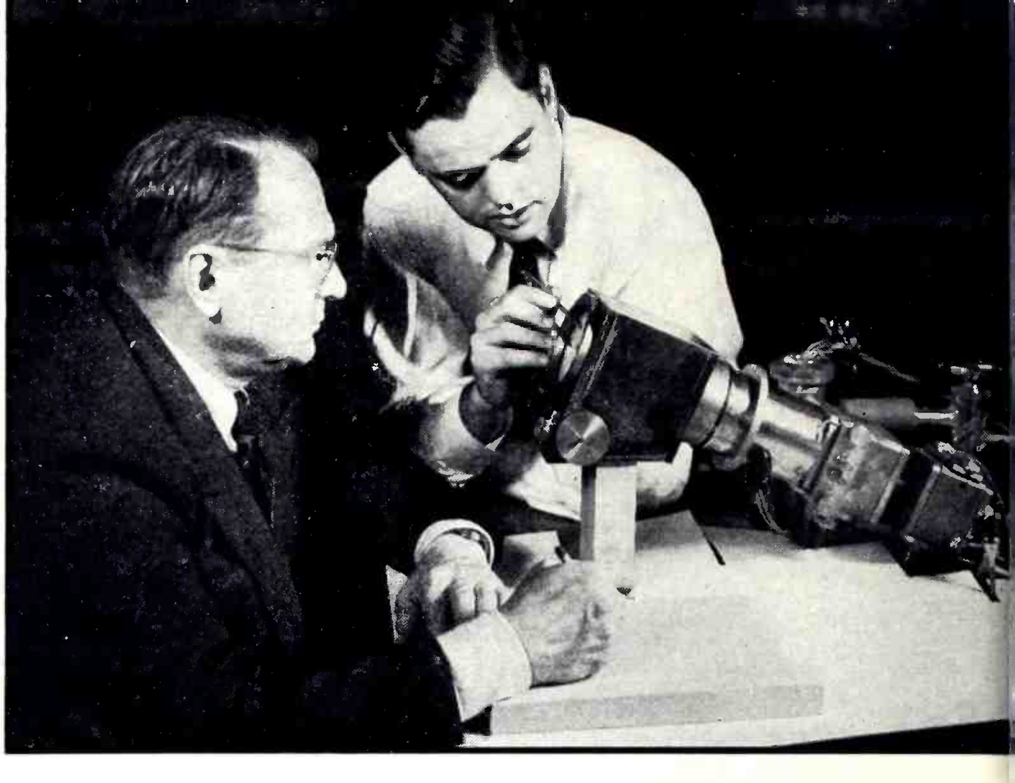
The lower-power x-ray tubes are air cooled, the larger tubes are cooled by circulating water, and the newest method of cooling uses a rotating anode so that the heat is spread over a larger surface. The anode is connected to the rotor of an induction motor which is contained within the glass envelope of the tube. The field coils are just outside the tube, separated from the armature by a thin layer of glass.

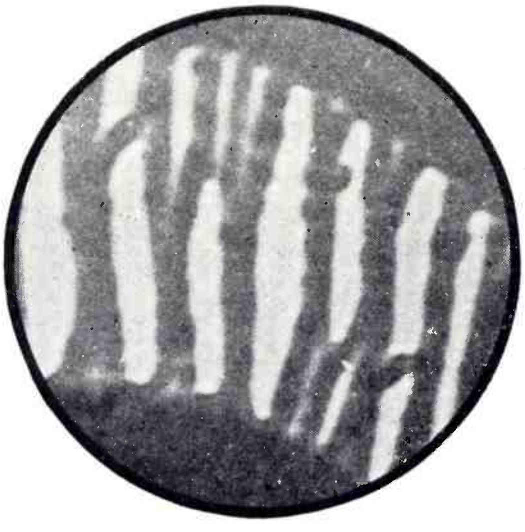
The x-rays have the power of exciting to fluorescence such substances as calcium phosphate, barium platino-cyanide, and zinc sulphide. If one of these salts is applied in a thin layer to a cardboard support, it provides an excellent means of observing the effect of the rays and the shadows produced by interposing any object to be examined between the screen and the x-ray tube. It is used clinically in this manner, as in the familiar fluoroscope.

X-rays also have an effect on photographic film similar to that of light, in that the silver halide particles are made susceptible to the action of developers. Pictures can thus be made of the x-ray shadows. In modern practice the film is sandwiched between two fluorescent screens, called the intensifying screens, to increase the sensitivity of the combination. The light pro-

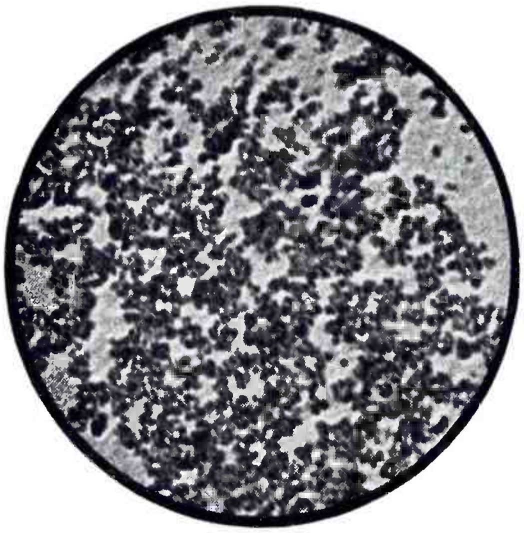
(Continued on page 236)

PORTABLE—Small, inexpensive microscope developed in RCA Laboratories. Drs. V. K. Zworykin and James Hillyer are inspecting the new 16-inch instrument, a distinct contribution to research.





POLYSTYRENE
Magnified 70,000 times



MERCUROCHROME
Magnified 65,000 times

ELECTRON
Most Recent

By V. K. ZWORYKIN, *Associate Director, RCA Labs*

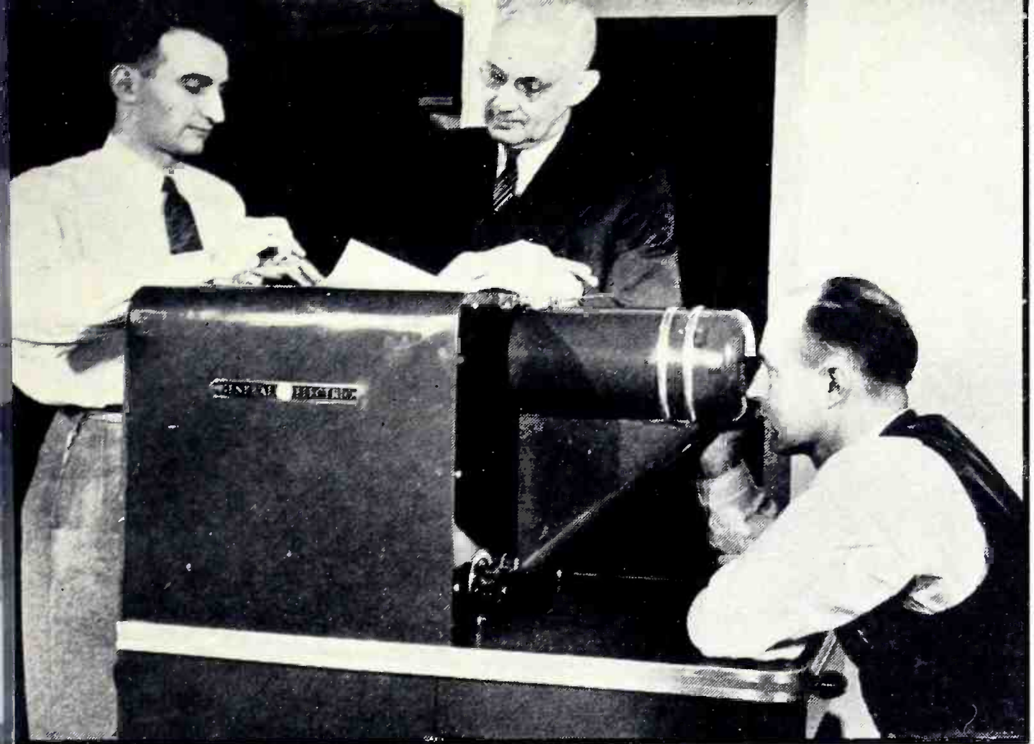
FOR MANY YEARS one of the most useful and practically indispensable tools at the disposal of metallurgists, chemists, physicists and biologists (including bacteriologists, pathologists, botanists, entomologists and the family doctor) has been the light microscope. Yet, in spite of the extension of vision that it provides for the innumerable workers in these sciences, the light microscope has well known limitations which prevent it from answering many of the problems which continually arise. It is to remove these limitations and to give the workers a still greater extension of vision that the electron microscope has been developed.

The electron microscope exists as a result of the discovery that an electron, or any electrically charged particle of matter, traveling through electric and magnetic fields obeys the same mathematical laws as a beam of light traveling through various optical media. This discovery led directly to the possibility of construcing lenses for electrons employing electric and magnetic fields through which the electrons are made to travel. Immediately there arose the possibility of duplicating in electron optics all the types of apparatus which use the lens systems of light optics. Scientific curiosity would probably have been, in itself, sufficient stimulus for the development of the electron microscope. However, a much more potent one was soon at work. For, it was realized that the limitations of the electron microscope were similar in nature to those encountered in the light microscope but about 100,000 times smaller! In other words, a perfected electron microscope should be capable of producing useful magnifications of the order of 200,000,000 diameters instead of the modest 2,000 diameters attainable with the best optical instrument.

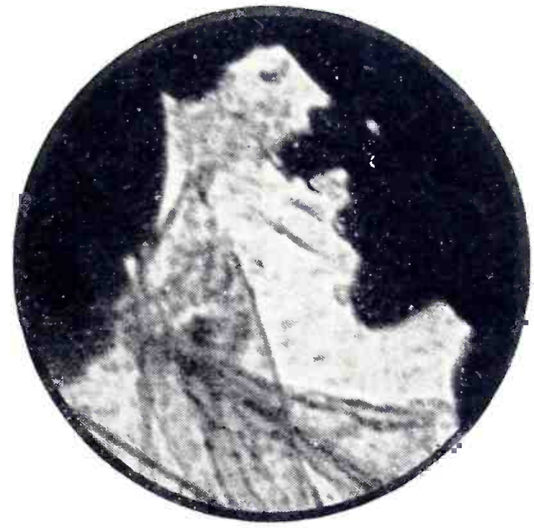
Of course, it is not expected and not even essential that such a fantastic increase in resolving power should be achieved in the near future; in fact, there are reasons for believing that all of it will never be achieved. From the practical microscopist's point-of-view, however, resolving powers which are 10 to 1000 times better than that of the light microscope are of greatest value; beyond that the indirect methods of atomic physics are much more useful. Already, the electron microscope has been developed to the point where the resolving power is about 100 times better than the light microscope.

The electron microscope itself is nothing more than the electron-optical counterpart of the light microscope. The well-known lenses of the light microscope have been replaced by magnetic or electrostatic lenses; an electron source has replaced the light source; the remainder of the structure is merely designed around the fact that all the elements of the system must be in a vacuum chamber.

During the past two years a substantial number of electron microscopes have been put into operation in various industrial, medical and university laboratories in this country and, in spite of the fact that the time of working with these instruments has been short, many start-



LABORATORY — G-E microscope which uses electrostatic lenses. Like the new RCA instrument, it will serve to bring the electron microscope to many hundreds of laboratories. Dr. S. Ramo, W. C. White and Dr. C. H. Bachman.



FACE POWDER
Magnified 54,000 times

MICROSCOPE
Research Tool

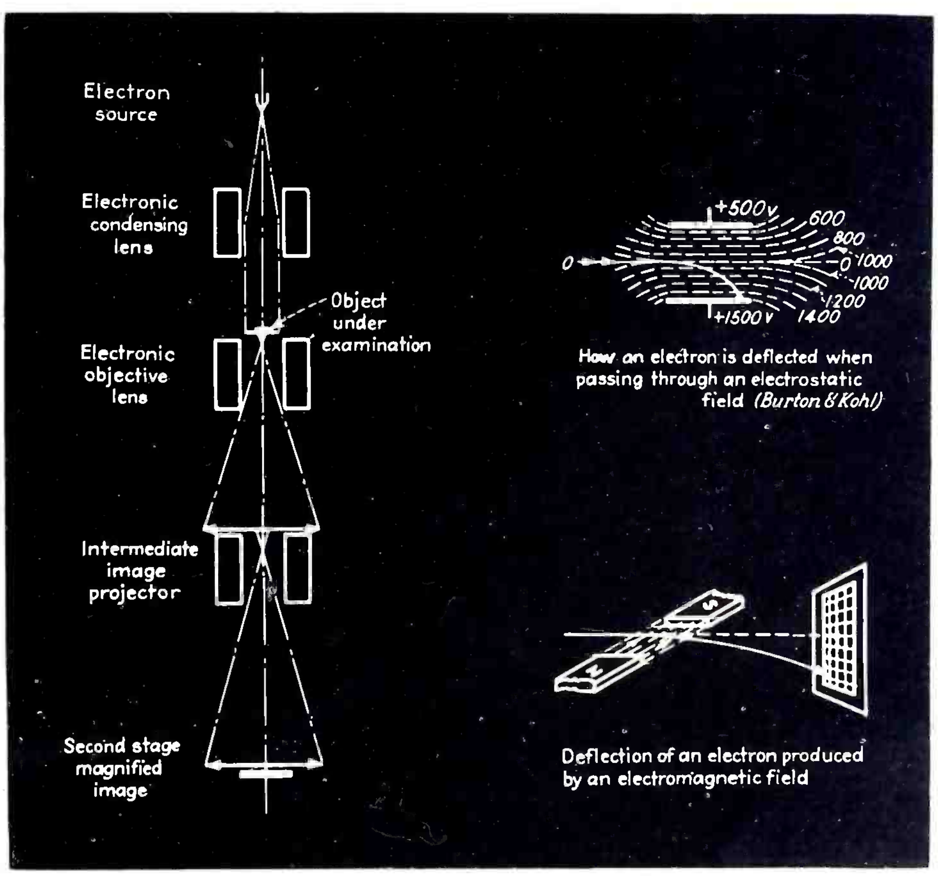
ling discoveries have already been made. A large number of viruses have been observed for the first time, confirming predictions based on indirect methods of investigation. Of these smallest forms of life, some have been found to have rather complicated structures in spite of their extremely minute dimensions. Much exploratory work has been done in the fields of bacteriology and immunology. Thus, specific actions of anti-serums as well as many structural problems with bacteria have been investigated. Most of this work has been done in an effort to explore the possible fields of application of the electron microscope and has not as yet settled down into the routine investigation of specific problems.

The electron microscope has already proven its value in industrial chemistry. Many of the problems encountered involve the shape and size of chemical particles. Here the electron microscope can be used to best advantage, for the results are given directly, quickly, and without any possibility of doubt. Even in this field of application the surface has scarcely been more than scratched.

The fact that the electron microscope is capable of much greater resolving power than the light micro-

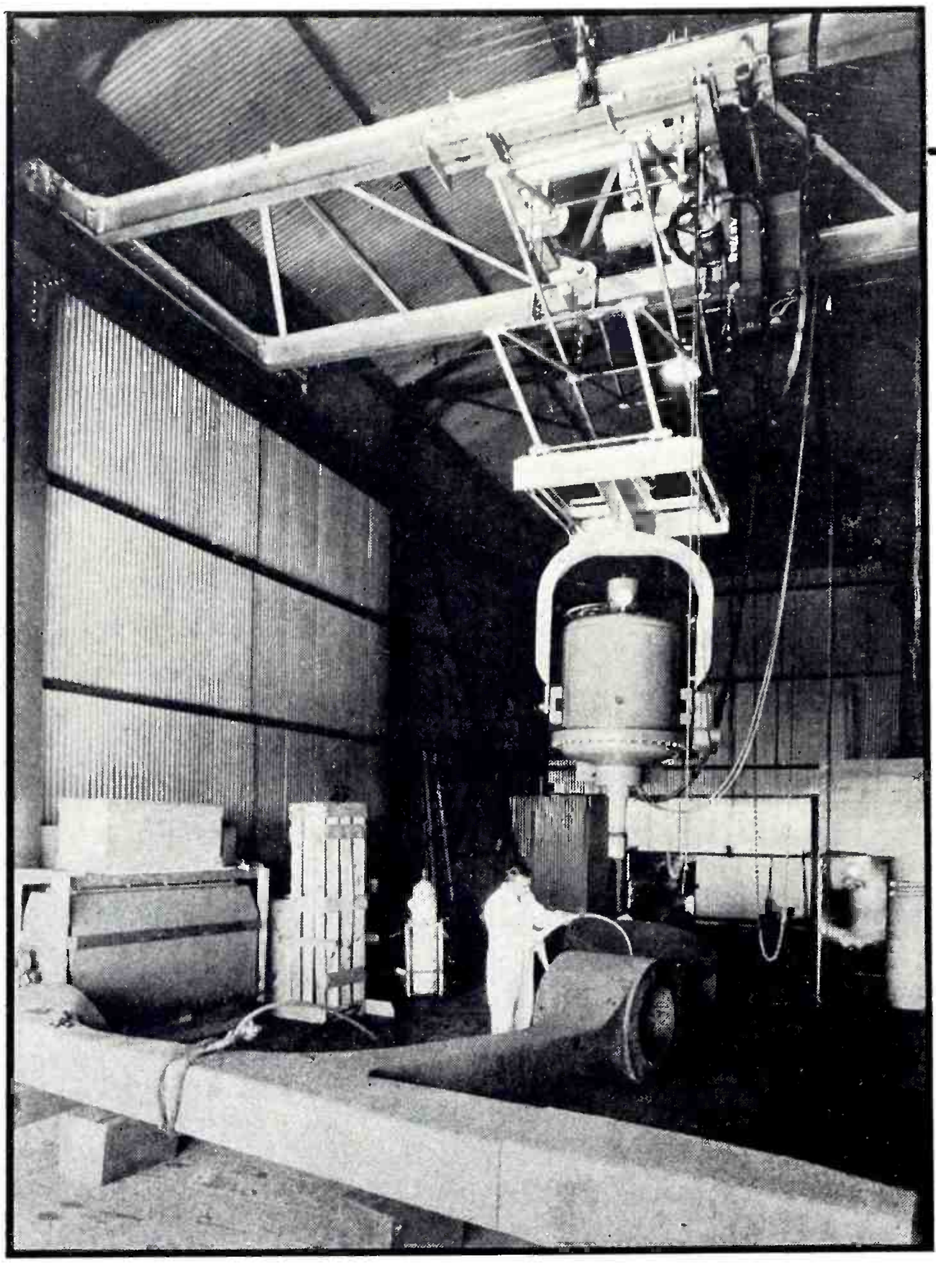
(*Continued on page* 254)

Basic Electron Microscope Principle



A fundamental discovery led to the development of the electron microscope. An electron in motion may be deflected by an electrostatic or electromagnetic field, much as light rays may be deflected by glass lenses. Thus a group of electrons speeding along a path can be concentrated or caused to diverge. In the electron microscope a heated cathode provides the electrons and these electrons take on the characteristics of the object to be examined when passing through it. They are then spread apart to produce an enlarged electron image of the material on a photographic plate or fluorescent screen.

X-RAYS... First



INDUSTRIAL GIANT—1,000,000 volt x-ray unit in position for examination of large casting. Entrapped slag, cracks, porosity and incomplete fusion are shown by this machine, which will produce a record on film through a 6-inch thickness of cold-rolled steel in 15 minutes

THE function of electronic devices as aids to research is largely to make possible measurements which could not previously be made. The extension of physical measurements through the use of electronic devices results from the extremely minute size of the elementary particles (electrons or photons, wavelengths of x-radiations, and the like) employed in electronic instruments.

X-ray diffraction methods have been widely adapted to the study of crystal structure since the wavelength of x-radiations is of the same order as the spacing of crystal planes which may be considered to lie between 1 and 20 Å. The wavelength, in Angstrom units, of radiation produced by an x-ray tube is so related to the voltage, V, that an x-ray tube operating at 30 kilovolts produces waves of 0,4 Å, which is of the same order as the interplanar crystal distances and thus suitable for such measurements. ($1Å = 10^{-10}$ meter.)

If a heterogeneous, parallel beam of x-rays is directed against a single crystal, the regular lattice structure of the crystal will diffract the x-rays in such a manner as to produce on a photographic plate a regular pattern or symmetrical design which is characteristic of the crystal under observation. Through the use of a monochromatic beam falling on the crystal, and various arrangements of crystal mountings and positions, line spectra or other diffraction patterns are obtained, which, upon analysis, may be made to yield considerable information as to the true nature of the crystal structure.

It is not the purpose of this article to discuss the various technical arrangements which may be used, nor the equipment required for such diffraction analyses; we shall be concerned with the applications of x-ray diffraction methods, however.

The application of x-ray diffraction to the problems of research in crystallography and to problems of applied science in chemical analysis and metallurgy, would fill many pages of ELECTRONICS, even in a condensed list. The scope of the information obtained with this method includes the nature of the crystallographic system, uniqueness or aggregation of crystals, grain size, internal distortion or strain, and the state of atomic chemical combination in a substance.

Applications to Metallurgy

In metallurgy, x-ray analysis is applied to the study of the constitution of alloys, their intermediate phases, solid phases, and crystalline structure. The effects of cold-working in producing grain distortion, fragmentation of crystal grains, and the introduction of preferred orientation by rolling and drawing are readily determinable, and methods for improving processes can be definitely established. Concerning the practical applications of x-ray diffraction to problems of the metallurgical industry, G. L. Clark writes in his book "Applied X-rays" (McGraw-Hill Book Co., 1940): "Without undue enthusiasm it may be stated

By MORTON D. FAGEN
Massachusetts Institute of Technology (on leave from G-E X-Ray Corp.)

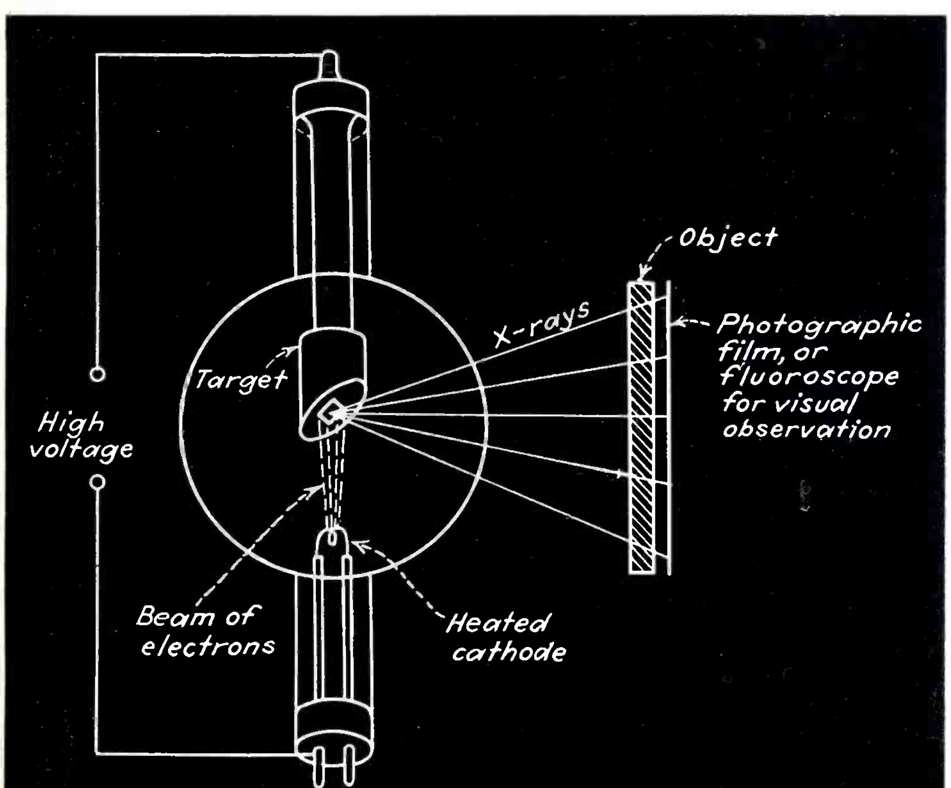
Electron-Tube Application

In wartime production, x-ray examination methods are of extreme importance. Gun mounts, cylinder blocks, crankshafts, armor plate, airplane propellers, valves, boilers—all offer good targets for x-radiation. Some lesser known uses of x-rays in research are described

as a fact that the contributions of x-ray research to metallurgical science *over so few years* surpasses the record of all other experimental methods."

Crystallography

The determination of a particle size has been extended into the range of submicroscopic grains, as in crystalline colloids of 10^{-6} to 10^{-8} cm. Substances like rubber, carbon-black, paint pigments, cellulose, glasses and other substances usually considered amorphous have been found to give diffraction rings, and even some liquids produce diffraction haloes which yield important information as to their nature and structure. Soils, minerals, dusts, and clays are being analyzed with new techniques, and the study of fibers as found in drawn metal wires, silk, muscle tendon, fibrin of blood, cotton, wood, rayon, starches, and stretched rubber is opening new approaches to geology, biology, and industrial medicine. Another and similarly new phase of crystal analysis is the investigation of the crystalline and molecular structure of organic compounds, leading to new insight into the mechanism of lubricating films and the behavior of insulating oils and waxes. Research on synthetic resins and synthetic rubber is dependent on diffraction patterns as an aid to the study of polymers with giant molecules.

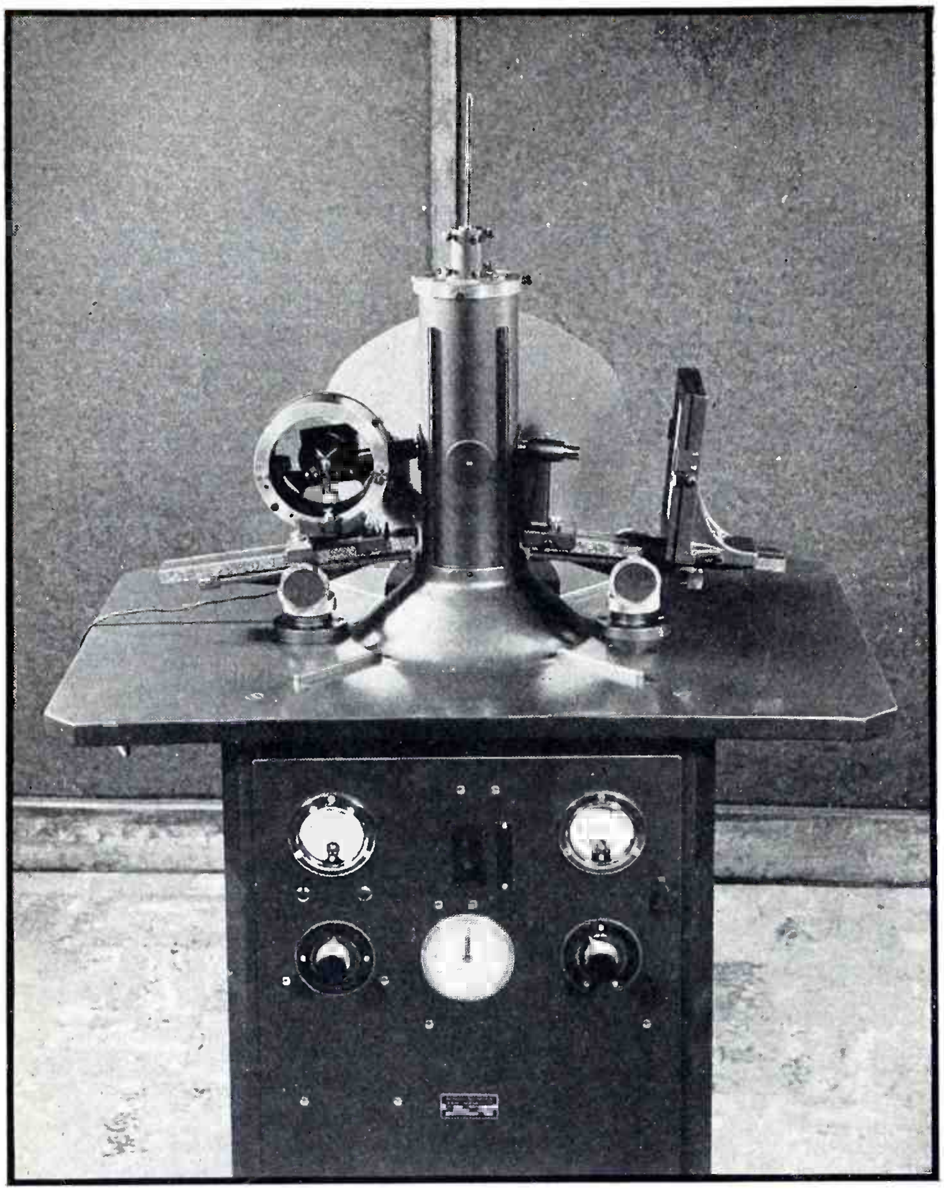


How X-Rays Work

High speed electrons strike target and deliver kinetic energy. Rays of light of extremely short wavelength, x-rays, are produced. These rays pass through materials to be studied to a greater extent than do rays of visible light; therefore objects of greater density (steel or concrete) can be penetrated by x-rays to expose photographic plates or be visually observed on fluorescent screens

Chemical Analysis

In the field of analytical chemistry, x-ray diffraction is rapidly growing in importance as systematization of patterns for reference is proceeding. The diffracted x-ray beam differentiates between a mixture, which produces superimposed patterns; a compound, which gives a pattern different from the constituents; and a solid solution, which resembles one or the other of the constituents with slight alterations. "Finger-print" files of more than a thousand chemical substances have been brought together to aid in the rapid identification of diffraction patterns obtained from as little as 0.2 mg of the unknown substance in powder form. Since only about 5 percent of the solid inorganic substances are essentially amorphous the field of application is quite inclusive for qualitative or semi-quantitative analysis. Operationally, the x-ray method of chemical analysis is particularly useful in that the preparation is simple, the analysis requires minute quantities of material, and different states of oxidation, hydration, or crystalline phase are dis-

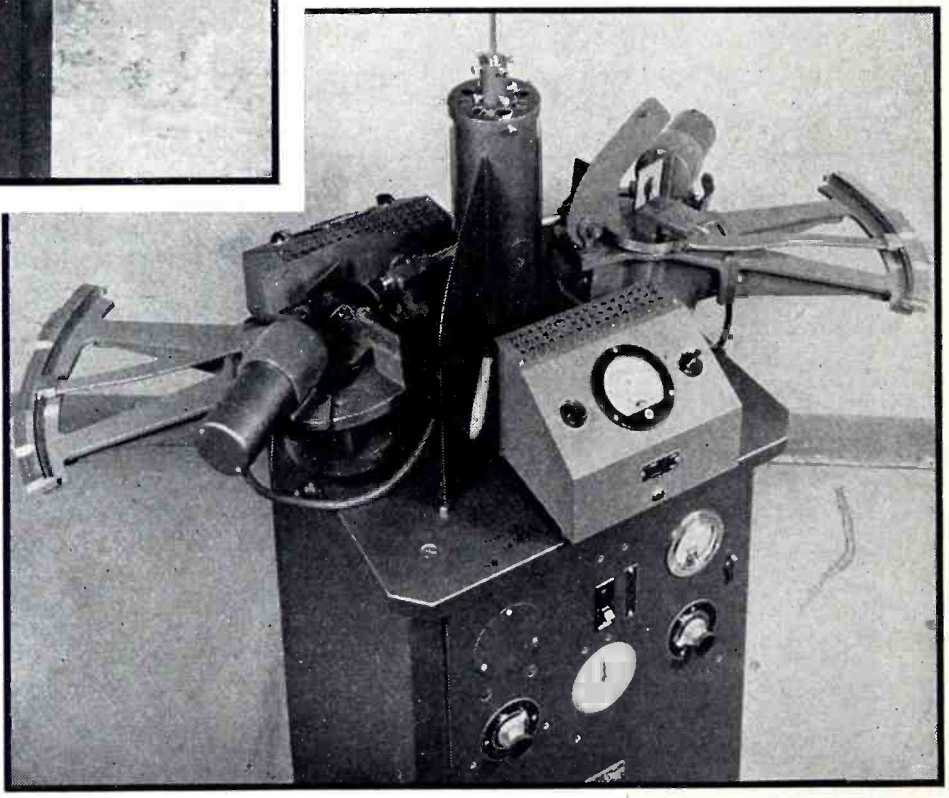


about surface layers with regard to crystal formation, orientation and grain size.

Electron Diffraction

Electron diffraction work on polished metals has given valuable information on the causes of piston and bearing wear. Research on the general problem of adhesion of electro-deposited metals can be expected to result in substantial improvements in plating techniques, while the knowledge gained of surface chemistry, of corrosion, and of the protective oxides on metals and alloys, is directly effective in solving many problems, theoretical as well as intensely practical.

The method is new and relatively little used. Improvements in techniques will overcome some of the present limitations, will make possible the use of any type of surface, and will permit electron focussing for limiting the area to any desired



DIFFRACTION—(Above) G-E diffraction study x-ray unit, with two of possible four cameras in place. The one at the left is a powder camera for Hull-Debye-Scherrer patterns. At the right is a collimator assembly and flat cassette for Laue patterns. (Right) Diffraction x-ray equipment designed specifically for determining crystallographic axes of quartz. Intensity of x-rays after diffraction by crystal is measured by ionization chamber and amplifier system

tinguishable on the pattern. At the present state of the art the quantitative accuracy of results in favorable cases is 5 percent but there is ample reason to believe that future developments will greatly increase the precision.

Just as waves from x-radiations may be scattered and diffracted, so may a beam of electrons be similarly scattered by the atoms of a crystal acting as a three-dimensional diffraction grating. This result, experimentally demonstrated by Davisson and Germer in 1927, verified the theoretical prediction of DeBroglie, three years earlier, that a particle in motion would have waves associated with it. As a result, electron diffraction methods have been devised which provide a practical means for obtaining structural information spot. Special tubes have been built for high temperature researches, and it is reasonably certain that the mechanical inconveniences of present systems will be overcome with further work.

X-ray Absorption

X-rays are absorbed to a certain extent by all substances through which they pass. The portion of the x-rays which are absorbed depends upon the thickness of the absorbing medium through which the rays travel, the character or nature of the absorbing medium, and the wavelength of the x-radiation.

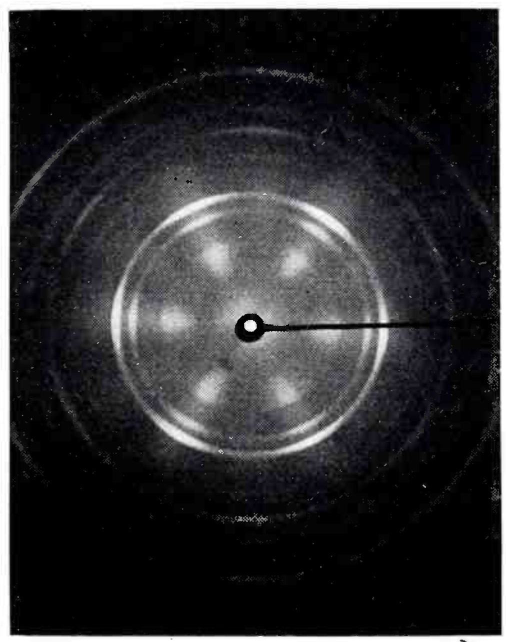
As an aid to research, the method of x-ray absorption has become possible as a result of a history of the earlier investigations which were, in themselves, intended to explain that very phenomenon. For example, research on the effects of direct radiation on living tissue has led to new concepts in biology and genetics, and to the utilization of x-rays as a tool for research in these fields. In similar fashion, experimentation with x-rays on hundreds of chemical substances in the effort to find reactions which might be used as quantitative means for radiation measurements has prepared the background for the use of x-rays in the study of mechanisms and the rate of chemical reactions and the stability of chemical bonds.

Absorption methods may be used to determine the true thickness of various specimens of material whose absorption coefficient is known, to determine porosity (as in welds or castings) of the aborbing material, to differentiate between genuine and counterfeit coins, precious stones, or other articles which may appear similar but which have different absorptions for x-rays, to determine variations in thickness of sample materials, to detect gross flaws such as cracks or fissures, or for determining the composition of mixtures and solutions.

Photochemical and Biological Reactions

Molecules of water and some very dilute solutions are activated by x-radiation, becoming unstable and highly chemically reactive. Hydrogen peroxide is formed from water with dissolved oxygen present; dilute solutions of organic compounds are decomposed and hydrogen, carbon dioxide and oxygen liberated. Oxidation and reduction processes occur with radiation as, for example, the oxidation of $Fe\ SO_4$ and the reduction of KNO_3. Catalysts are activated in the presence of moisture and metastable solid states of some substances are converted to stable forms. Cell proteins are denatured and flocculated, a reaction which is of great importance in the biological effects of x-radiation.

The production of changes in the composition of genes and the establishment of mutations of form, size, color and reproductive power has led to the use of x-ray and gamma ray absorption as the only means of artifically producing these changes. The treatment of cancer by destruction of localized growths is an extremely important therapeutic technique for the control of advanced malignant disease, and for the cure of a great number of less advanced cases. Medical research on the biological effects of radiation and the nature of cancer is bringing us closer to the reasons for much of what is now known empirically. This research is largely dependent on electronic devices for producing x-rays, now commercially available in various units, to cover the entire spectrum of wavelengths from 1 Å (10 kv) to 0.01 A (1000 kv).



PATTERN — Laue pattern of cold-drawn steel, obtained by means of x-ray diffraction equipment. Sharply defined rings are evidence of fibering and fragmentation which greatly affect mechanical properties of material

The newest source of penetrating radiation and high speed electrons is the magnetic induction accelerator.* By using a magnetic field to produce a spiral electron path and by causing the electrons to be continually accelerated by a time variation of the field, a velocity equivalent to that obtained with 5,000,000 volts can be obtained in a tube only 20 cm in diameter. The distance traveled by an electron from the injector to the target has been calculated to be about sixty miles and the radiation is equivalent to that obtained from one gram of radium. A large induction accelerator has recently been completed which produces electrons with energies of 100 million electron volts. What this will mean to nuclear investigations and biological research is just becoming evident. Only the future will reveal the ramifications of the present beginnings.

TYPICAL USE—Tubes like this Westinghouse type are used for many industrial x-ray studies

* Krest, D. W., *Physical Review*, 60, 47–53, 1941.

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electronics

Tubes have untapped potentialities in research and industry as well as in communications but not all wartime developments will be immediately applicable to peacetime problems and some techniques born of military necessity may never prove economically sound

THE SCIENCE of electronics is at present enjoying merited publicity. Much of this publicity revolves around the virtual certainty and some of it around the mere supposition that technical developments which are helping to win the war will have immediate practical peacetime applications.

While wartime innovations must naturally be kept in mind when attempting to peer into the future it is also true that unless other factors are also considered conclusions may be more apparent than real.

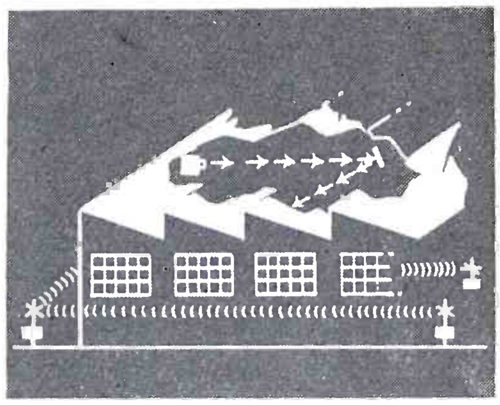
Effects of Two Wars

Electronics has gone through certain definite phases. Up to the time of World War I, it was an activity of scientific interest to just a few research groups. During that war it acquired a practical status which, a few years later, broadcasting transformed into a vast commercial undertaking. Shortly thereafter, applications for vacuum tubes other than communications were initiated but, in general, the reaction was unfavorable in this "first period of glamor." Fragile little radio tubes were not suitable for the rigid requirements of industry.

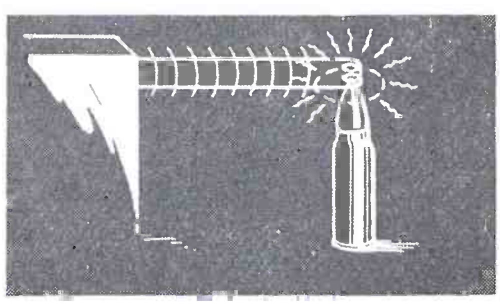
Then along came the late 20's, when it was again freely predicted that electron tubes would do all sorts of wonderful things. During the depression years some progress actually was made in commercially applying electronics in fields outside of radio. This was because any new thing at that time had to prove itself of real value to be accepted by hard-pressed industry and electronics did this in a certain few definite cases.

World War II has brought the second glamorous stage. In times like the present, when only technical accomplishments count and not the cost or economic soundness of the application, one is apt to forget these latter factors. However, in a peacetime future, these factors may rule out many beautiful electronic schemes that recently have been publicized.

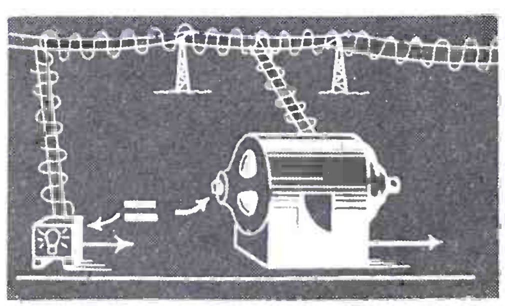
INDUSTRY



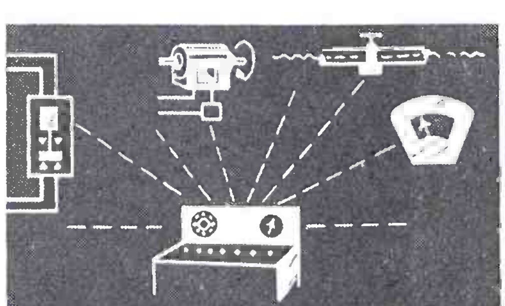
Protection



High Frequency Heat



Power Conversion



Remote Control

There has also been a tendency of late in publicity to capitalize on the fact that all matter and energy under modern physical concepts is related to the electron. However, the engineer working directly on electron tubes and their applications confines his attention to free electrons which are electrons that he can do something about; in other words, electrons in a vacuum tube. This imposes some very definite application limitations.

Fortunately, real progress was made not only in the difficult years of the depression but has continued right up to the present war period. This progress will be maintained and bear fruit. Just as, in 1917 and 1918, wartime radio laid the foundation for broadcasting and many of its by-products, the present war is laying a firm technical foundation for other new applications to contribute to post-war times.

The future is not predictable in detail but the general trend does seem reasonably clear. This trend may be grouped under three headings:

(1) Commercialization of old ideas that had made but little progress up to the outbreak of the present war.

(2) Application of war-inspired technical developments as improvements for old technique.

PROMISE OF TOMORROW

By W. C. WHITE

Electronics Laboratory
General Electric Company

(3) Radically new electronic devices and application.

It is obviously impossible to discuss all applications with promise here but the following highlights will serve as a broad guide.

Expansion of Applications

Power Conversion. Rectifiers for outputs between a few hundred watts and a few hundred kilowatts have enjoyed wide recognition and use abroad for a considerable number of years. However, in this country they have made relatively little progress in competition against rotating equipment. The reasons for this are somewhat difficult to explain but probably could be best summed up by the statement that conditions differ somewhat and that our electrical engineers have not been "rectifier minded."

There is a very definite indication that this situation is now changing. This is partly due to the fact that rectifiers in large sizes can now be obtained on somewhat lower priorities and better deliveries than rotating equipment. It is believed, therefore, that the tide has turned in this country and that rectifiers will be more widely used for this class of service. Thyratrons will probably be used for the lower powers and sealed, steel-envelope ignitrons for the range up to several hundred kilowatts. The economics of such rectifiers is now on a sound basis.

High-frequency Heating. Heating equipment using electron tubes as power generators has in the past enjoyed only limited application. Tube-equipped heating machines have been used largely in the manufacture of electron tubes themselves. In this case, heating in an electro-magnetic field was employed. Application of high-frequency heating in an electrostatic field was limited almost entirely to therapeutic apparatus of the so-called "fever machine" type.

The advantages of high-frequency heating equipment of both types using, electron tubes, are now being more generally appreciated. Surface hardening of small steel parts has introduced the subject into the industrial field, where it will undoubtedly spread to other applications as it becomes better known and understood.

Heat generated by high frequency equipment is usually expensive heat. This probably means that it will be used in peacetime chiefly where the dollar value of the material to be heated is high per unit of weight or volume. The fact that high-frequency heating can be made selective, so that there is heating of only certain portions or materials of the body in the high-frequency field is also an important factor, the value of which will come to be more generally recognized and utilized. Then, too, certain industrial processes may be effectively handled only by means of high frequency heating.

Motor Control. For a number of industrial applications requiring small electric motors, the d-c motor still has certain desirable characteristics that cannot be duplicated with any type of a-c motor. This is particularly true for certain light machine-tool applications. On the other hand, a-c distribution systems are becoming more universally employed, so that the localities where small d-c motors can be directly utilized are very limited.

The electron tube steps in as an almost perfect solution to this problem. It provides variable voltage d-c from constant potential alternating current. Thus a relatively small piece of additional equipment allows standard d-c motors to be operated with a wide variety of control and automatic features directly from standard voltage a-c distribution lines. Such electronic motor control equipment even provides characteristics not readily obtainable from a straight d-c supply. Tubes have a bright future in this important application.

THREE WAR CONTRIBUTIONS

1

Readier acceptance of electronics by industry

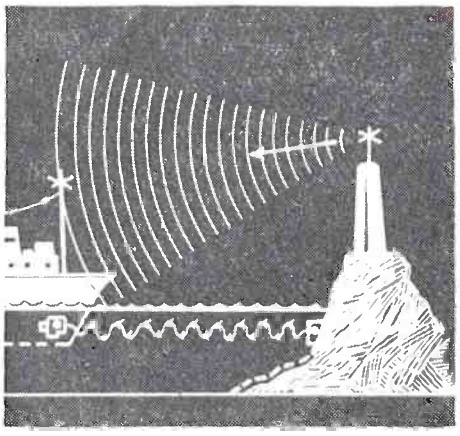
2

Improvement of electronic equipment performance

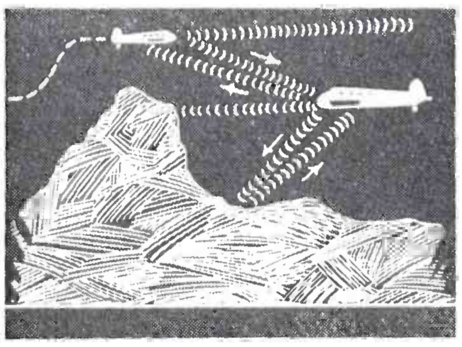
3

Some radically new electronic developments

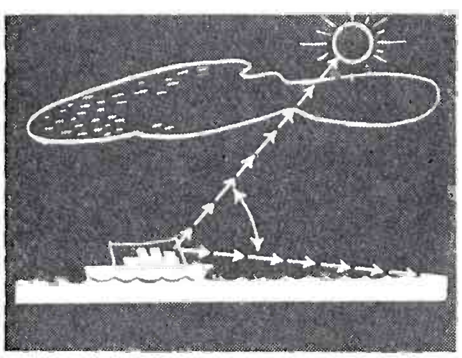
NAVIGATION



Lightless Lighthouse



Anti-Collision Systems



Blind Bearings

A-C Contactors. For the past few years, ignitrons have enjoyed rapidly expanding use in the resistance welding field, where they serve as silent, high-speed a-c switches or contactors free from moving parts and mechanical wear.

As their characteristics and uses become better understood ignitrons will also be employed as a-c contactors, such as controls for electric furnaces.

Continuous Control. In many cases where there is automatic control of electrical equipment the controlling device at intervals switches the power on and off, at full potential, in order that the average over a period of time may be some desired value. This is particularly the case in electric heating. Continuous control is highly desirable for certain applications formerly requiring the use of rheostats or regulators, with their attendant complications. Thyratrons and ignitrons lend themselves well to continuous control due to their ability to be phase controlled cycle by cycle. They should, therefore, have wider application.

Radio. Greater use of the uhf regions is a foregone conclusion. The war has greatly increased our knowledge of how to generate, control and receive these frequencies. Many improvements in television and in FM broadcasting will result.

Use of uhf transceivers, much like the "walkie-talkies", for personal uses is easily possible, for example in camps, between boats and vehicles and to fixed points from these units.

Other Devices. There is another class of electronic device that is sure to play an important part in the future. In this group is the electron microscope, the electron diffraction camera, the electron mass spectrograph, the cyclotron, and the induction electron accelerator. These are all characterized by the fact that they are high-vacuum, high-voltage devices equipped with evacuating pumps. They can be opened up and later re-assembled and re-evacuated.

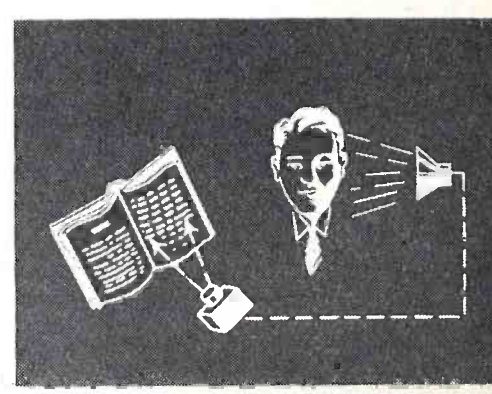
Improvement of Technique

Uses for UHF. The outstanding improvements in technique in the past two years have frequently involved practical utilization of ultrahigh frequencies. There are still several octaves in the gap between what was recently called the very short waves and the infrared region. However, more rapid progress has been made in closing this gap, as regards practical utilization, in the past two years than in the previous ten years. This progress has not only resulted in practical use of these much higher frequencies but in continual increases in the amount of power that can be generated and utilized.

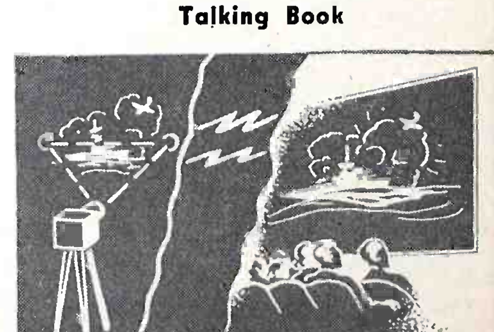
Looked at broadly, these frequencies are chiefly valuable because they utilize much smaller radiating and receiving structures; they can be more easily utilized in the form of narrow beams and they permit a vastly increased number of available channels. Looked at in another way, these factors can also be expressed by saying that these ultrahigh frequencies have more of the properties of light than the long radio waves. For certain applications, their use has many of the advantages of light without certain of the disadvantages. High frequencies may be generated and received with relatively compact units and lend themselves readily to use with reflectors and refractors. High-frequency beams will also travel farther and can be sent along conductors and around corners to a greater extent than light.

Engineers now working with extremely high frequencies are in an entirely new environment. They find themselves in much the same situation as Edison must have been in during his development of the electric light. Not only did Edison have to develop the incandescent lamp itself, but he had to develop generators, engines to drive them, governors, regulators, switchboard instruments, circuit breakers, and other items for the generating station. In addition, he had to develop and perfect distribution systems and all of the items that go into the premises of the user, such as sockets, switches, fuses and other wiring devices. In other words, he had to develop practically a whole new system. This same thing is true with the very high frequencies. Every element in the system has to

ENTERTAINMENT



Talking Book

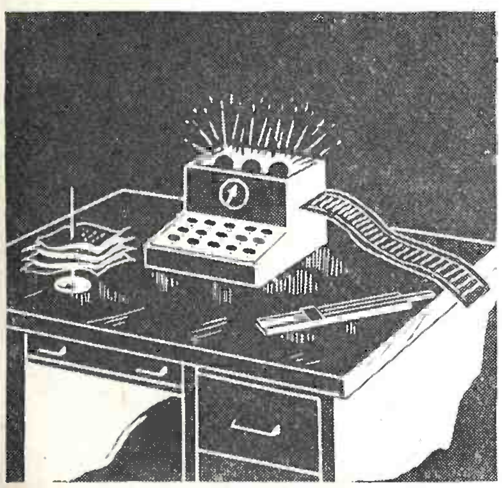


Television Movies

be designed virtually from scratch. To transmit power even a few feet requires specialized engineering knowledge.

UHF vs Light. In many ways, as has been pointed out, ultrahigh frequencies behave like sound and light and, therefore, acoustical and optical concepts are often very helpful in understanding ultrahigh-frequency phenomena. In a like way, therefore, it is reasonable to assume that some of the uses of ultrahigh frequencies will be along the lines of applications that now utilize optical phenomena. The obvious ones, of course, are in connection with navigation, where optical instruments have been commonly employed. In cases of this sort, it is reasonable to suppose that an ultrahigh-frequency transmitter, a beam radiator, and a receiver incorporating an amplifier may take the place of the sun, mirrors, lenses,

BUSINESS



Electronic Calculator

and the human eye, enhanced by a field glass or telescope. In other words, we could have the electronic equivalent of a telescope with cross hairs. We could use an electronic method equivalent to sighting on an object to determine its angular relation to some point of reference.

Over the past few years, light beams employed in conjunction with photoelectric relays have enjoyed an increased usefulness in industry. In a similar way, uhf beams may well find some applications in industry somewhat along the lines of photoelectric relays but applied where light will not function due to the fact that it will not go through certain materials or will not readily carry a sufficient distance. It must also be remembered that when employing light we can utilize only a few colors for selective purposes, whereas in the high frequency radio spectrum tuning methods permit the use of a tremendous number of non-interfering wavelengths.

UHF Relaying. Ultrahigh frequencies will undoubtedly be used to an increasing extent in connection with broadcasting and television, for the relaying of programs between studio and transmitter as well as from city to city to accomplish chain broadcasting.

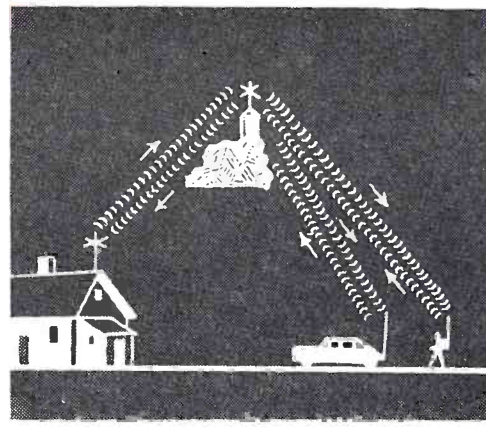
UHF in Medicine. The ultrahigh frequencies open up an entirely new field of research in the medical field due to the fact that devices for applying these high frequencies can be made so small that heating effects can be highly localized. This is not possible at the longer wavelengths. It is also possible that very high frequencies will be found to have some effects on tissue and bacteria other than heating and that these effects may be selective.

In the field of medicine, however, we must expect that the results obtained will be relatively slow in being established because of the many complications involved.

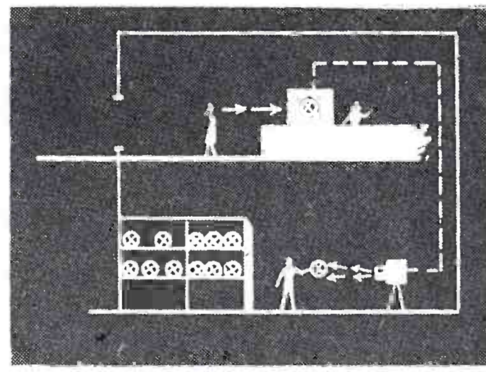
UHF-Trained Manpower. Tens of thousands of men who have joined the military services or are in Government employ are acquiring knowledge and experience on electron tubes and electronic devices at ultrahigh frequencies. These men cover the whole field. At one extreme are highly skilled scientists, both theoretical and experimental, who are becoming interested in some phase of the subject. At the other end of the scale are relatively unskilled men who are now being taught the maintenance equipment. In between these extremes are many other classifications involving both technically trained men and non-technically trained men.

It is possible that at the end of the war a situation may arise which is quite unusual. In the past, when men have returned from military service they have almost always had to adapt themselves to new occupations and new devices and machines. This has meant that these returning men were at a disadvantage in comparison to the men who stayed behind in re-establish-

COMMUNICATION



Personal Portables



Pictures by Wire

ing themselves. Perhaps the situation will be reversed in this case and these thousands of men with knowledge and skill along UHF electronic lines will return home with up-to-the-minute knowledge so that those who remained at home in industry will be at a relative disadvantage and will have much to learn to keep abreast in the electronic field.

Radically New Applications

C-R Tubes. The points that have been raised in connection with the use of ultra high frequencies bring to mind the principle that whenever work has been done in science to make something many times smaller, bigger, faster, slower, heavier or lighter than previous accomplishments, then a host of new opportunities are opened up for research and utilization. Recent work inspired by the war has done this very thing by increasing the range and availability of the very high frequencies and, therefore, it is certain that we can expect some radically new applications.

This is a field, however, in which it is inadvisable to be definite. By really new applications is meant something like broadcasting, which introduced major changes into every-day living. It appears reason-

(*Continued on page* 256)

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WAR PRODUCTION
Theme of IRE-AIEE Conference

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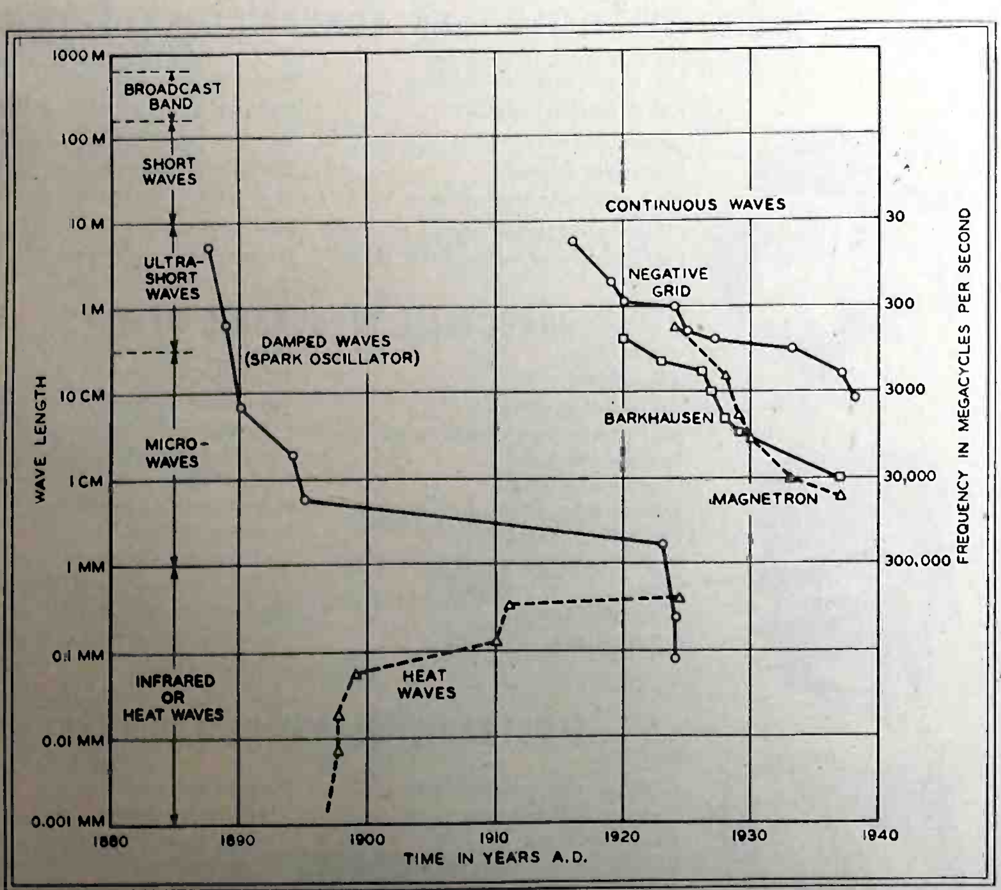
Broadly speaking, the program for the Conference was divided into two main divisions: (1) I.R.E. business activities and non-technical discussions, and (2) the presentation of papers, most of which dealt with problems of production of equipment for military requirements.

At the business meeting early in the afternoon A. F. Van Dyck, president for 1942 gave an account of his term of office and noted the trend of the Institute's accomplishment for the past year. At the end of the year, 8,775 persons were members of the I.R.E., a New York Section had been formed during the year and several changes in personnel had taken place in the headquarters office during 1942. The most notable of these, namely, the resignation of H. P. Westman, secretary, to devote full time to standardization activities in the war program of the American Standards Association, has already been reported in ELECTRONICS. The important activities of the Institute in a program of simplification and standardization were also outlined by Mr. Van Dyck who indicated that it was his belief that 1942 recorded the end of one era in radio communication and the beginning of another.



Development of high frequency oscillating circuits during the past half century. Curves at the left represent frontiers established mainly by physicists. Curves at the right represent primarily the "homesteading" activities of engineers, according to Dr. C. G. Southworth

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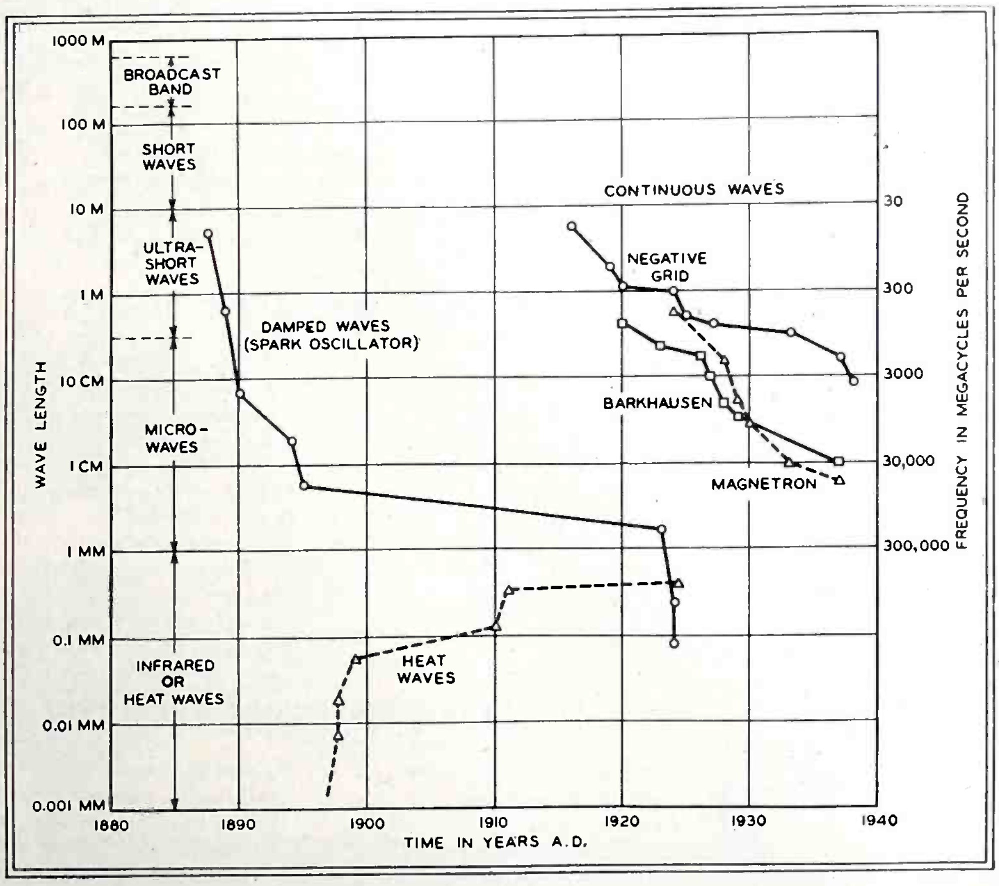

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(*Continued on page* 272)

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Jackson
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Lansing
General Electric Supply Corp.
Knight Elec. Co.
Muskegon
Fitzpatrick Elec. Supply Co.
Saginaw
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St. Joseph
St. Joe Radio Co.

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Duluth
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Northwest Radio
Minneapolis
General Electric Supply Corp.
St. Paul
General Electric Supply Corp.
Hall Electric Company

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Jackson
General Electric Supply Corp.

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Joplin
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General Electric Supply Corp.
Radio Equipment Corp.

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General Electric Supply Corp.
Newark
General Electric Supply Corp.
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So. Tier Electric Sy. Co.
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Stallman of Ithaca
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Radio Wire Television, Inc.
Sanford Samuel Corp.
Sun Radio Company
Terminal Radio Corp.
Service Radio Engineers
Niagara Falls
General Electric Supply Corp.
Plattsburg
Bragg Bros.
Poughkeepsie
Electra Supply Co., Inc.
Rochester
General Electric Supply Corp.
Beaucaire, Inc.
Radio Parts & Equip. Co.
Brown Radio Service & Lab.
Masline Radio Parts
Rome
Radio Service Lab.
Syracuse
Gould-Farmer Co., Inc.
W. E. Berndt
Utica
Langdon & Hughes Elec. Co.
Vaeth Electric Company

NORTH CAROLINA
Asheville
Freck Radio & Supply Co.
Charlotte
General Electric Supply Corp.
Shaw Distributing Co.
Greensboro
Johannesen Electric Co.

NORTH DAKOTA
Fargo
Dakota Electric Supply Co.

OHIO
Akron
General Electric Supply Corp.
Brighton Sporting Goods Co.
Canton
Furbay-Sommer Company
Burroughs Radio Company
Cincinnati
General Electric Supply Corp.
Jos. N. Davies
United Radio, Inc.
Cleveland
General Electric Supply Corp.
Progress Radio Supply Co.
Radio Serviceman's Sy. Co.
Columbus
General Electric Supply Corp.
Dayton
General Electric Supply Corp.
Crosley Distributing Corp.
Kent
Kladag Radio Labs.
Lima
Lima Radio Parts Co.
Toledo
General Electric Supply Corp.
Youngstown
General Electric Supply Corp.

OKLAHOMA
Oklahoma City
General Electric Supply Corp.
Southern Sales Co.
Tulsa
General Electric Supply Corp.
Radio, Inc.

OREGON
Portland
General Electric Supply Corp.
Radio Supply Co.

PENNSYLVANIA
Allentown
General Electric Supply Corp.
Erie
General Electric Supply Corp.
Warren Radio Co.
Harrisburg
Raub Supply Company
Lancaster
Raub Supply Company
George D. Barbey Co.
Philadelphia
General Electric Supply Corp.
Elliott Lewis Electrical Co.
Consolidated Radio Corp.
Radio Elec. Serv. Co., Inc.
M & H Sporting Goods Co.
Eugene G. Wile Company
Pittsburgh
Ochiltree Electric Company
General Electric Supply Corp.
Cameradio Co.
Reading
General Electric Supply Corp.
Geo. D. Barbey Co.
Scranton
General Electric Supply Corp.
Fred P. Pursell Company
Uniontown
Zimmerman Wholesalers
Williamsport
Lowry Electric Co., Inc.

RHODE ISLAND
Providence
General Electric Supply Corp.
Kraus & Co.

SOUTH CAROLINA
Charleston
Perry-Mann Elec. Co., Inc.
Columbia
Perry-Mann Elec. Co., Inc.
Dixie Radio Supply Co.

SOUTH DAKOTA
Sioux Falls
Crescent Elec. Supply Co.

TENNESSEE
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General Electric Supply Corp.
Jones-Sylar Supply Co.
Knoxville
General Electric Supply Corp.
Memphis
General Electric Supply Corp.
Bluff City Distributing Co.
Nashville
General Electric Supply Corp.

TEXAS
Abilene
General Electric Supply Corp.
Amarillo
General Electric Supply Corp.
Austin
The Hargis Co.
Corpus Christi
Strauss-Frank Co.
Dallas
General Electric Supply Corp.
Southwest Radio Service
Wilkinson Bros.
Denison
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El Paso
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General Electric Supply Corp.
Fort Worth Radio Supply Co.
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General Electric Supply Corp.
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San Antonio
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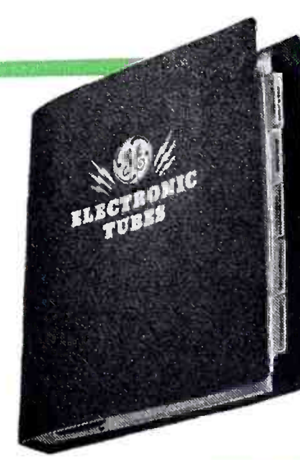

THERE'S A G-E TUBE FOR EVERY ELECTRONIC PURPOSE

GENERAL ELECTRIC

176-B1

 (Continued from page 91)

on a voice-frequency basis was accompanied by a large increase in the number of telephone repeaters as indicated in the table.

Carrier Systems

The idea of deriving more than one circuit from a communication path is an old one. In fact it was in connection with experiments on a multichannel carrier telegraph system that Alexander Graham Bell invented the telephone and one can well imagine that the possibilities of multi-channel operation tempted the early telephone engineers. To provide two circuits on a pair of wires, it is necessary to transmit a band of frequencies at least twice as wide as that which could be used for one circuit. Since the transmission loss of practically all types of line structures in general use increases as the band of frequencies is increased, one of the major obstacles to the early provision of a multi-channel system was the lack of a suitable amplifying device to compensate the added losses encountered in that method of operation. The development and improvement of the electronic amplifier, therefore, opened the way for the practical carrier system. The first of these systems was placed in service in 1918 on open wires between Baltimore and Pittsburgh. At that time the bulk of the really long haul circuits was open-wire construction, using heavy gauge wires. Whereas the introduction of the voice-frequency repeater made possible the use of smaller wire sizes in cables with accompanying savings in cost, the extent to which the size of the conductors of open-wire circuits could be reduced became limited then not by transmission but by the physical strength required to withstand the strains of that type of construction. It was but natural, therefore, that the first application of carrier methods was to open-wire circuits for here, because of the lengths involved and the relatively heavy copper conductors, the greatest economies were obtainable. For many years three carrier channels was the maximum number which could be operated on the line conductors over and above the voice-frequency circuits. By 1939, however, modern amplifier technique and improved line construction methods made it possible to operate a 12-channel carrier system simultaneously with the older three-channel carrier and voice-frequency circuits, making a total of 16 circuits on a single open-wire pair.

With the ever increasing requirements for circuits, the urge to operate multi-channel carrier telephone systems on cable pairs became more desirable, but the problems imposed by this method of operation were many and varied. Whereas with the single voice-frequency circuit operation over cables a total over-all line loss of more than 1,000 decibels is not unusual, multi-channel carrier operation would increase this loss many times. The problem of matching this huge loss with a correspondingly huge amplification to a precision of one or two decibels was a problem of no small magnitude, but the advancing electronic technique was equal to solving it. Mr. H. S. Black of the Bell Telephone Laboratories invented a new type of amplifier employing the principle of negative feed-back in which stability and fidelity of transmission of amplifiers may be improved several hundred fold. It is this type of amplifier which is used in the so-called cable carrier sytems and, indeed, in most of the other modern amplifier applications as well.

The cable carrier system provides 12 telephone circuits from two pairs of 19-gauge wire, one of which is used for transmission in one direction and the other for transmission in the opposite direction. This system may be applied to cables designed and placed especially for carrier operation or to the small gauge cables which were placed initially for voice frequency operation. In recent years new long-distance cables have been designed primarily for carrier operation.

Cable Across the Continent

Among the recently completed cables was the last link between the vast cable network covering the eastern half of the country and the growing cable network on the Pacific Coast. The twin underground cables recently completed between Omaha and Sacramento are designed for cable carrier operation and provide

WAVE GUIDE—G. C. Southworth, holding one of the resonant chambers used for tests of wave guide transmission. Behind him are two experimental wave guide transmission lines at the Holmdel Station of Bell Telephone Laboratories

Death to U Boats! Coast guard cutters sweep the seas tracking down enemy subs.

THE LITTLE MAN THAT'S ALWAYS THERE

about 500 telephone circuits from the 54 pairs of wire contained in each cable. As of December 1942, it is now possible to talk entirely over cable facilities from Bangor, Maine to San Diego, California. On such a connection, the speech currents travel nearly 4,000 miles, pass through more than 200 amplifiers with a total of over 600 vacuum tubes in tandem. The overall line attenuation on such a connection would be well over 10,000 decibels. The control of this amplification is accomplished automatically by means of electronic devices with the result that the circuits of today, such as that cited above, have a stability unequalled in the days before the vacuum tube.

Radio Extensions of Wire Circuits

Although most of the telephone and telegraph communication plants in this country employ wire systems, radio is extensively used to reach points overseas, ocean liners at sea, smaller ships in coastal and inland waters, for emergency telephone service, and in other special applications such as the bridging of natural barriers. The first overseas telephone service was inaugurated in 1927 between New York and London. This development represented an extension of the experiments undertaken in 1915 which were interrupted by the war. Since 1927 radiotelephone circuits have been extended to practically all parts of the world and today, except for the war, it would be possible to reach 83 foreign countries and overseas areas and for any telephone in the United States to connect with 93 percent of the world's telephones. Prior to the war, radiotelephone service was available to 24 luxury liners on the principal trade routes of the world. Service to boats in coastal and inland waters which was introduced in 1932 has now grown to 27 stations serving about 3,000 boats.

The techniques employed in these radio system are for the most part outgrowths and extensions of those employed in carrier telephony. Here again, as in the case of wire telephony, the advantages of multi-channel operation were significant, and advanced techniques have made possible a type of operation in which radio transmitters and receivers are used by a number of channels simultaneously. Arrangements of this type are now in use on nine of the regular radio-telephone links.

One of the recently developed carrier systems—the coaxial system—employs a specially arranged transmission path over which hundreds of circuits can be obtained. This structure consists of a central conductor arranged coaxially with an outer hollow tube about ⅜ inch in diameter. One such unit is used for transmision in each direction and a second pair of units is provided for standby operation. The repeaters on this system are spaced at intervals of about 5 miles and employ amplifiers which transmit a frequency band of several megacycles. This system is not yet in extensive use and is employed for only a few hundred circuits. Another transmission system using an unusual type of line structure is the wave guide system in which waves are transmitted along hollow conducting tubes. The wave guide system is still in the research stages and has not been placed in practical operation in the telephone plant. This system employs frequencies in the order of thousands of megacycles and has required the development of new types of vacuum tubes and associated systems.

Developments in Vacuum Tubes

When it is considered that each one of the hundreds of vacuum tubes in tandem on long-haul telephone connections has its individual responsibilities for getting the message through, or that a single tube in a carrier repeater controls the destiny of 12 circuits, it is seen that the application of the vacuum tube to the telephone plant has been accompanied by improvements and changes in design leading to a long life and a high degree of uniformity, stability and reliability.

As a result of continuous research the life expectancy of the most widely used filamentary type triode is now five years of continuous operation 24 hours a day. Certain tubes have longer life and the indirectly heated cathode type pentodes used for most present-day carrier systems have an expectancy of two years of continuous operation.

Future Possibilities

Any effort to foretell the future must be very general since changing conditions, together with unforeseen developments, may make significant changes in the course of developments. The present trends are in the direction of the use of higher and higher frequencies providing broader bands and larger numbers of circuits over a given path. Continuing this trend will impose more severe requirements upon vacuum tubes and the associated circuits and will require the development of new types of tubes, particularly where wave guide and ultrahigh frequency radio operation is concerned. Present systems are sufficiently stable to permit operation on an essentially automatic basis going for long periods without maintenance visits. As vacuum tube development results in greater stability, the future may expect to see electronic devices located in quite isolated places and remotely controlled. Serious thought has been given to the design of a submarine cable with built-in repeaters housed in an enlarged splice. Such a system was described in the Kelvin Lecture by Dr. Oliver Buckley, President of the Bell Telephone Laboratories, and presented for him before the Institution of Electrical Engineers in London, April 23, 1942.

Power for the undersea repeaters would be supplied from the terminals in somewhat the same manner as power for the auxiliary repeaters, located at intervals of about 5 miles on coaxial cable, is supplied over the cable from main repeater stations located about 50 to 75 miles apart.

High Power Not Necessary on UHF

Another significant trend is the use of lower power output from amplifiers and radio transmitters even on the multi-channel systems. As higher and higher frequencies accompanied by increased numbers of intermediate amplifier points are used, the power output consistent with balanced design will tend to be reduced even further. Although there can be no certainty of it, it is not unlikely that future systems, especially those employing wave guide or ultrahigh frequency space radio, may operate at very low powers and obtain their power from small batteries not unlike those employed in the portable radios today.

When peace opens the door for the more extensive application of newly developed techniques, the part of electronics in communications seems destined to be an important one.

TELEGRAPHY . . . SEE PAGE 166

ELECTRONIC TUBES . . .

in Wire Telegraphy

By ALDER F. CONNERY

Chief Engineer,
Postal Telegraph-Cable Company

ELECTRON tubes are widely used in the wire telegraph systems in the United States, and it is but natural that the Postal Telegraph-Cable Company, which operates a nation-wide wire communication system throughout this country, should employ electronic means to a large extent.

Power Packs. Direct current is required for the supply of the various signalling circuits in the telegraph offices. In the largest offices motor-generator sets are used for converting the alternating-current supply to direct current. In the moderate sized and smaller offices the conversion from a.c. to d.c. is accomplished by means of power-packs which use mercury-vapor tubes for the rectifying element. The design of the rectifying units for the supply of telegraph currents must be such that not only is the output voltage constant within very small limits under varying load but there must not be any appreciable voltage change at the instant that heavy drains are applied or removed. Power-pack units that meet the severe requirements have been standardized in various sizes and have made small motor-generators obsolete in the telegraph field. Among the advantages of the rectifiers over the motor-generators are freedom from noise, freedom from radio interference and greatly reduced amount of routine maintenance.

Carrier Telegraph. Between New York City and Washington, D. C. a ten-channel audio-frequency telegraph system is in constant use. Generation of the audio tones is produced by a motor driven multi-frequency tone generator. Vacuum tubes are used at the terminals for detection and amplification. At the three repeater points vacuum tubes are used as amplifiers in the uni-directional repeaters.

Telephone Repeaters. Postal Telegraph owns and operates a number of toll telephone systems in various sections of the United States. All of the longer circuits contain one or more repeaters. These repeaters are all a-c operated and vacuum tubes are used as amplifiers and rectifiers.

Carrier Telephone. In addition to the physical toll circuits, Postal has a number of superimposed telephone carrier channels. A frequency of 7 kc in one direction and 10.5 kc in the opposition direction is standard. Vacuum tubes are used in the carrier terminal sets as oscillators, modulators, amplifiers and rectifiers. The longer carrier circuits are equipped with one or more carrier repeaters in tandem, and vacuum tubes, of course, are used as amplifying devices.

Induction Neutralizing. On several important pole lines the close proximity of high voltage power parallels for long distances have made it necessary to provide special protective methods to permit normal use of the wires. One conductor on the pole line is selected for use as a pilot wire and this is connected to an induction neutralizing device at the repeater station which tends to feed back into each wire on the pole line a current equal in intensity and opposite in direction to the disturbing current and thus effectively neutralizing the disturbing current. The induction neutralizing uses a considerable number of vacuum tubes.

Metallic Telegraph. For many years telegraph traffic between the larger centers of population has been carried over "multiplex" equipment. Two or three channels are derived by means of synchronously rotating distributors which divide the line time at regular intervals among the several channels. This multiplex equipment was operated over ground-return duplexed wires. In recent years the increase in the number of electric power distributing systems paralleling the grounded multiplex circuits has seriously reduced the efficiency of these circuits. Ground-return telegraph circuits are also seriously affected by disturbances from adjacent telegraph circuits and also, at infrequent intervals, by circulating currents resulting from aurora-borealis displays.

Metallic telegraph circuits in which two line conductors are used instead of a single conductor with ground return have been designed but heretofore have not been very successful. The electro-mechanical relay necessary for handling the received signal requires a certain minimum current for efficient operation on high-speed signals. Using a reasonable value of transmitting voltage, 120 to 160 volts, insufficient current is transmitted over the loop of wire between repeater stations if they have the normal spacing (250–300 miles). The receiving relay operation was inefficient and severe distortion to the signals was the inevitable result. Higher sending voltages have been tried but difficulty is experienced in controlling the high voltages at the sending end without introducing severe signal distortion.

Postal Telegraph has solved this problem of designing an efficient metallic telegraph circuit by the novel use of a pair of electron tubes to drive the receiving polarized relay. With this circuit, the relay will be operated by a current of the proper value for efficient operation regardless of the value of current in the loop circuit. A further advantage of the system is that the reactance of the relay windings does not appear in the loop circuit and therefore does not complicate

(Continued on page 258)

Paved with Good INVENTIONS

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CHATTANOOGA, TENNESSEE

(Continued from page 135)

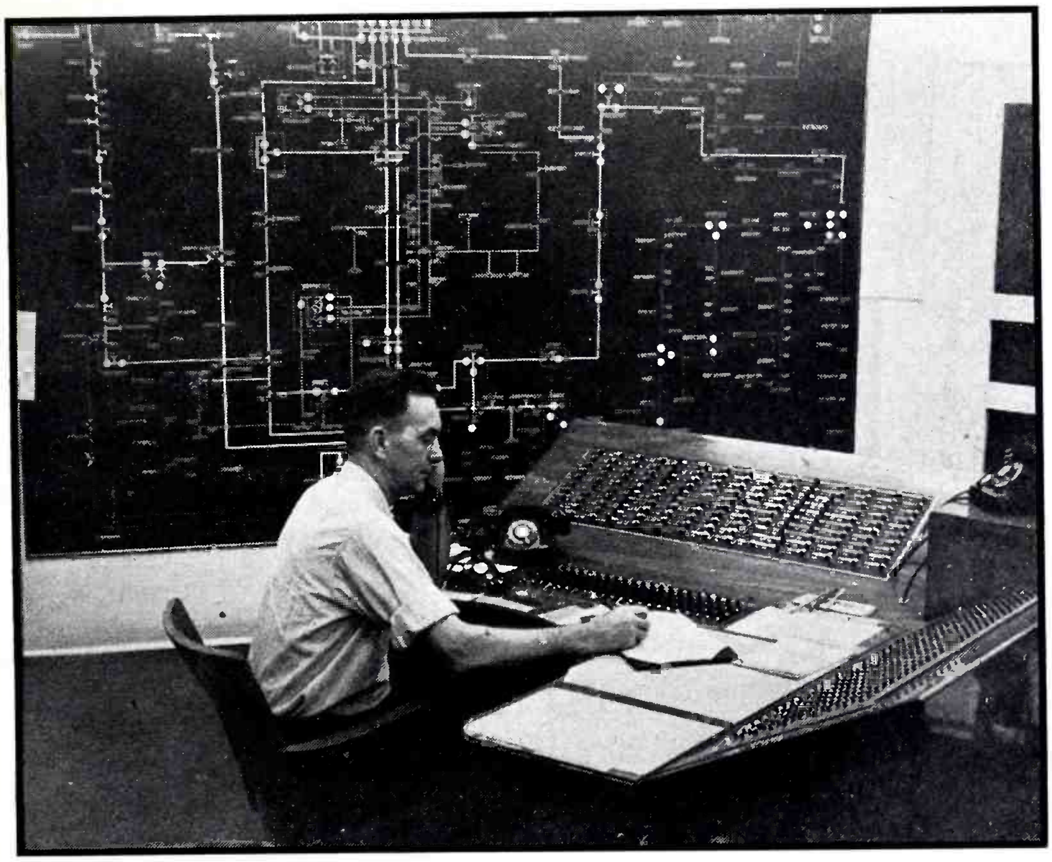
the power and telephone can be rerouted in the event of a line failure at any other point. In other words the power and associated telephone system becomes a series of loops, or lines which can be connected as loops if necessary. The telephone circuits, of course, would not normally be connected in loops but the communications can be rerouted in event of the loss of any one section.

When a line failure does occur for any reason, some systems now use carrier remote control to aid in quickly locating the bad section of line. Carrier controlled switching stations are installed along the lines so that it becomes only a matter of dialing a number from the supervisory desk to open or close a remote switch. In this way, it is possible to quickly determine the approximate location of the line fault and drop out that section of line. The remote control method accomplishes in a matter of a very few minutes what might take many hours if a patrolman had to go to each sectionalizing switch to operate it manually.

Another unique electronics application is a method now used for determining the location of a line fault from the substation or point of termination of the line in question. The device consists essentially of a variable frequency oscillator which feeds radio frequency power into the line under test. A meter in the oscillator circuit measures the current fed into the transmission line. By varying the frequency steadily in one direction, standing waves are set up on the transmission line. The line fault constitutes an impedance irregularity which causes reflection and standing waves result at certain frequencies. The separation in the frequencies at which standing waves are set up on the line supplies all the information necessary to calculate the distance to the line fault. The frequency-versus-line-current-curve is automatically recorded by the machine.

The greatest portion of power system electronic development is involved directly or indirectly with power transmission. Electric power is so very important that constant vigilance is required by many people to keep the power on the lines. The continuity of power flow is aided in many ways by electronic devices but there is much to be done before the field is fully developed.

From the standpoint of communication, the telephone network folowing the transmission lines becomes very long with high signal attenuation as the result. This is true especially with the large spreadout systems in the west where so much distance is covered over the more sparsely settled areas. The high attenuation of the signal in combination with the usual noise level makes many telephones impractical to use without the aid of electronics.



SWITCHING—R. Penhale, dispatcher for the Montana Power Company, seated at the main control desk. The open or closed position of every oil switch and airbreak switch in the system is indicated on the diagram board. This is the electrical center of 5000 miles of power transmission line and an equal length of carrier-current switching and telephone circuit

Communication in Power Systems Aided by Electronics

The most recent electronic telephone development for power system use, is a special form of repeater. This arrangement combats high noise levels, and attenuation, very successfully. It operates through the private branch exchange board of either the manual or automatic type. The fundamental principle is high level transmission with fixed attenuation in the receiving end of the circuit. By this system signal is "traded" for noise and extremely noisy lines become excellent communication circuits.

A very popular electronic application now used by power systems is represented by the special emergency radio systems. These radio networks are normally used for standby communication to supplement or replace the telephone system if the latter is put out of service or is inadequate during an emergency.

The Special Emergency license permits the use of radio during emergencies or for contacting patrolmen and repair crews when other communication is out of service or inadequate. This standby communication becomes especially valuable during heavy storms which may cover much territory and destroy several lines at one time. Radio communication speeds up the ordering out of the necessary crews and material for repairing the line breaks. Also, radio is used to report the completion of the job so the line can be quickly restored to service.

Carrier Current Applications

The application of carrier current to power lines has had little publicity outside of the power field. The result is that the average man not in contact with that work has had no opportunity to become acquainted with it. Much of the equipment is similar to conventional radio transmitter and receiver design, still several special circuits are necessary to adapt the principles of radio to power line use.

Carrier current constitutes one of the most important electronic applications in the power field. It would be classified in the low power branch and in some cases could be classed as medium power. The uses of carrier on power systems seem almost unlimited so that it promises to be of far greater value in the future than it is at present. Some of the important carrier applications are telephony, telemetering, relaying, supervisory control, phase angle control and load control.

The most popular telephone arrangement is the single-frequency automatic. This is a voice operated changeover from receive to transmit. Recent voice switching circuits are entirely electronic and operate so rapidly that clipping is unnoticed. An automatic dialing system is used for calling the desired party. A few two-frequency carrier sets are in use where only two stations are required.

Carrier telemetering is used for transmitting to a distance, such readings as voltage, current, wattage, pressure, temperature, water level and frequency. The transmitter is tone-amplitude modulated, interrupted or frequency-modulated as the case may be, by the instrument indicating the value measured. At the receiving end the proper discriminator or impulse filter translates the modulated carrier to a direct current proportional to the distant measured value.

Phase-angle control and load control are accomplished in about the same manner as telemetering except that the received signal controls, through additional circuits, either the frequency or voltage respectively. When two or more power systems are interconnected it is sometimes difficult to maintain the desired power flow through the tie line. In some cases the carrier phase-angle control is used to measure the relative phase angle of the systems and then to automatically shift the frequency of a key generating plant to maintain the optimum phase relation. Load control operates similarly except that it is on a power basis. In this case the controlled station shifts the voltage in a direction to maintain the desired power flow through the system interconnection.

Carrier relaying is used in conjunction with high speed protective relaying systems. The carrier signal is used to prevent operation of all relays except those nearest the line fault. Thus the bad section of line is dropped out of service with a minimum disturbance of the system. The carrier transmitter at a relay station is started by the power relay action if the line fault is not located between that station and the adjacent one. The receiver at the other end of that section of line then blocks the power relays from operating.

DETECTION—Metal locator, equipped with an electronic amplifier. It facilitates the finding of buried pipe lines and valves

Supervisory control systems use carrier signals as a means of remote control for opening and closing switches, operating voltage and speed controls, etc. One popular use of carrier is the control of street lights from a centrally located substation so that a blackout can be accomplished in a minimum of time. A combination of carrier remote control and telemetering allows complete supervision and control of a distant substation or generating plant.

Miscellaneous Applications

Another weak-current application in common use by power systems is the photo tube and circuit. Most of these applications are more or less standard. However, there are a few specialized circuits which appear from time to time for solving the individual problems that arise.

The hole in the meter-scale idea is often used in power work. The meter needle or indicator breaks a beam of light at a predetermined setting and operates the phototube relays and associated equipment. The principle can be used for regulation of current or voltage, over-or under-voltage and current alarms, and numerous other similar devices.

Many electric utilities now use a commercial phototube device for testing and adjusting wattmeters. A beam of light is projected against the rotating wattmeter disk so that the holes in the disk allow light to fall on a phototube. An electronic circuit counts the impulses and after a definite number of impulses are received, a relay turns off the power to the wattmeter and standard test meter. Checking meters by this method eliminates the human element in timing and counting revolutions and is entirely automatic.

A variation of this principle uses a circle of holes in the rotating disk of wattmeters. A beam of light is projected against the meter disk so that the holes in the disk permit light impulses to fall upon a phototube as the disk revolves. The phototube relay impulse frequency is proportional to the power flowing in the wattmeter. The impulses can be sent to a distant point by wire or carrier channel. At the receiving end an impulse filter translates the impulse frequency into a direct current and the wattage is then indicated on a properly calibrated d-c instrument. By such methods of telemetering the system operator knows the load values in the various lines without the necessity of an attendant at each wattmeter. It is often important to know these power

values instantly and without the delay which would result from values read by an attendant and telephoned to the system operator.

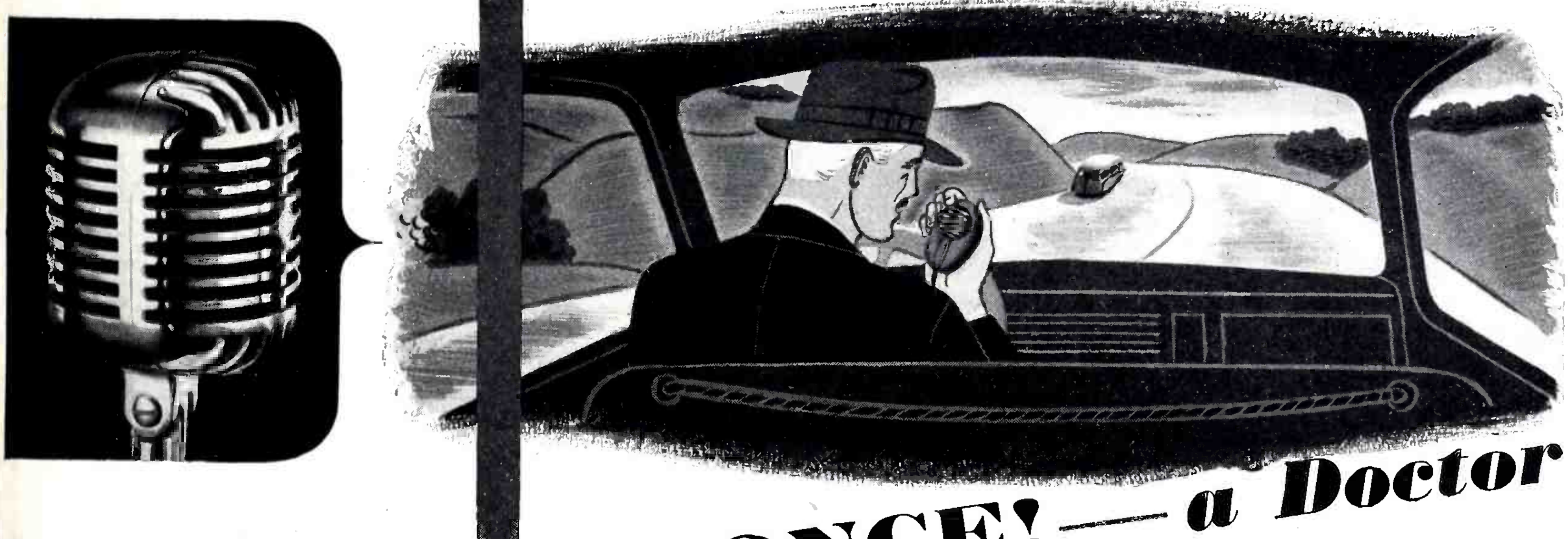
Other weak-current devices to be found are various types of amplifiers, synchroscopes, electronic wattmeters, no-voltage indicators and cable fault and pipe locators. Even the common portable cathode-ray oscilloscope is now finding much use in power system practice. There are also numerous electronic relays such as time delay circuits, sensitive and polarized relays and no voltage alarms.

Another branch of applications which reaches into the medium and heavy power devices is the use of rectifiers for obtaining high d-c voltages for testing purposes. Both the high vacuum diodes and controlled gas-filled and mercury tubes are used for this work. The high d-c voltages are needed for cable and insulation testing, smoke elimination in stacks, and in various laboratory tests. The protecting rubber goods which are used by linemen while working on "hot" lines are tested with a d-c voltage supplied by diode rectifiers.

At present the electronic voltage regulator is perhaps the most popular medium power device. These regulators use small thyratrons as the primary controlling element. The thyratron circuit works into the field of the rotary exciter or into an electronic exciter. In either case the controlled exciter voltage in turn determines the voltage of the large alternator. The index voltage upon which the thyratrons act is obtained through a step-down transformer fed from the output of the alternator.

Grid controlled rectifiers are now used for charging power station batteries. The electronic circuits govern the charge rate so that the correct tapered charge is applied to the battery.

In the high power electronics field in power system work the outstanding developments have been the controlled rectifiers and frequency changers now used for several different purposes. One very popular use of the rectifier alone is for supplying power for d-c traction systems. Another common use of this equipment is the supplying of direct current for electrolytic processes for the production and refining of alumi-



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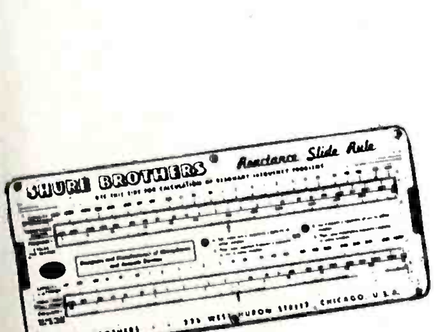

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Makes extremely simple the calculation of complicated problems in resonant frequencies. Also helps in the solution of circuit problems involving inductances and condensers. Covers a frequency range of 5 cycles per second to 10,000 megacycles. Indispensable for radio and electrical engineers, technicians and circuit designers. Send 10c in coin to cover mailing costs to **Dept. 174M.**

SHURE

num, copper, zinc, etc. Many thousands of kilowatts of direct current are developed by controlled rectifiers for production of metals.

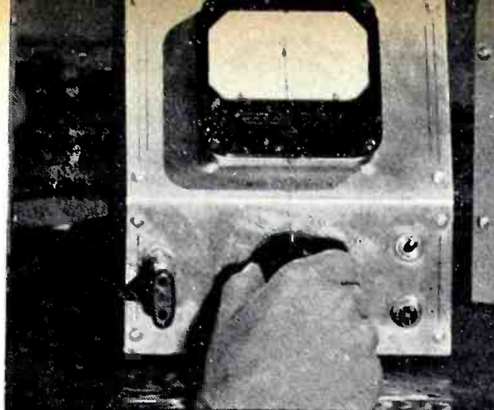
Electronic frequency changers handling 5000 kw continuously are in use at the present time. This equipment is used for supplying power for traction purposes at a frequency other than the available power frequency. The electronic type of changer offers several advantages over the rotary type.

Chief among the advantages of the rectifier over rotary machines is the ability of the electronic equipment to accept momentary overloads and even short circuits without damage. A load which varies rapidly and over great values is easily handled by electronic equipment. Rotary equipment under the same conditions may flash over at the commutator or require load shifting. The factor of overall efficiency is a little in favor of the electronic equipment.

Much thought has been given the idea of using high voltage d-c power transmission lines instead of the present a-c type. This would eliminate the line drop due to inductance and also the effects of line capacity. The voltage could be raised to a value higher than that now used for a-c work before corona losses occurred. Dielectric losses of the transmission line could be greatly reduced. With this system the generation and distribution of the power would be in the form of alternating current as at present. Grid controlled mercury arc rectifiers would change the a-c power of the correct voltage to direct current for transmission. At the distribution end of the line, electronic inverters would change the power back to alternating current of the desired frequency. Constant-current as well as constant-voltage systems have been designed for the d-c operation. This is another example of the adaptability of the grid controlled mercury arc tube.

The future of power system electronics appears to be as unlimited as it is in the related applications. Upon the cessation of our world conflict, such electronic development will receive more attention than ever before. The science of electronics is destined to become one of the most important aids to mankind.

nstruments for measuring frequency including sec-
ndary frequency standard and electronic frequency
neters. Model 500A Electronic Frequency Meter above



Instruments for measuring voltage in the audio and high frequency range. Model 400A Vacuum Tube Voltmeter above

Audio frequency oscillators of the resistance-tuned type. Excellent frequency stability and freedom from wave form distortion. Model 200B Resistance-Tuned Oscillator above

Research into the fields of electrical engineering, physics, chemistry and all phases of science is greatly aided by the use of modern electronic measuring devices. The accuracy with which measurements are made is the yardstick of progress. Time is always an important element. Thus, electronic instruments should combine speed of operation with accuracy.

To gain speed of operation without sacrifice of accuracy, all *-hp-* instruments are designed to operate with a minimum of adjustment. For the first time a variable frequency audio frequency oscillator which does not require a zero adjustment is available. The *-hp-* vacuum tube voltmeter is as simple to operate as a multi-range d.c. instrument.

To accomplish certain measurements more quickly *-hp-* model 205AG incorporates a resistance-tuned audio oscillator, input meter, output meter, attenuator and impedance matching system . . . all in a single unit.

Investigate *-hp-* services today. Write, giving details of your problem so that *-hp-* engineers can give you most accurate information. DO IT NOW!

Audio signal generators providing standardized voltage throughout the audio frequency range. Model 205AG Audio Signal Generator above

R GREATER PROGRESS IN ELECTRONICS

Harmonic wave analysers with many new features including variable band width. Model 300A wave analyser above

Laboratory Instruments
for speed and accuracy

PROMPT DELIVERY. *Due to the demand of war, production facilities have been greatly expanded. Immediate delivery can be made in many cases where orders are covered by high priority ratings.*

Instruments for making over-all measurements on audio equipment including total harmonic distortion, frequency response, and hum level. Model 325B Distortion Analyser above

Fully illustrated 24-page Catalog gives complete data and valuable information relative to electronic instruments. Get your copy NOW *for the edition is limited.*

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ION A,
) ALTO,
FORNIA

EWLETT-PACKARD CO. • PALO ALTO, CALIF.

Post-War Radio

(*Continued from page* 95)

employed in electronic devices which detect, count, sort, measure, control, and perform many other tasks with infinitely greater precision and skill than it is possible for a human to do.

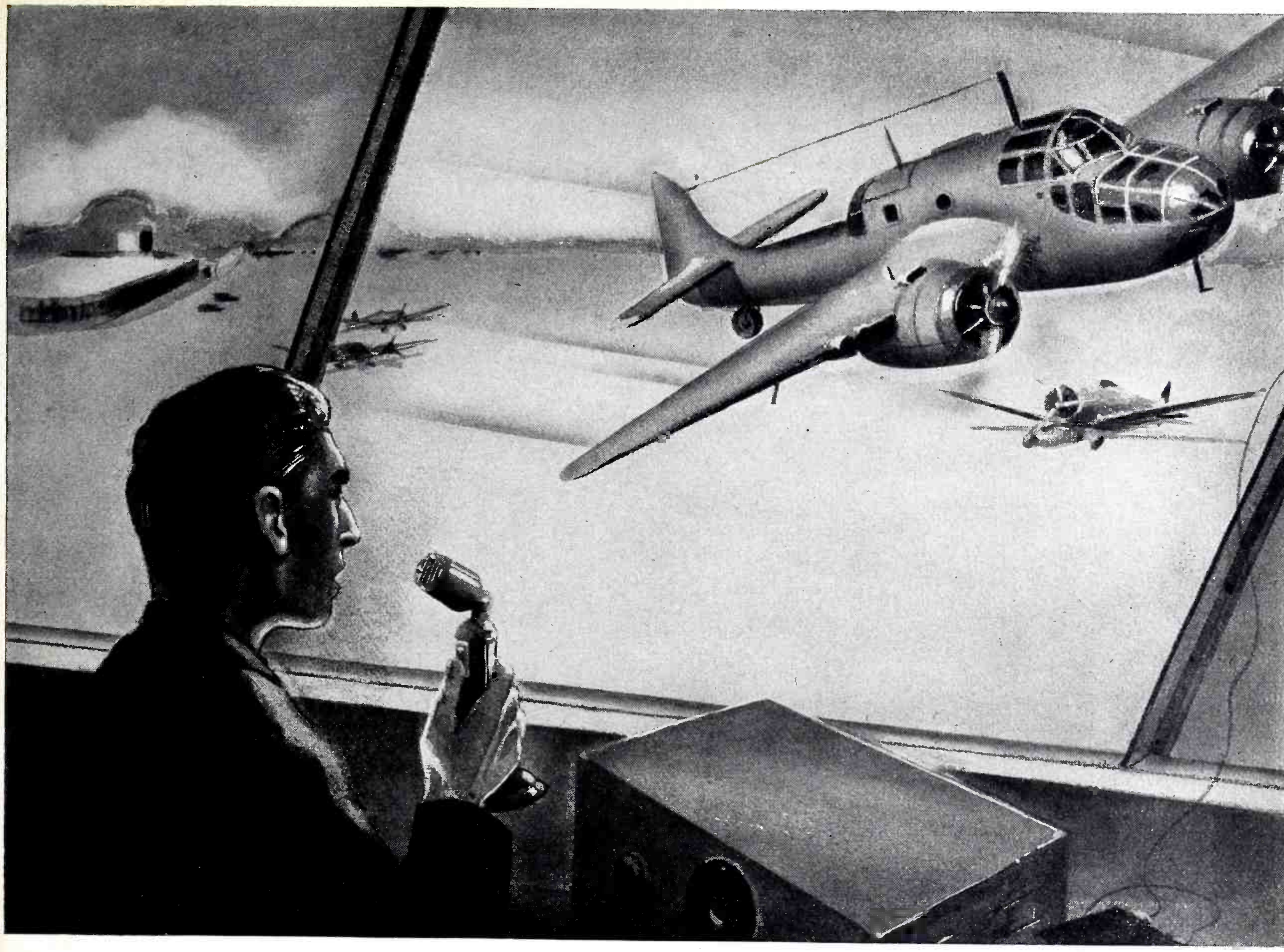
A most outstanding application of radio science to non-communication purposes is the electron microscope. This instrument, for many years a theoretical possibility and then a laboratory novelty, became a practical reality through research in electronic television.

Under the impetus of war, still another branch of radio is being brought forward with a rush. Radio Corporation of America engineers call it "radiothermics." It is a development which employs high-frequency radio waves to heat, glue, dry, case harden, anneal, rivet, weld, deactivate enzymes, and to perform other industrial and scientific processes that cannot be revealed now. Because high-frequency heating shortens production cycles, improves products, and enables processes once regarded as impractical, many industrial products and services of the future will be better and cheaper.

War also has stimulated the development and growth of the new field of industrial sound—an offspring of radio. Manufacturing plants, railroad yards, and airports in many parts of the country have installed comprehensive systems of sound reproduction, which speed up communication and the handling of traffic to a degree thought impossible a few years ago. They also are used to play music for employees, who find that this new service relieves fatigue and breaks the monotony of repetitive tasks. Industrial sound will have an important role in the post-war world.

I doubt that any other industry holds the challenge represented by the future of radio-electronics. The electron, smallest known bit of matter, is assumed to be one of the basic building blocks from which the ninety-two stable chemical elements are formed.

The industry accepts the challenge of the future; for radio is not simply an agency of communication. It is a gateway to progress.



Television

(*Continued from page* 99)

the possibilities of theater television, as distinguished from television broadcasting for reception in the home. Equipment has been developed and demonstrated capable of projecting a satisfactory television picture on a 15 ft x 20 ft. screen in a motion picture theater. Connection of theaters in a metropolitan area to a central distributing point either by means of special radio circuits or specially equalized telephone circuits (this has been demonstrated to be feasible for short distances) may be readily accomplished. This would appear to offer a supplementary service for motion picture theaters.

So far, we have considered only the entertainment and educational possibilities of a television broadcast service. Obviously, any medium for the transmission of sight intelligence practically instantaneously from one point to another over great distances offers many other attractive possibilities and television may find a wide variety of special applications. Remote supervisory monitoring of industrial operations, demonstrations of techniques to large groups in classroom and laboratory teaching, remote identification of persons or objects, etc., suggest themselves at once as possible uses for this powerful new tool.

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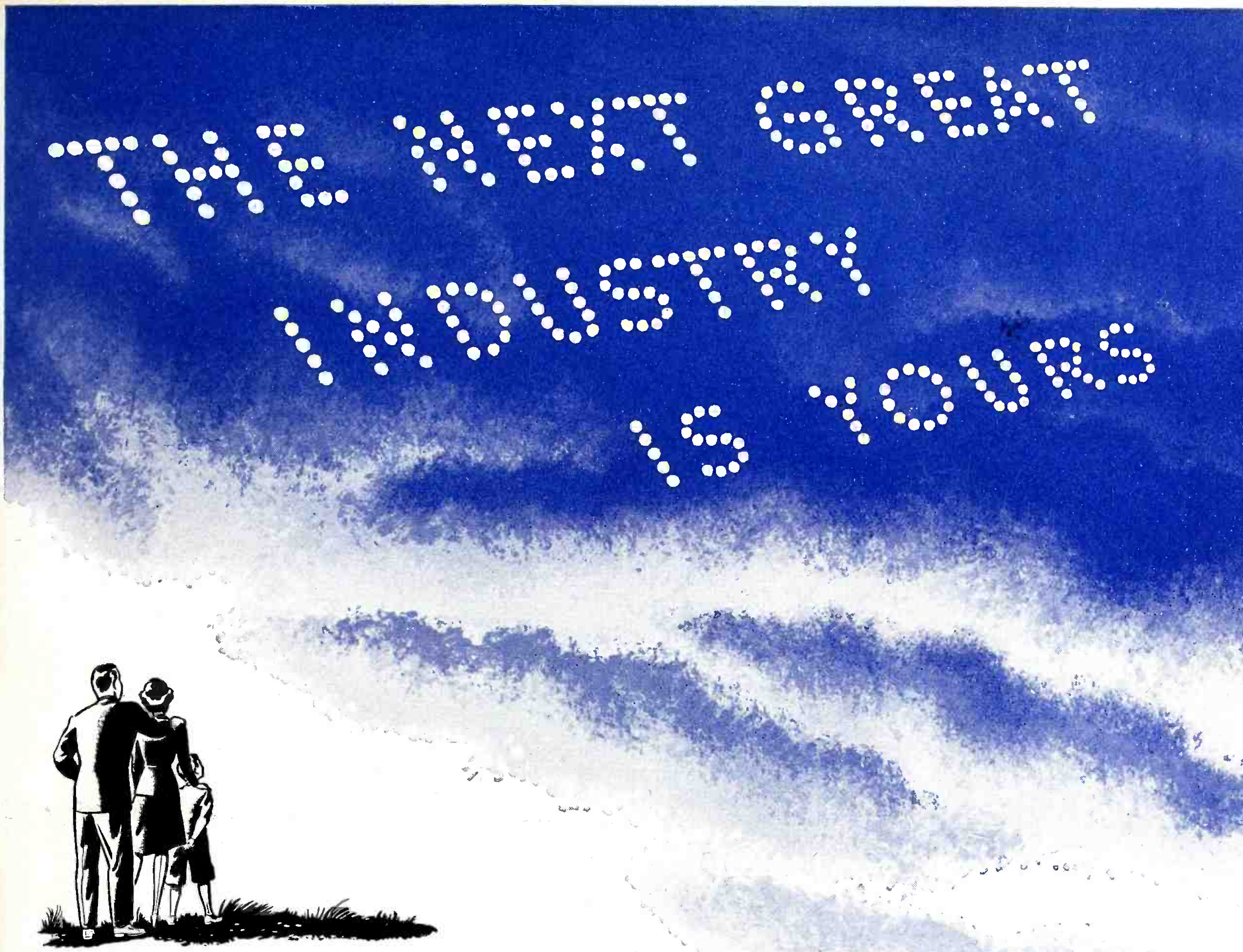

EVERY ONE connected with the electronics industry can be proud that television is destined to be the big new industry of the post-war years. Business leaders and economists expect it to rival the growth of the automobile industry after the last war. It should help America "take up the slack" when Peace comes — enlist piled-up savings — make thousands of new jobs.

Farnsworth, pioneer and natural leader in television manufacture, is already enlarging that opportunity. Our advertising, right now, is telling America about the television to come — when the war is finally won.

Farnsworth production, today, goes entirely to the armed forces . . . fine precision equipment that will help United Nations win. When the war job is done, we'll be ready to supply the most advanced and most complete studio and station television equipment — the fruit of 16 years of research and invention in this field.

Television has always been Farnsworth's primary interest. And for the precision manufacture necessary, we have the plant and people who have built the superb Capehart Phonograph-Radio.

Farnsworth research made electronic television a reality . . . Farnsworth equipment will bring it — at its best — to America.

• PREPARING THE COUNTRY for television is the job of Farnsworth advertising. Read the current advertisement in March 22 *Time*, March 27 *New Yorker*, March 29 *Life*, April 3 *Collier's*, and April 5 *Newsweek*.

FARNSWORTH TELEVISION

• Farnsworth Television & Radio Corporation, Fort Wayne, Indiana. Manufacturers of Television and Radio Transmitters and Receivers; Aircraft Warning Equipment; the Farnsworth Dissector Tube; the Capehart, the Capehart-Panamuse and the Farnsworth Phonograph-Radios.

Military

(Continued from page 102)

are permanently installed in vehicles and obtain power from the vehicular electrical system. Others are portable, low-power transmitters and receivers which can be carried like suitcases and are operated from batteries. Auxiliary equipment makes it possible to install these portables in vehicles and operate them off the vehicular electrical system.

Messages may be sent either by radiotelegraph or radiotelephone. Special abbreviations are used in either case to convey the information which an observer, either at a forward vantage point or in the air, is in a position to get through to the fire control station. The Field Artillery radio sets provide communication for purposes of reconnaissance, direction of fire, and warning against impending attacks of enemy aircraft or tanks. One feature of these sets is remote control, enabling an operator to put a set in a physical location which provides for good transmission while he personally can work from a position with less exposure to enemy fire.

Considerable attention has been paid to the portable radio set carried by one man. The walkie-talkie, carried on a man's back, has already become familiar to all Americans. In the field of combat, it has already performed admirably in front-line reconnaissance and artillery observation. Better and more compact portable radios are under continual development. One of them is the tiny transreceiver which a man can hold in one hand while listening or talking. It is known as the "handie-talkie," although some troops like to call it the "cracker-box radio" because its size and shape resemble the common retail biscuit box.

Radio, Vital to Aerial Combat

Aerial warfare has provided a huge and diverse field for the application of radio. Communication itself is only one of many ways in which radio is used in aerial war. Radio plays a major role in helping the navigator plot his course in flying in a definite direction with or without the aid of a radio beam.

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Embossed Reference Recordings— .015" Thick!

AT THE LISTENING POST

Ethocel Sheeting reference recordings are on duty today at monitoring stations and listening posts in many sections of the country. Large, 16-inch diameter recordings—playing an hour on each side—are easily made by the operator. With no chipping or cutting, there is no need to watch every rotation of the turntable. Instead, the Ethocel Sheeting record is embossed accurately, steadily, surely.

Private broadcasters, as well as governmental agencies rely on Ethocel Sheeting for their permanent records.

Requirements for embossed reference recordings are of necessity severe. The recording surface of the material employed must take embossing operations without chipping—yet be hard enough to remain dimensionally stable over many playbacks.

To meet the specific needs of such recordings, Dow has developed a special formulation of Ethocel Sheeting. Made of Dow ethylcellulose, the toughest cellulose material commercially available, it provides the right medium for reference recordings. It is exceptionally hard. It is extremely flexible. It does not chip.

Moreover, Ethocel Sheeting is only .015" thick—a factor of importance whenever storage facilities are limited. Most important, it assures a maximum number of playbacks—each as clear and distinct as the last.

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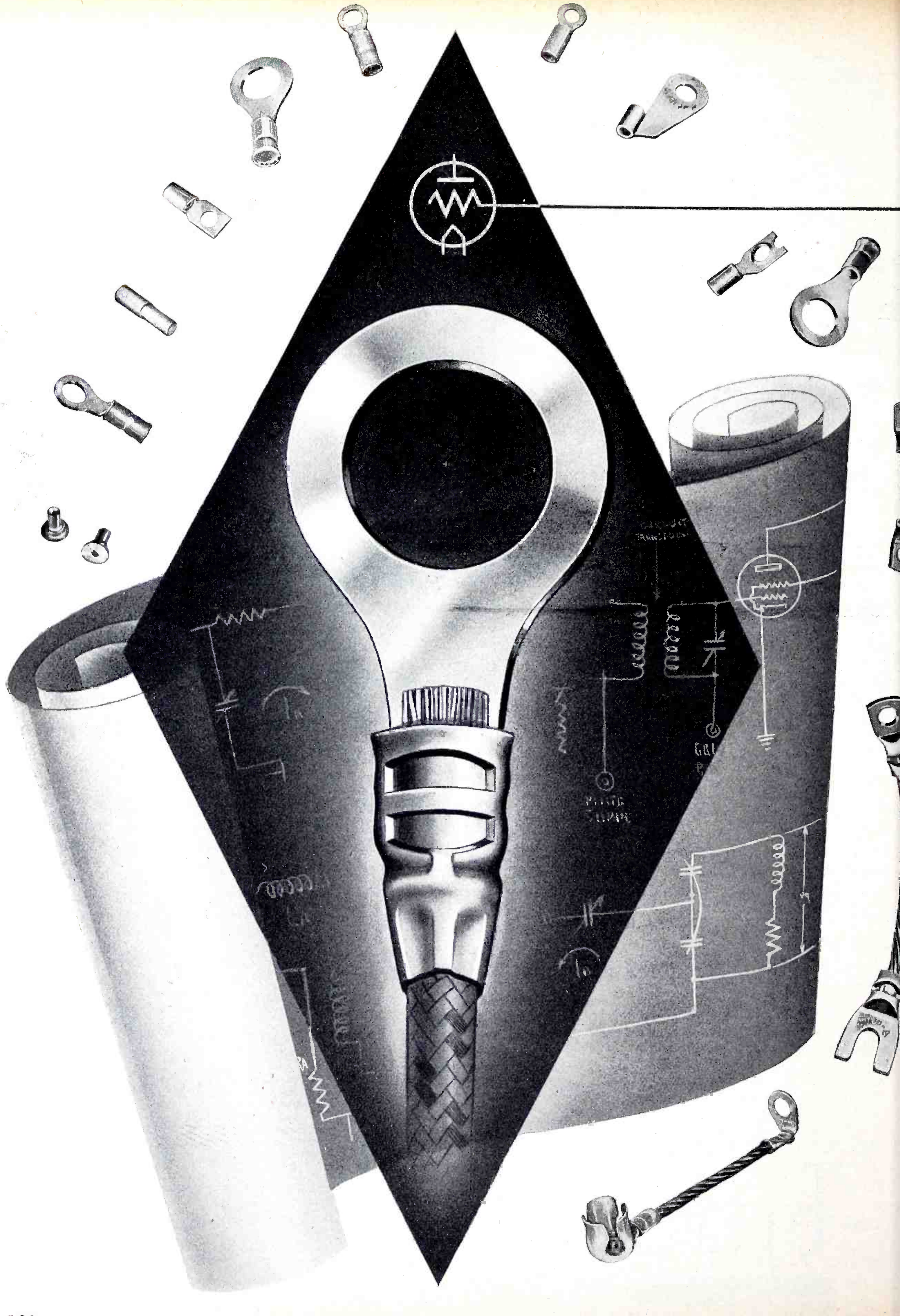

TO ENGINEERS FROM AN ENGINEERING MINDED COMPANY

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AMP SUPPLIES TO THE ELECTRONIC INDUSTRY SUCH OUTSTANDING DEVELOPMENTS AS DIAMOND GRIP SOLDERLESS INSULATION SUPPORT TERMINALS WITH PRECISION HAND AND POWER INSTALLATION TOOLS PLUS A MULTITUDE OF OTHER SOLDERLESS WIRING DEVICES SPECIFICALLY DESIGNED FOR ELECTRONICS

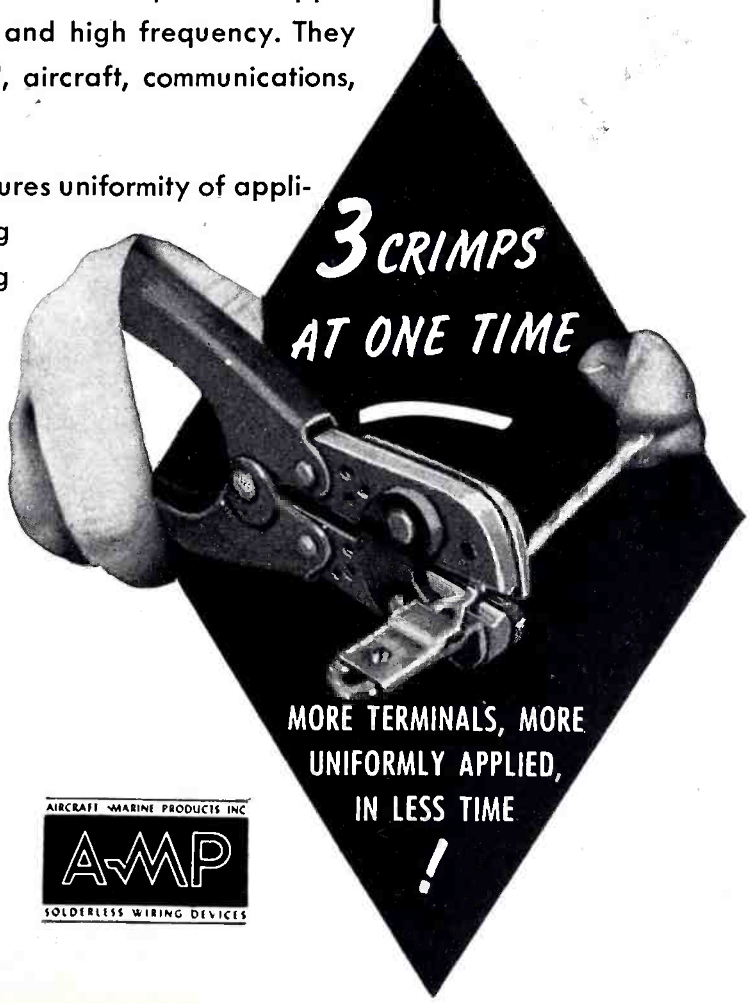
Because of the dramatic impact of the results of developments in the electronic field and of the swift progress made in this field, it apparently is possible even for engineers to overlook the importance of changing practices and conceptions in the smaller components that go into development of electronic products.

AMP Diamond Grip Insulation Support Solderless Terminals and AMP Precision Hand Tools and Power Tools have introduced new concepts of the economics and engineering of applying millions of perfect terminals to the ends of millions of wires.

AMP Diamond Grip Insulation Support Solderless Terminals, lighter in weight, shorter in length, and accommodating in one terminal, wire sizes from 16-22 with assured visual inspection, are definite steps forward in engineering design.

AMP Diamond Grip Insulation Support Solderless Terminals are used in many critical applications in a multiplicity of electrical circuits including low voltage and high frequency. They have performed in the exacting conditions of war in gun control, aircraft, communications, radio, electronics and many other electrical fields.

The AMP Solderless Wiring System saves production time and assures uniformity of application by unskilled workers without the requirement of a pre-training period. Every connection applied under the AMP Solderless Wiring System is exactly like the one before.



AIRCRAFT-MARINE PRODUCTS, INC.

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Tests made by unbiased, non-commercial laboratories show that AMP Diamond Grip Terminals show no significant change in resistance of the terminal even under the severest operating conditions. The tests included a multiplicity of circuits, variations in current, voltage, temperatures and corrosion. ***Detailed test data will be sent you on request.***

"PRECISION ENGINEERING APPLIED TO THE END OF A WIRE"

Radio altimeters tell the pilot how high he is over the nearest terrain obstacles, a tremendous improvement over the pressure type altimeters which indicated altitude above sea level, and even then only after further correction was made in accordance with the barometric pressure variations due to weather conditions at the moment. Radio serves in bringing pilots back to their home base and in guiding pilots to a blind landing under conditions of "ceiling zero." Radio also serves in a very remarkable way in the secret devices used for detecting and locating enemy craft.

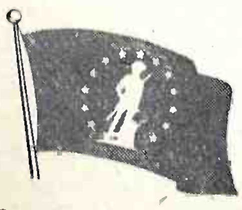
CONTROL—Wire communications as well as radio communications play an important part in war. Here a gunnery Sergeant is shown receiving azimuth and elevation from a range-finding crew by telephone

In preparing for any aerial undertaking, a knowledge of the winds and other meteorological conditions at various altitudes is of the utmost importance. For this purpose, the Signal Corps has applied radio in the form of tiny automatically operating transmitters carried by balloons to the upper layers of the atmosphere and sending signals to the ground to provide a continuous record of temperature and humidity at successively increasing altitudes.

Radio direction finders play an important part in locating enemy transmitters. Special signal radio intelligence personnel are assigned to monitor the enemy wavelengths and keep a record of their transmissions. In our own operations, of

Cannon Connectors, used wherever electrical connections must be made quickly, safely and securely, now serve as the means for connecting the many electrical circuits used in the control and operation of the weapons of war.

When the war is won, these same Cannon Connectors will again be available for peacetime consumers on a host of electrical devices not even dreamed of now. And, having passed the rigorous tests of war, they will assure even a higher degree of dependable performance under the less strenuous demands of peaceful living.



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Cannon Electric Development Company, Los Angeles, California

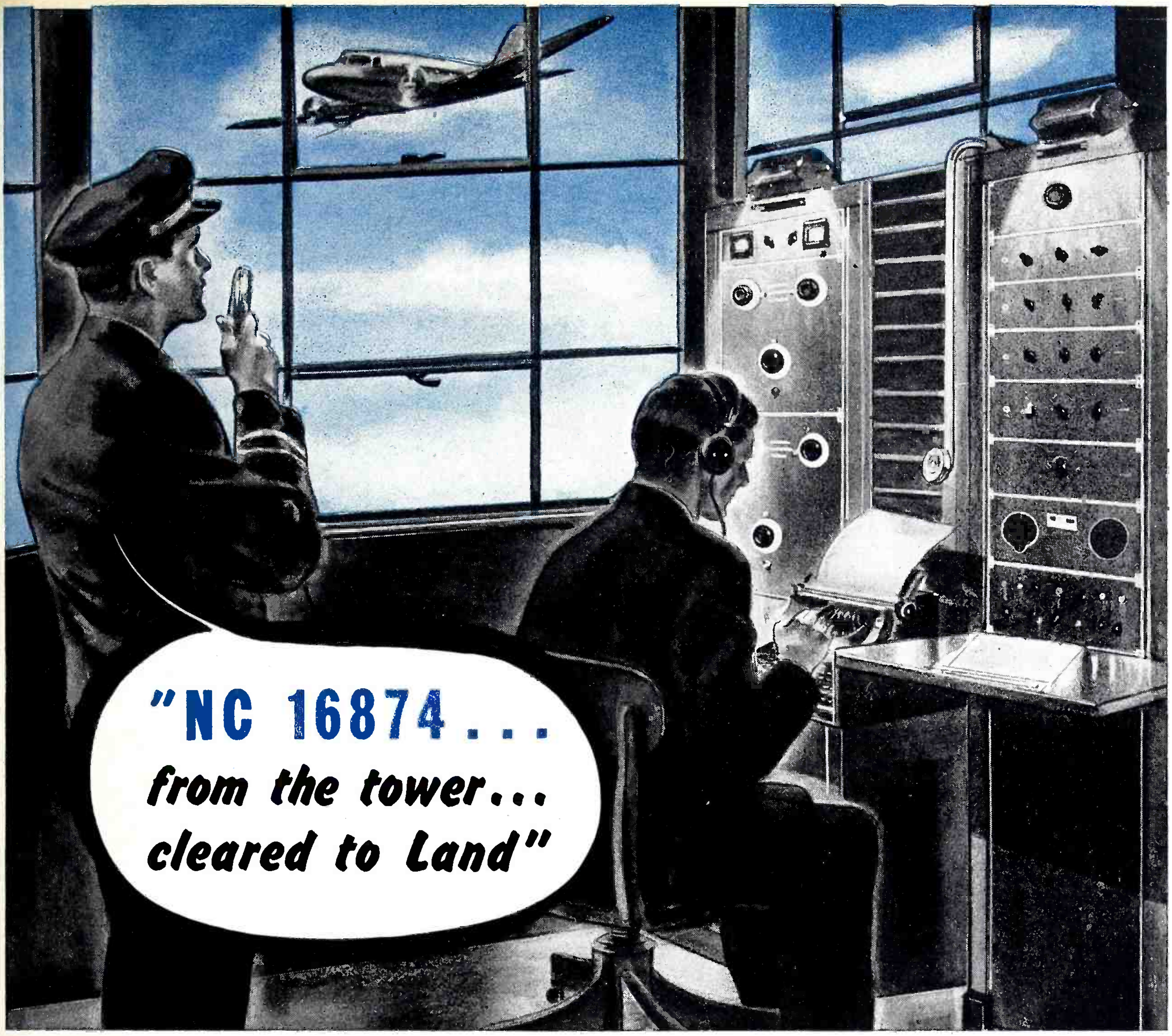
Canadian Factory and Engineering Office: Cannon Electric Company, Limited, Toronto, Canada

Representatives in principal cities — consult your local telephone book course, discretion is observed to prevent the enemy from hearing too much. However, there is one type of radio transmission to which the enemy—both his troops and his people at home—are invited to listen. These are the broadcasts which present factual news and the viewpoint of the United Nations to the people of the Axis nations and the people of nations subjugated by them. The Signal Corps is charged, among other things, with providing these powerful transmitters, although the decision as to what program shall be carried on them is made by other agencies. A notable example was the transportation of a powerful station to North Africa which set up business on a wavelength adjacent to the regular Morocco station and played an important part in putting the American story before the French population during the confused days that followed the initial landing. Technicians of the United States Signal Corps are always prepared to take over radio stations in occupied areas and adapt them to serve the military and political ends of the United Nations.

The Echelon Concept Applied to Communications

In the organization of military communications, the concept of "echelons" is very important. An echelon is a level of organization. Suppose that a national radio network were so arranged that each local station, instead of broadcasting its program directly to the listener, sent it out to a limited number of sub-stations, and then, in turn, each sub-station covered a number of low-power transmitters located in each city block. We would then have a series of levels through which the broadcast information finally reached the public. Of course, such a system would be unnecessarily elaborate for the broadcasting of public information. Such a system, however, must be used in military operations. Reports and orders are not meant for all ears. They are designed for the exclusive use of particular listeners.

In military communications, the responsibility for transmission of information always devolves upon the higher echelon. In other words, the commanding general of an overseas theater of operations is responsible for the communications lines


"NC 16874 . . .
from the tower...
cleared to Land"

by which his orders are transmitted to the separate forces under his command and by which information and reports are transmitted from them to him. His subordinate, say the commanding general of a corps, is responsible for communications down to the headquarters of the divisions under his command. He carries out this responsibility through the use of several signal battalions and companies which specialize either in radio or wire communication. In turn, the commanding general of each division is responsible for the communications to the regiments and other components of that division. These are carried out by a special division signal company whose commanding officer is the division signal officer, a lieutenant colonel. The division signal company includes a headquarters platoon which runs the administrative functions of the company, a message center platoon, a wire platoon, and a radio platoon, the latter being divided into sections for radio communications and radio intelligence. In the higher echelons, such as the corps, there will be entire signal companies devoted exclusively to radio repair or to radio intelligence or to some similar function.

Radio Maintenance also Operates in Echelons

The maintenance of Army Signal Corps radio equipment is also accomplished in a series of echelons. The first echelon is constituted by the using operator. The man who operates a walkie-talkie or a field radio set is not necessarily skilled in the mechanics or theory of radio repair. However, he has available to him as standard equipment a certain number of spare parts such as tubes and extra batteries. When a battery runs down or a tube burns out, it is his prerogative to replace it with a fresh one. Or if a wire gets loose, he may reconnect it to the terminal. However, anything beyond that normally would be sent back to the division signal company for repair. This company's repair section has testing equipment and men skilled in the knowledge and techniques necessary for utilizing that equipment to the best advantage. If a set can be put back into shape by additional replacements or by ordinary rewiring, this is done.

However, if the equipment has been badly smashed up or if it is of an extremely complex nature, it might be sent back to the third echelon, which would be a signal repair company installed in a depot or at Army headquarters. Supporting these forward echelons, which are staffed by troops of the Signal Corps, are the rear echelons of repair in the continental United States. These are maintenance shops staffed by civilians in all the service commands. The final echelons are large and elaborate shops, also staffed by civilian mechanics, located in the larger Signal Corps depots such as the Philadelphia and Lexington Depots. If *they* can't salvage a set, it's junk.

Not only do electronic means speed the flow of information and orders on the battlefield, but they figure in the life of the soldier in the training camps. The films by which the new soldier is instructed in many of the fundamentals of Army life are provided with electronically recorded and amplified sound tracks. And electron tubes even serve to get the soldier out of bed in the morning—for the sleep-slaying sound of reveille no longer comes, in the up-to-date training camp, directly from the frost bitten but nevertheless human lips of a bugler, but from an impersonal phonograph record feeding into an electronically operated Public Address system.

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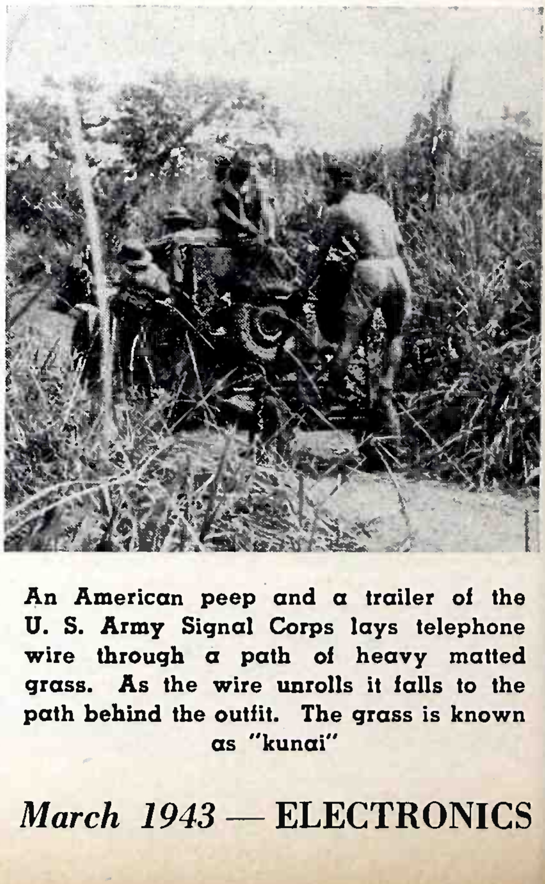
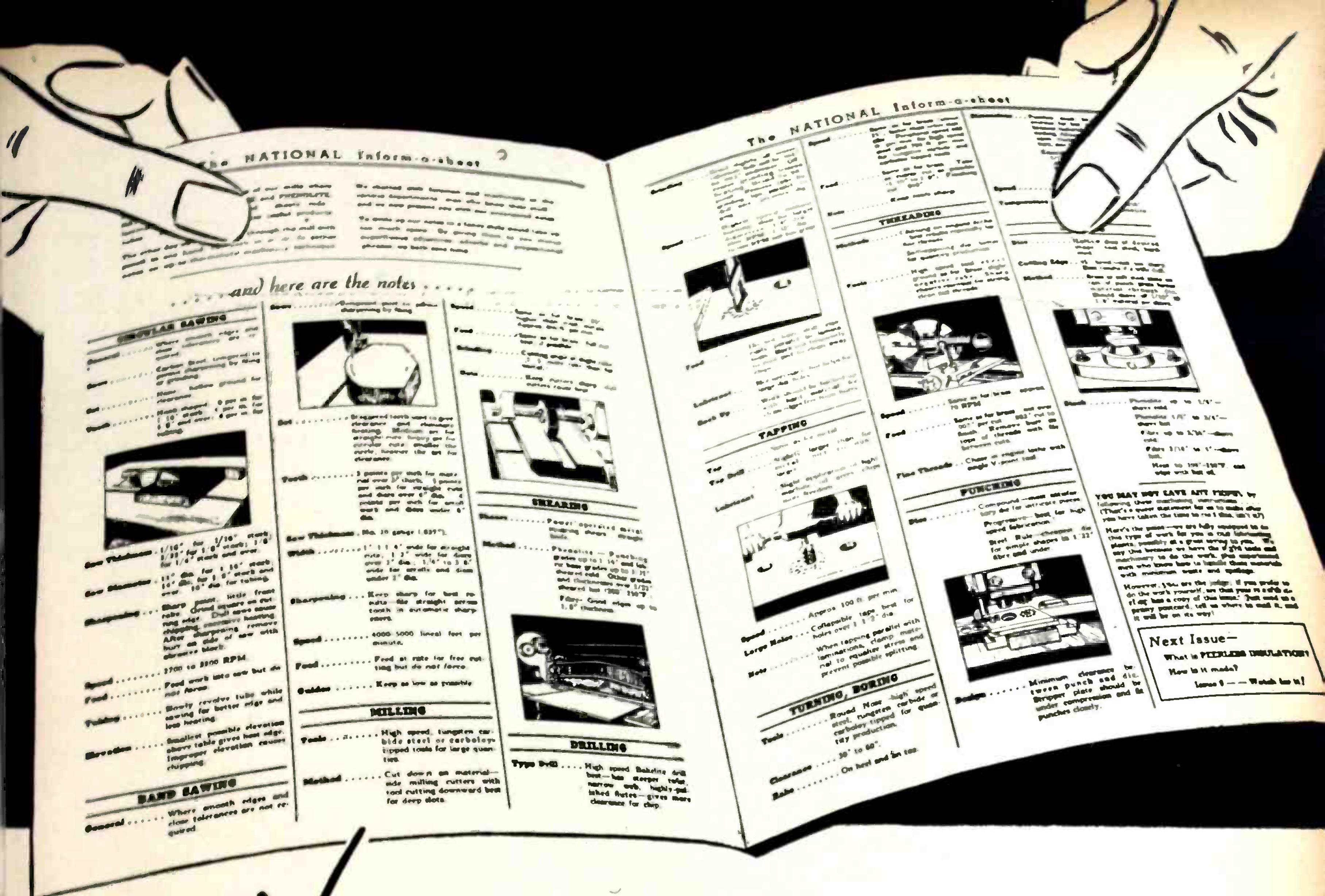
TELEPHONE LINEMEN



An American peep and a trailer of the U. S. Army Signal Corps lays telephone wire through a path of heavy matted grass. As the wire unrolls it falls to the path behind the outfit. The grass is known as "kunai"



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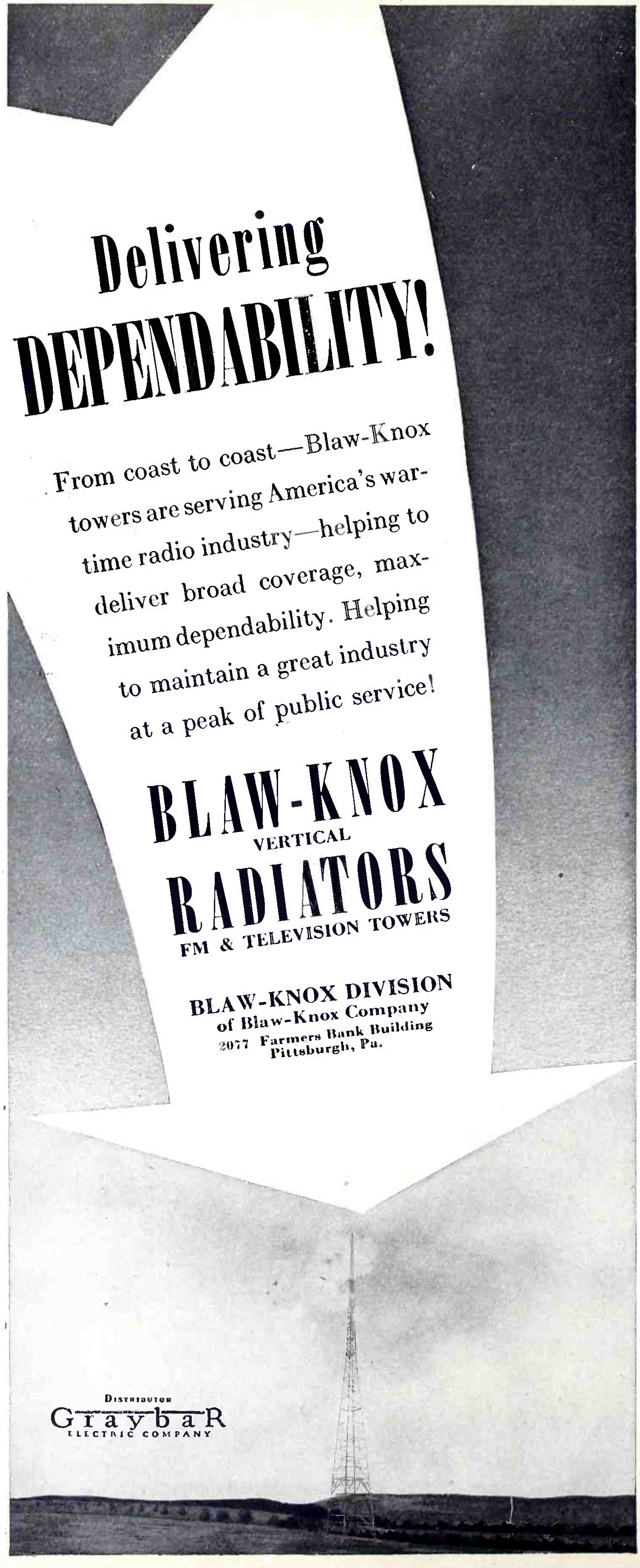


Aviation

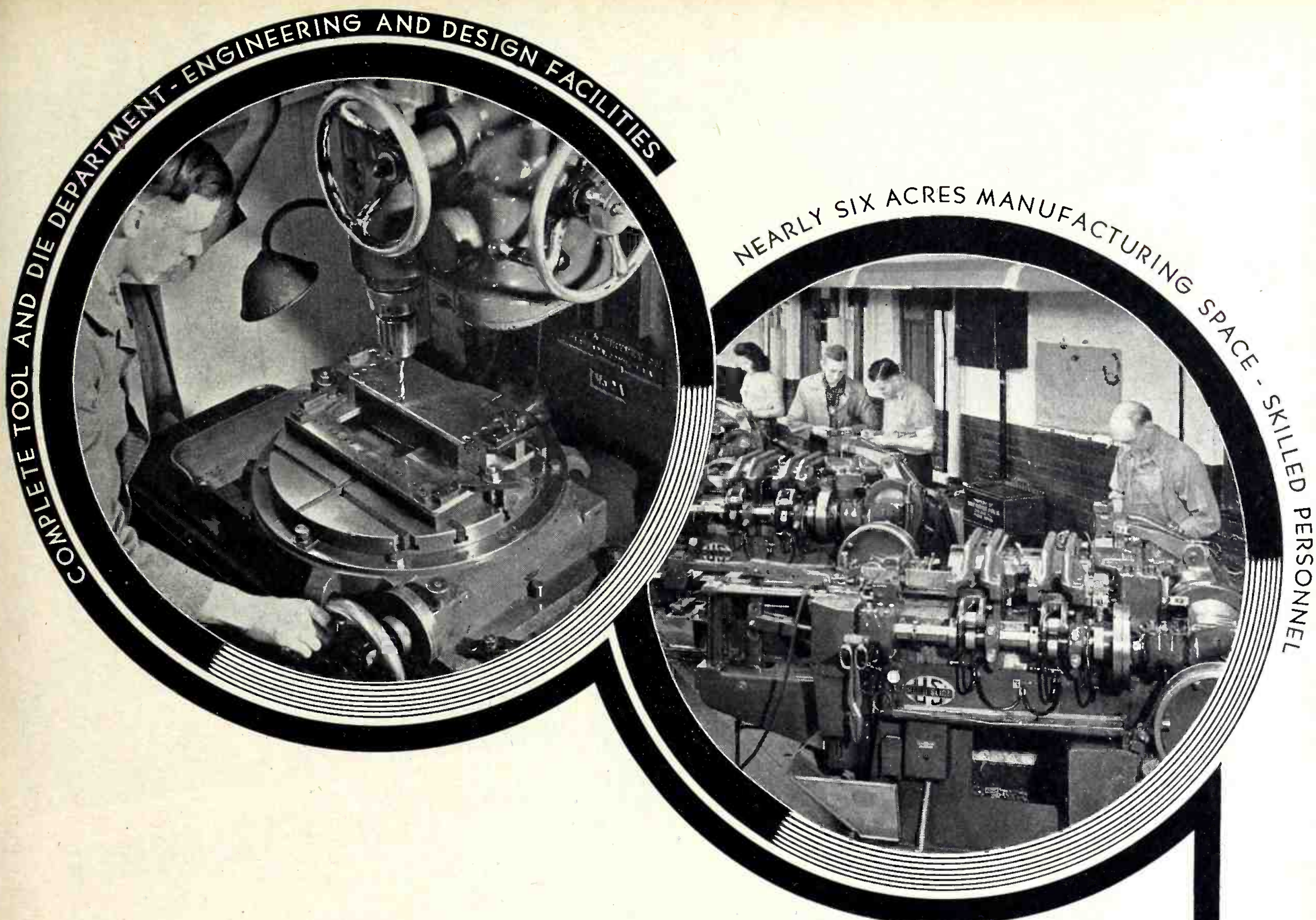
(*Continued from page* 105)

facility consisted of a group of transmitters operating on a frequency of 75 megacycles. These transmitters are equipped with one of two types of antennas. One type of antenna produces a circular field pattern in the horizontal plane while the other gives an elliptical pattern. This marker facility is received on a separate radio receiver in the airplane and serves to light a lamp whenever the marker signal is received. The circular pattern is used to indicate the position of the terminal radio range station, while the elliptical pattern is used to mark the intersection of two radio range courses. The sensitivity of the receivers used for receiving the marker signal is adjusted to give an indication for any desired period of time, and remains fixed. Despite the operation of all marker transmitters on the same frequency, the range of these marker signals is so limited that there is no interference.

In addition to the markers just described, which indicate terminals and airway intersections, some are used to mark the outer approaches and boundaries of a landing field. These latter markers also operate on 75 megacycles but employ modulation distinctive from that employed by the other markers. In the airplane, the various audio frequencies are suitably filtered and illuminate white, amber, or blue lamps. Because they operate at high frequencies, these facilities are not troubled by static to any large degree. When the static has obliterated reception of the long-wave radio, these lamps in the cockpit still become illuminated and indicate the true location of a point on the ground.

Development of Instrument Landing

After an airplane has avigated two dimensions in safety it is still necessary to travel a third—*down*—before the trip is completed. The matter of instrument landing, possible only because of the electronic art, has had a long and interesting history. Instrument landing systems (means for landing under so-called "blind" conditions) were installed and tested by the National Bureau of Standards as early as 1931. Recently the Civil Aeronautics Admin-



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istration announced the installation of the first steps in a Government instrument landing net intended to cover all major cities in the United States. The reason for the long period that has elapsed between the time of initial installation and commercial use was due to continued development in order to arrive at a satisfactory system. Since an instrument landing is the most difficult maneuver that an airplane executes, it was wise that the problem should have been treated with extreme caution.

The system now being installed is not far different in principle from the initial system of the Bureau of Standards; however, the instrumentation, as might be expected, has been greatly improved. The system consists of a miniature radio range similar to the ultrahigh-frequency range previously described, the markers of the type already discussed, and a third element known as the glide path. The radio ranges mark the runways and the approaches to them, the markers indicate progress toward the point of contact, while the new element indicates the position of the airplane with respect to a fixed and predetermined glide path. The glide path is indicated on an instrument with a horizontal pointer. Displacement of the needle from the center of the meter indicates that the airplane is above or below the desired landing path. A second needle on the face of the same

• • •

BLIND REPAIRMAN

Byron H. Webb, blind graduate of DePaul University, teaches Army Signal Corps members to repair radios. His fingers and keen hearing take the place of eyes and he uses ear-phones instead of the usual meters. In the photo he is showing Corp. Peter Miller (left) and Pvt. Edward Mosebach how to estimate voltage by the strength of auditory signals and to locate any defects in the wiring

instrument moves to the right or left indicating the position of the airplane with respect to the center of the runway. The pilot flies his airplane so that the needles of this instrument are crossed in the center.

The instrument landing system indication can be obtained in the airplane by the addition of a receiver operating on 93 megacycles. With this receiver the glide path indications are obtained. The same receiver used to receive the ultrahigh-frequency ranges also receives the runway indication, and the same marker receiver used to indicate the airway markers receives the instrument landing marker indications.

Electronic Altimeters are Next Step

In 1938 the first successful radio altimeter was announced. This device gave directly the distance from the airplane to the ground. This unit was considered to be rather heavy and the power consumption was large for the power systems used in the airplanes of 1938; however, further development was conducted up to the time of the war. The adoption of such a device will probably be given favorable consideration by the airlines when conditions become normal.

The radio altimeter has many uses. While it does not indicate the presence of an object directly ahead, it does indicate a decrease in altitude such as would be experienced when foothills of many ranges are approached. One of its most important uses will be as a check on the instrument landing systems. With this device, the pilot making a descent will know how soon he may expect to contact the ground.

The above outlined navigational and avigational systems are made possible only because of the existence of electronics. It can be seen that while electron tubes were big aids to navigation, they were the very essence of avigation.

Many devices have been developed that will assure safe travel of the large air transports of the future. Installation of many of these, which had just begun, had to be stopped when the war broke out. It seems unfortunate that this should have been the case; however, the experience in electronics that will be gained during the period of the war may lead to developments that will offset the delay in installation.


JOIN UP
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SIGNAL
CORPS
WHERE SKILL AND COURAGE COUNT

Facsimile

(*Continued from page* 107)

tems in the frequency band above the highest telegraph channel. The telegraph industry looks to the concentric cable and other wide-band transmission mediums to provide the channels necessary for a more rapid expansion of long distance facsimile transmission in the future.

At the present time facsimile telegraphy is enjoying its greatest development in the field of local pickup and delivery. Here, where facsimile has exclusive use of the circuit, the possibilities are almost unlimited. Here not only has facsimile made it easier for the patron to telegraph, but it has reduced tremendously the time required for pickup and delivery which has always been a major factor in the handling of telegrams. Systems of this type in operation in New York, Chicago, Atlanta and San Francisco handled over 1,000,000 telegrams in 1942. Rapid expansion of such systems was in progress when wartime conditions forced temporary curtailment. Facsimile installations are now being restricted to those of military necessity.

Frequency modulation has not yet been employed extensively in facsimile transmission over wire lines. Its use is not likely to prove as advantageous as in radio transmission due to the greater stability of wire circuits, although tests have shown it to be of value in certain instances.

Facsimile is definitely making it easier to telegraph. It is not too difficult to visualize the eventual replacement of the branch telegraph offices by simple automatic facsimile machines installed in office buildings, bus, railroad and plane terminals, factories, apartment house lobbies, perhaps even in the corner drug or cigar store. Facsimile telegraphy will undoubtedly be among the new industries which will help keep the wheels of production turning when the world turns back to peaceful pursuits once again. Just as facsimile's rapid progress of the past decade must be credited largely to developments in the science of electronics, so to an even greater degree facsimile's hopes for the future are based on expectations of new developments in this field.

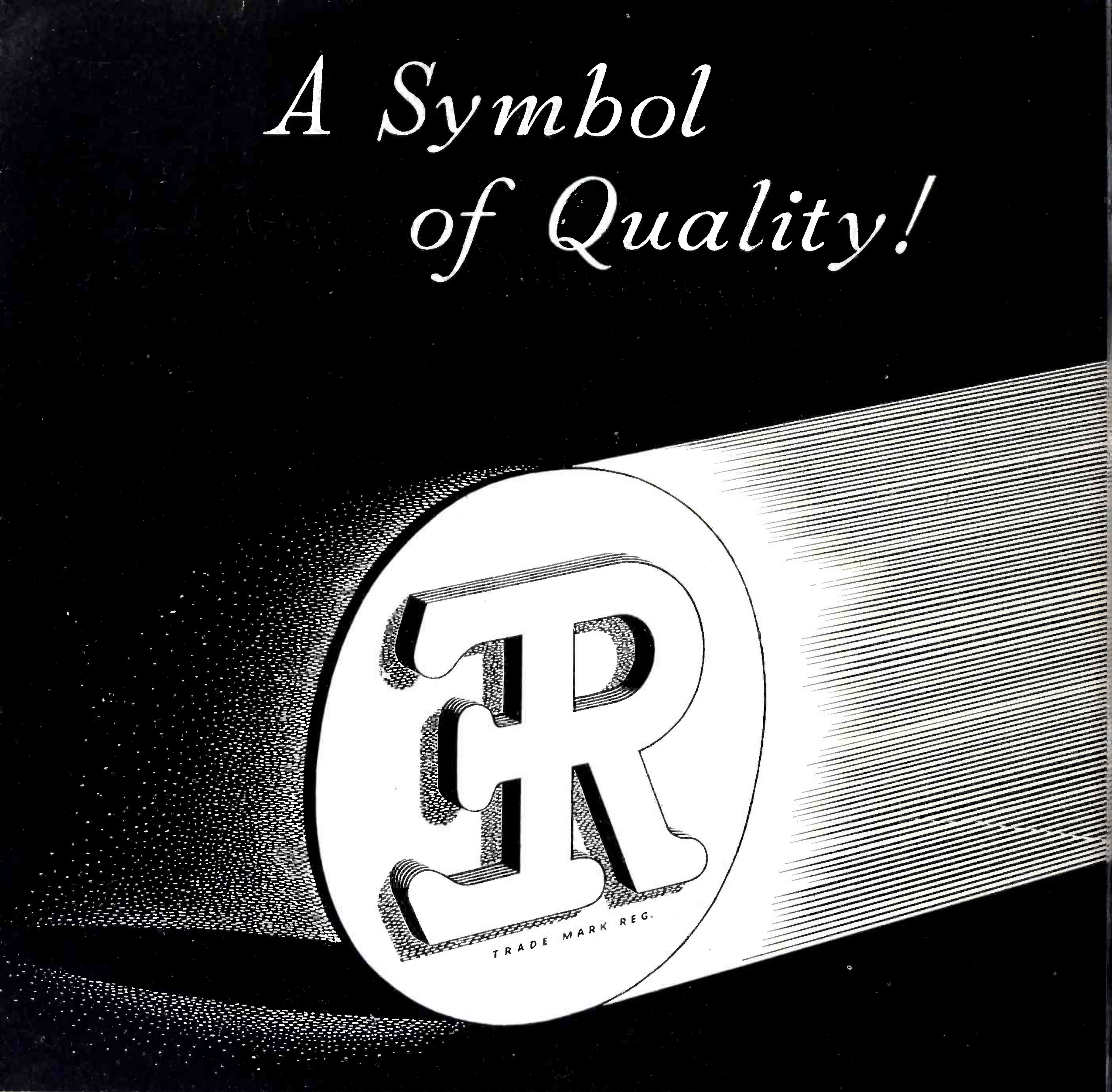
* Editor's Note. Although very simple facsimile systems have been developed for home use as adjuncts to the ordinary broadcast radio receiver, war has stopped work in this field. Since post-war facsimile for home use will undoubtedly be greatly different than prewar systems, this phase of facsimile has not been covered in this symposium.

Illustrated above is a Motorola 4-Frequency F-M Station Specially Designed to Meet Military Needs. Both Transmitters and Receivers are Automatically Controlled by Dial Telephone.

Pioneers in the development of Portable and Mobile F-M and A-M Radiotelephone Equipment, Motorola engineers are today applying their accumulated skills and scientific knowledge to solving problems which confront our country, its states, counties, cities and towns. Housed in a new Engineering Building, with expanded facilities for research and engineering, the Motorola capacity for vital service is greater than ever. Electronic knowledge thus gained will one day soon be applied to the normal peacetime demands of a nation eager for better things in all phases of its living.

THE ARMY-NAVY "E"—Awarded for excellence in the production of Communications Equipment for America's Armed Forces

Motorola Radio Communication Systems
Designed and Engineered to Fit Special Needs
GALVIN MFG. CORPORATION • CHICAGO



The science of Electronics forges ahead with *Accurate, Dependable Components* . . .

The tremendous progress in the electronic arts, to which Erie has made many contributions, probably surpasses the development in any other scientific field during any equal period of time.

This rapid progress of electronic communications and controls is not the result of any single research activity, but rather the fruits of continued, persevering thought and labor in the development and production of the many components incorporated in the final dependable mechanisms.

Erie Resistor's part in this research and development is an important one. The Erie products, illustrated on the next page, show how much Erie has contributed to the progress of the electronics industry by making available a wide variety of dependable components.

Hearing Aids

(*Continued from page* 111)

The usual transmitter or microphone is essentially similar to that of a telephone system. It contains particles of carbon which are agitated by sound striking the transmitter diaphragm. Agitation of the carbon particles varies the amount of electrical energy drawn from the battery and so a current is sent out over the wires which is the electrical equivalent of sound pulsations striking the transmitter.

The receiver has a diaphragm which is moved by variations in magnetic force caused by changes in the amount of electric current arriving over the wires from the transmitter. It is found expedient to provide two types of receivers, the air-conduction type and the bone-conduction type. The bone-conduction receiver usually requires more amplification than does the air-conduction receiver. It is, however, useful where hearing deficiencies are caused by troubles associated with the user's outer ear.

Amplifiers are of two kinds, the so-called "carbon" type and the vacuum-tube type. The carbon amplifier will give moderate amplification when supplied with a relatively small amount of voltage and has so far been most widely used in electrical hearing aids because of its relative simplicity. The vacuum-tube or electronic amplifier now coming into more general use requires two batteries of different voltages, an "A" battery to heat the filaments of the tubes and a "B" battery to supply amplifying power. Such a device is capable of considerable amplification. It is also capable of delivering this amplification with relatively little distortion.

Tube Amplifier Advantages

The added amplification available from a vacuum-type amplifier makes it possible to exercise more complete control over the quality of response, or frequency characteristic of a hearing aid device.

This is particularly important since it has been found that the auditory deficiencies of people who are hard of hearing vary greatly between individuals. Different people require instruments with different

We are proud of our Gang serving in the Armed Forces. You may be sure that they and all their pals —wherever they are—will never lack for the Link radio communication and electronic equipments which we are building in ever-increasing number for them.

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frequency characteristics to meet their needs.

With the higher amplification available from the vacuum-tube amplifier it is also possible to use higher quality transmitters and receivers even though these have less output volume. Crystal transmitters or microphones may, for example, be used. So also may crystal receivers.

One possible handicap which must be surmounted by vacuum-tube hearing aids is that if they fail in their operation they may go completely dead at once, whereas a carbon type hearing aid usually gives some preliminary warning. Improved components and design will undoubtedly decrease the possibility of such failures in the future. The upkeep of a vacuum tube instrument is also usually greater than that of a carbon type hearing aid because of the cost of batteries and the expense of occasional tube replacements.

Despite a few disadvantages, the use of the vacuum-tube as the means of amplification in the hearing aid has widely increased the usefulness of such instruments and has been the means of bringing satisfactory hearing to additional thousands of people.

Editor's Note—The market for hearing aid devices of the general type described is by no means limited to individual purchasers. Air-conduction and bone-conduction receivers are frequently installed in certain church pews, or an entire row of theater seats may be equipped, so that patrons afflicted with poor hearing can directly tap speech and music transmitted over the sound systems normally found in such places.

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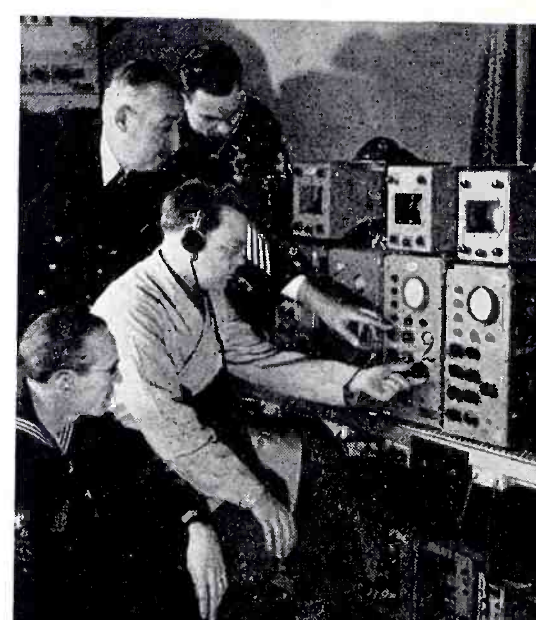
TELEVISION IN THE NAVY



Navy men, studying high frequency radio to enable them to use the new device for detecting the approach of enemy aircraft, are also being schooled in television. These navy students are being given an explanation of a television control room

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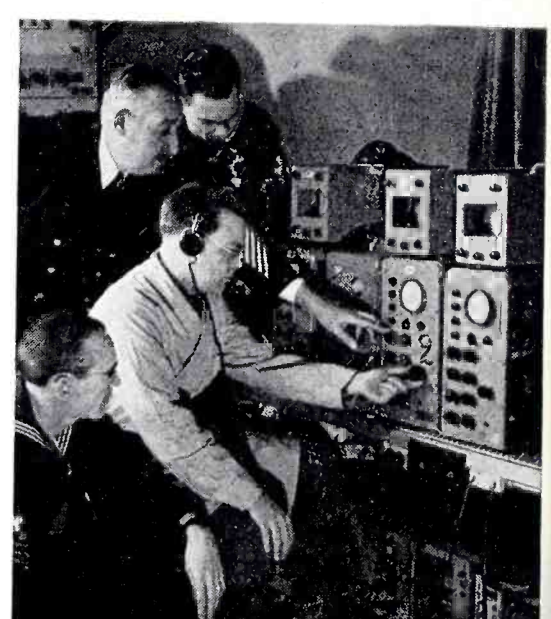

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Photos by Wire and Radio

(*Continued from page* 113)

cylinder of a sending machine, a picture half the size of an ordinary newspaper page. Out across the nation in Chicago, San Francisco, Kansas City, Omaha, Syracuse and Philadelphia and in 18 other cities, Associated Press experts made ready their telephones and receiving machines. Eight minutes later in each of the 24 newspaper offices on the network, attendants picked cylinders from their receiving machines and hurried into darkrooms. Another few minutes and finished prints, reproductions of the picture on the sending machine in New York, were in the hands of editors around a 10,000-mile circuit.

Newspapers, large and small, have since benefited greatly from the development. Although the service was expanded, some newspapers elected to receive photos by train or airplane from the nearest wirephoto station. For smaller papers AP began making news picture "mats" at strategic cities on the network and mailing these mats to its member papers. This meant, for example, that pictures on an important story could be sent from San Francisco to New York within a matter of minutes and there could be made into mats for quick mailing to newspapers in the New York area. This system is now nationwide.

Expansion of Service

Coincident with the development of a basic system of transmitting pictures along an established network, engineers worked on the problem of getting pictures from the scene of the story to the nearest sending bureau. While it took only minutes to transmit a picture the necessity for fast handling between the source and the sending machine assumed new proportions. The time thus consumed was important and even greater speed was required.

The solution was a portable transmitting set with means enabling these portable machines to be hooked onto an ordinary telephone line, thus simplifying the transmission of a picture from a news outpost to the receiving equipment wherever it might be.

Resistance Welding

(*Continued from page* 119)

they were adapted particularly for high-speed or heavy-welding current applications. In one installation, where ignitron contactors were installed near the ceiling with a saving of valuable floor space, out of a total of 150 contactors installed some four years ago, approximately 50 percent of them are still in use in the manufacture of truck bodies for the armed forces.

The Adjustment Problem

Prior to the introduction of electronic control, welding current was adjusted by the use of taps on the welding transformer. The necessary tap switches were bulky and, unless an excessive number of taps were used, the steps of adjustment were relatively coarse. Since with electronic control it is possible to control the starting of each half-cycle of current, the phase-shifting method of heat control was developed. With this method, a small potentiometer is used for adjustment and the current can be quickly and easily controlled with a fineness of adjustment that cannot be obtained with any other practical method.

Flexibility

With each of these developments, an additional degree of flexibility has been added. It is quickness of response, flexibility and preciseness of control that has steadily expanded the use of a-c electronic control until today our war effort would indeed be impaired without it. Thousands of plants are using this type of control in the manufacture of war products. During 1942, several thousand electronically controlled welding machines were purchased, ranging from the smallest of several kva rating up to some with demands of several thousand kva. In one plant alone there will be installed approximately 800 machines and controls.

Low-capacity controls are being used by the hundreds in the manufacture of the millions of tubes needed, not only for industrial equipment, but to even a greater extent,

for radio equipment being supplied the armed forces. Many of the metals and alloys in these tubes are difficult to weld satisfactorily without electronic control.

With reference to large resistance welders drawing a thousand or more kva, adequate feeder capacity is a problem. For these applications there has been developed, in addition to the standard controls, controls which can be operated directly from a 2300-volt power supply system, with a direct saving in copper and low-voltage distribution transformers. These same high-voltage controls can be used also with welders having their power-factor corrected by means of series capacitors.

Energy Storage Welding

The tremendous expansion of our aircraft program has required hundreds of precision-controlled resistance welders for welding aluminum and aluminum alloys. Since the resistance of aluminum and aluminum alloys is much lower than that of steel, a much larger welding current is required. Unless power-factor correction is used, this large demand imposes a severe burden on the already heavily overloaded plant distribution system. It was primarily for this reason that stored-energy methods of welding were in a sense redeveloped and refined for use in this country; they have been used for years in Europe.

Energy storage welding has the advantage that the demand is small and power is taken from a 3-phase power supply line instead of a single-phase line, as is usually the case with a-c welding. There are two forms of energy storage welding. One form uses a d-c source, such as a low-voltage rectifier, to store energy magnetically in the primary of a special welding transformer. This energy, when released, inductively produces the necessary welding current in the low-voltage secondary winding of the transformer. With the second form, a high-voltage rectifier (3000 volts maximum) is used to charge a bank of capacitors. When the capacitors are discharged into the primary winding of the welding transformer, the resulting secondary current is sufficient to produce the weld. Since the time required to charge either the special welding transformer or the capacitors is

long compared to the discharge time, the kva demand from the line is reduced appreciably below that which would be required if the energy were taken directly from the power source.

With both methods, electronic tubes are used in the rectifiers and associated controls. Also, as in a-c welding, tubes are required to obtain the necessary flexibility and preciseness of control.

In one plant alone, more than 100 energy storage welders are installed.

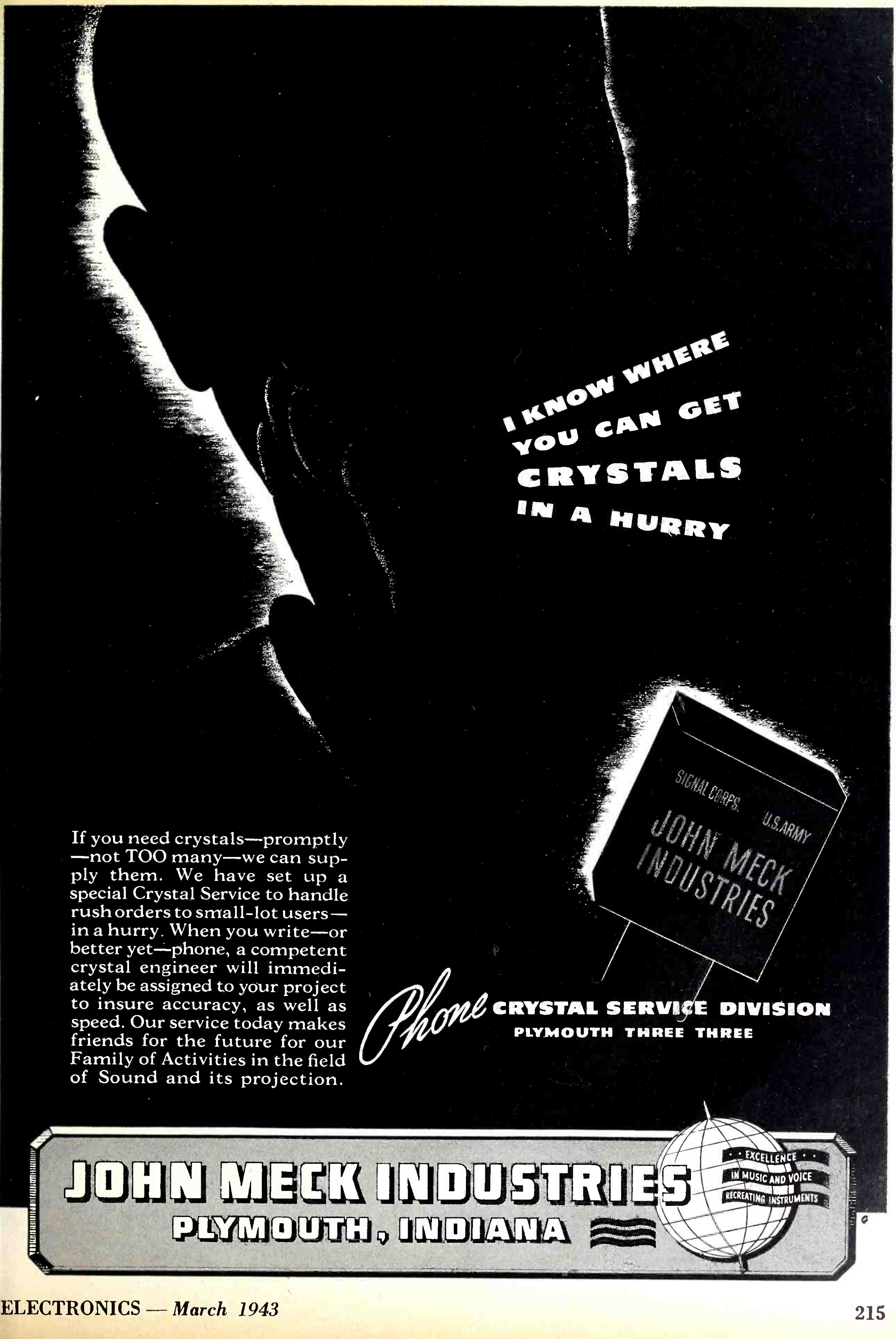
Future of Electronic Control

Even though the growth of electronic control has been almost phenomenal during the last several years due partially to the war program, the future is still very promising. Future growth should continue along three lines. First, it is expected there will be a general expansion of its use by practically all metal fabricating industries. Second, there will be continued refinements and modifications in both welding machines and electronic control. Third, new electronic controls will be developed to meet the needs of new resistance welding applications.

With reference to expanded use of electronic resistance welding control, at the present time only 10 percent of the riveting in aircraft fabrication has been replaced by the faster and less expensive method of spot welding. (Experience in this industry indicates that the cost of spot welding can be expected to be 1-½ to 4 mills per spot.) One aircraft design calls for approximately 50 percent welding and if we use this figure conservatively, there is a possible fivefold expansion.

There are a great many rabricators doing sub-contracting, who are now using resistance welding for the first time. When they again go into normal production they will use this method more because of the many savings and high rates of production. In most cases, quality welding is required and this can best be accomplished by means of electronic control.

The machines of the future will be integral units containing the timing control, circuit breakers, sequence controls, and other control apparatus. The trend toward such integral equipment has definitely started and the advantages are that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less floor space is required and such equipment is easier to install and service.

Future controls will be simplified, particularly for easier servicing. Plug-in arrangements will probably be used to an even greater extent for those plants using a number of machines, so that a new control can be installed with a minimum of down time. In order to simplify and decrease the size of controls, new circuits will be developed using more radio-type tubes and fewer special tube designs.

There are interesting possibilities in the development of electronic controls that will hold the welding current constant even though the line voltage varies. The elimination of this variation would not only improve weld quality, but would permit the use of distribution systems having poorer voltage regulation. Voltage compensators have been developed during the last year to hold the welding current within specified limits for such variations.

There is also the problem of holding the weld current constant when large pieces of steel are introduced into the throat of the welding machine. The introduction of such pieces changes the impedance of the secondary circuit, thereby causing a variation in weld current. Current-regulating compensators have been developed to hold this current within specified limits. At the present time, these controls cannot be applied universally, but it is expected that they will be soon developed to such a point that they can be applied widely.

As one well-known welding engineer has stated, a number of the steels available today are not formulated from the view-point of strength or ability to form alone, but frequently are formulated on their ability to be arc or torch welded. With the weld-ability limits removed, steel manufacturers will be able to give the fabricating industry inexpensive steels of the type best fitted for their needs.

Also, considerable work has been done on the development of the correct process and control for the welding of higher carbon and alloy steels. Information on some of this work is now restricted but, without question, the use of these steels will increase both during and after this war program.

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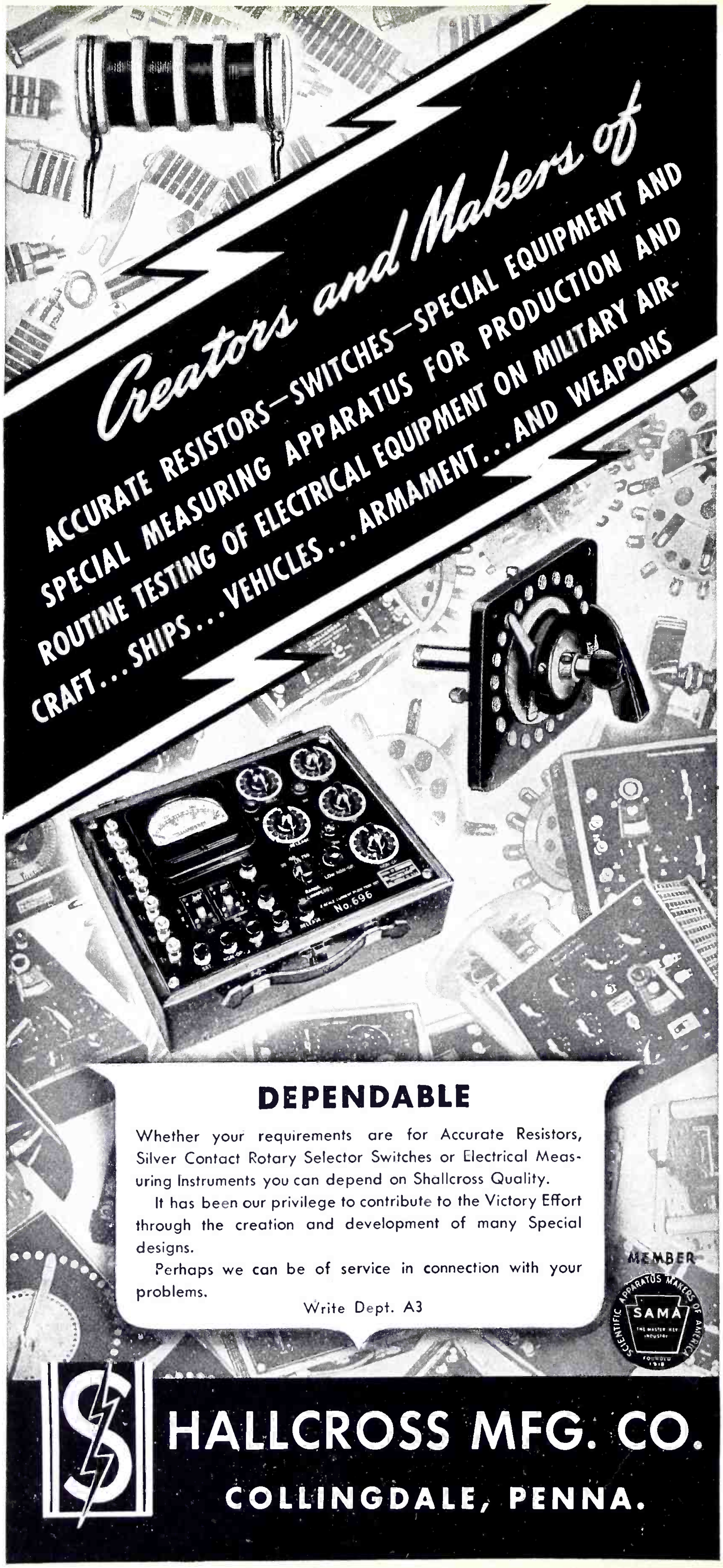

Property Protection

(*Continued from page* 122)

the electronic age, electronic systems will provide one of the foremost methods of protection.

Undoubtedly, the biggest opportunity will be in the burglary or intrusion detection field, since the success of such systems depends upon their automatic operation.

Invisible light is now being used successfully for detecting intruders and photoelectric equipment for that purpose has been highly developed and widely used. In the future, more sensitive phototubes having response further in the infrared will extend the range and scope of this protection.

In still another part of the spectrum sound is being used in thousands of installations for the purpose of revealing attacks upon vault structures. These sound waves are principally within the audible frequency range. In the future it is quite possible that supersonic sound waves in the neighborhood of 20,000 to 30,000 cycles may be employed to establish standing waves or beams of wave energy to detect intrusion.

Just as the heat from stars may be measured by radiometers or bolometers, so may the heat from incipient fires be detected. Using more sensitive versions of these devices the radiant heat from the human body has been found sufficient to actuate an alarm system even over a distance of a few hundred feet.

Unquestionably, the greatest advance will occur in the field of microwaves where electronic development of circuit elements is now receiving such a tremendous impetus due to war needs. It does not require a great stretch of the imagination to see how premises to be protected might be interwoven or encircled with invisible radio waves which if even slightly disturbed would cause a reaction in the associated equipment to signal an alarm.

These few remarks only scratch the surface of what the future may hold in the field of protection based on electronic principles. It would be unwise to prophesy further at a time when much secrecy surrounds many of the amazing developments in the electronic field.

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Detection

(*Continued from page* 133)

waitresses walk through quickly, quietly, and without fatiguing door-pushing. In factories that employ hand trucks, motorized inter-building carriers and people carrying bundles frequently, it is a considerable economy to save the time each requires to open a door. Throughout a day, the savings in time and fatigue for such employees and for the drivers of trucks is greater by far than the cost of operating the door automatically.

Garages employ photoelectrically controlled electric doors to open and close the overhead rolling door for autos and trucks. The saving in heat, plus the saving in personnel, make this worth while.

Phototubes also control automatic signals at road intersections for changing the traffic signals only when traffic requires it, and making unnecessary the time-consuming stops and starts to traffic that often are made without need.

A photoelectric installation on a main road is more likely to be a counting machine, to determine the amount of traffic on the road at each period of day or to record the speed at which cars go past.

A photoelectric system has been developed, and awaits normal times for tryout, by which traffic is permitted to move along a highway until a car exceeds any desired speed limit. Then the lights turn red, forcing the car to stop at the next intersection to be penalized. When traffic thickens up enough to warrant it the same photoelectric control turns itself into a traffic regulating system and permits cars to move along the highway or across intersections at a rate depending upon the conditions at the moment.

Racetracks often employ phototube devices for the "photo finish" of the race. In this equipment, a beam of light across the race track near the finish line is interrupted by the first or winning auto or horse; this operates photographic equipment, usually in the form of a motion picture camera, which takes a series of photographs as the leading contestants pass the finish line. The small amount of film involved is readily developed and examined without loss of time, and invariabl

The marvels in electronics developed during the war will not pass with the war. Their application to post-war life will be as wide and amazing as only American imagination and enterprise can make them.

More efficient hearing aids, inexpensive ship-to-shore phones for small craft, wireless intercommunications systems for business, improved counting and color sorting devices are but a few of the obvious developments of existing electronic applications. Even portable, personal two-way radio phones may become a reality. Where electronics will take us no one can foretell.

In this time of need, it is TUNG-SOL'S job to design and produce necessary transmitting, receiving and amplifying electronic tubes for our government. After the war the new experience so gained will be at the disposal of those who will be instrumental in building the new electronic era. Manufacturers will find at TUNG-SOL a wealth of equipment, engineering and production skill to help them make new or better electronic devices.

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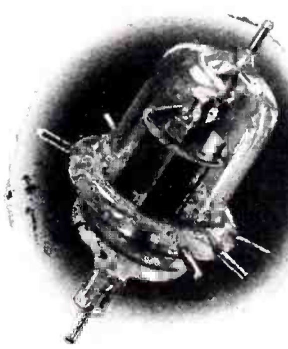

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Phototubes also control automatic signals at road intersections for changing the traffic signals only when traffic requires it, and making unnecessary the time-consuming stops and starts to traffic that often are made without need.

A photoelectric installation on a main road is more likely to be a counting machine, to determine the amount of traffic on the road at each period of day or to record the speed at which cars go past.

A photoelectric system has been developed, and awaits normal times for tryout, by which traffic is permitted to move along a highway until a car exceeds any desired speed limit. Then the lights turn red, forcing the car to stop at the next intersection to be penalized. When traffic thickens up enough to warrant it, the same photoelectric control turns itself into a traffic regulating system and permits cars to move along the highway or across intersections at a rate depending upon the conditions at the moment.

Racetracks often employ phototube devices for the "photo finish" of the race. In this equipment, a beam of light across the race track near the finish line is interrupted by the first or winning auto or horse; this operates photographic equipment, usually in the form of a motion picture camera, which takes a series of photographs as the leading contestants pass the finish line. The small amount of film involved is readily developed and examined without loss of time, and invariably

The marvels in electronics developed during the war will not pass with the war. Their application to post-war life will be as wide and amazing as only American imagination and enterprise can make them.

More efficient hearing aids, inexpensive ship-to-shore phones for small craft, wireless intercommunications systems for business, improved counting and color sorting devices are but a few of the obvious developments of existing electronic applications. Even portable, personal two-way radio phones may become a reality. Where electronics will take us no one can foretell.

In this time of need, it is TUNG-SOL'S job to design and produce necessary transmitting, receiving and amplifying electronic tubes for our government. After the war the new experience so gained will be at the disposal of those who will be instrumental in building the new electronic era. Manufacturers will find at TUNG-SOL a wealth of equipment, engineering and production skill to help them make new or better electronic devices.

TUNG-SOL
vibration-tested
RADIO TUBES

TUNG-SOL LAMP WORKS INC., NEWARK, N. J., *Sales Offices:* ATLANTA, CHICAGO, DALLAS, DENVER, DETROIT, LOS ANGELES, NEW YORK
ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERRUPTERS

some one in the group of pictures shows the winner just at the finish line, and the other contestants following him. With a clock and calendar, and a card showing the number of the race and the name of the track, all in the picture, this photograph becomes an indisputable, permanent record.

Special Purpose Robots

The ultimate objective in all automatic control systems is to find an assembly of equipment capable of doing a job that a person does not want to do or cannot do or to do it better (faster, cheaper, more accurately, etc.,) than a person could do it. It matters not to a good electronic engineer whether the tube used is a phototube, or an amplifier or any combination of the many forms of tubes now available. His job is to see that the apparatus performs the desired job with a cost and accuracy at least commensurate with other means of doing the same task. Very often the tube itself is a very small part of the entire system; most of the complexity coming between the tube and the final control apparatus. Often the initiating impulses may be derived very simply and very ingeniously.

Electronics now controls elevator doors in several ways. Light beams shining across the door of large department store elevators prevent the doors from being closed so long as any part of the passenger or his purchase obstructs the beam. Phototubes may accurately level the elevator at the floors at which it is to stop. In another leveling system the cars carry a small vane of metal which is caused to be interposed between two coils of an oscillator tube system, and thus to accurately stop and level the elevator at the desired floors.

The same principle of elevator control may be used to automatically cut off desired lengths of steel rod, paper tubing, rubber slugs, etc. Some form of machine or conveyor pushes the material involved out at a fast rate; when the material has moved out far enough to intercept a beam of light, or to enter a coil and influence the electrical qualities of the coil, or to operate a contact device, then a cut-off mechanism is caused to operate. Depending on the requirements of the job, the cut-off may be designed for extreme accuracy, for simplicity

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and ruggedness of operation, or for low cost without high accuracy.

Automatic Registering Systems

Remove the printed wrapper from any package of food, and there is a good chance that you will find a rather heavy black stripe on it, near one edge. This usually means that the package is wrapped automatically, and that a phototube is used to look at this stripe and thereby "register" the cutting of the wrapper accurately with the printing. The paper is printed in rolls and is drawn through the machine until the stripe comes under the phototube. Strong light, reflected off the paper, provides an image of this stripe as the paper moves by. The image is transmitted through a slit onto a phototube and causes a sharp decrease in the amount of light arriving at the phototube. Through amplifiers and electromagnetic equipment, this furnishes an impulse which determines whether the next cut should take place a little earlier in the cycle, or a little later in the cycle, or at the same instant in the cycle. As a result, the position of the cut with respect to the printed design on the wrapper is being continuously readjusted and therefore cannot stray off.

The four-color printing which so beautifully adorns some of our newspapers and magazines is made possible by similar equipment also. Phototubes find the stripe which is a part of each color plate, and change the position of the printing of each succeeding color to assure accurate registration of one color with another.

Future Prospects

It is possible, in a review of this extent, merely to touch upon the several places in industry where tasks of the sort described are performed by electron tubes. Many hundreds of other applications could be described, all beginning with the detection of a change in some physical, electrical, or chemical property and leading to a control of that property.

One thing is certain—in the new world all of us look forward to, after the war, there is little reason why so many of the repetitive tasks of drudgery now done by man cannot be replaced by electronic devices, thus relieving man for more important and dignified jobs.

Geophysics

(*Continued from page* 137)

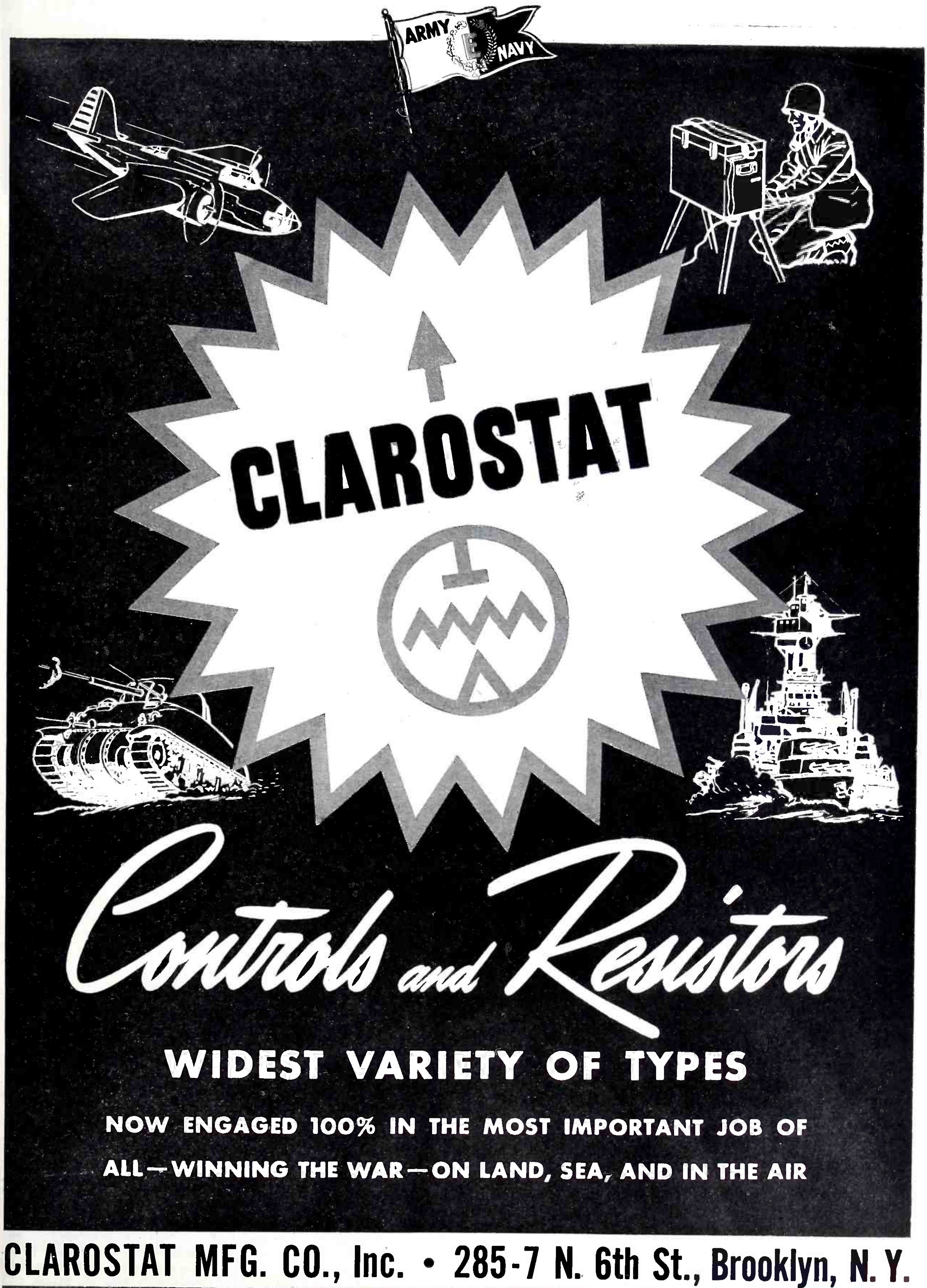
0.1 seconds or more. This furnishes a criterion for deciding whether a wave is refracted or reflected. Recordings made simultaneously with pickups covering at least two sides of the shot point afford additional data for identifying the reflections. The time from the instant of explosion of the dynamite charge to some definite characteristic of this event is counted to the nearest one thousandth second; the depth to this reflecting horizon is then computed from these times. Thus, contour maps can be drawn of the subsurface strata at depths of from a few hundred feet to around 20,000 feet. Carrying the survey over a large area, subsurface anomolies where petroleum might exist may be detected.

In the reflection seismogram shown, six reflection channels are recorded with the seismic pickups placed two hundred feet apart and in line with the shot point. The instant of explosion of the dynamite charge is shown at *A*. The refracted waves recorded on the six galvanometer traces represent the first arrival at the individual pickups of the impulse due to the explosion. The point marked *B* on this seismogram indicates a prominent shallow reflection. The succeeding events at *C*, *D*, *E* and *F* are also reflections. The reflection at the point marked *G*, which occurs at a time of 2.327 seconds after the explosion, corresponds to a depth of approximately 10,000 feet. Beyond the reflection at *G*, ground disturbances due to wind and traffic movements obscure any further reflections.

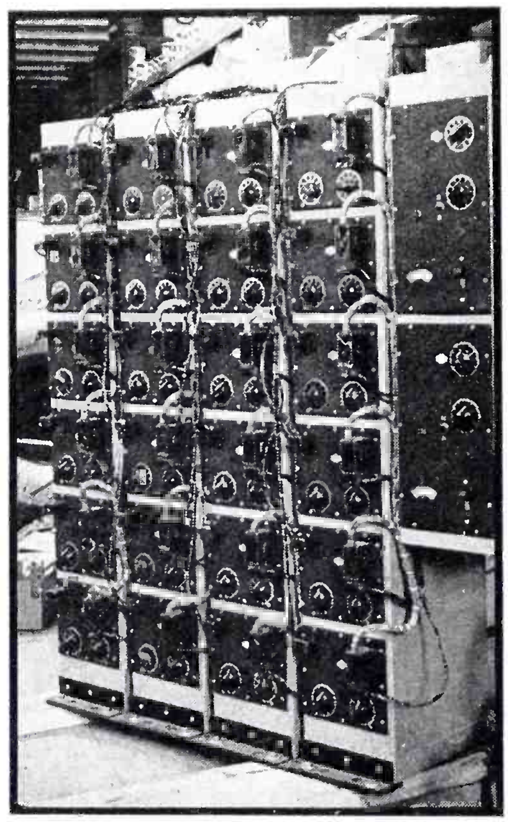
The velocity of propagation of the seismic wave depends upon certain properties of the medium through which the wave passes. If hard rocks are involved, the velocity of propagation may be 8,000 to 20,000 feet per second. If the materials are soft, the velocity will be much less than this. In some instances, the velocity of propagation through certain shallow formations is even less than the velocity of transmission of the sound wave through air.

Characteristics of the Pickups

The seismic pickups used for detecting the seismic reflections are somewhat similar to the microphones


ARMY E NAVY
CLAROSTAT
Controls and Resistors
WIDEST VARIETY OF TYPES
NOW ENGAGED 100% IN THE MOST IMPORTANT JOB OF
ALL—WINNING THE WAR—ON LAND, SEA, AND IN THE AIR

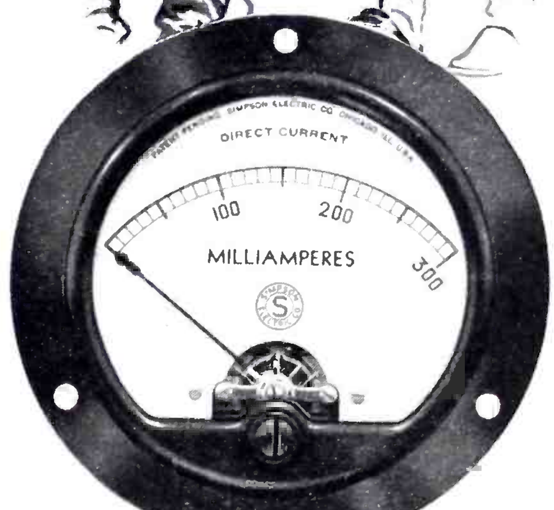
used in broadcast stations. They usually consist of a suspended mass that is connected to some form of generator of electrical energy. These pickups, like the broadcast microphone, may take the form of the carbon button, piezo-electric, condenser type, moving-coil type or moving-armature type microphone. The moving-armature type, known as the variable-reluctance type, and the moving-coil type are very widely used in the reflection seismograph method. These types are very rugged



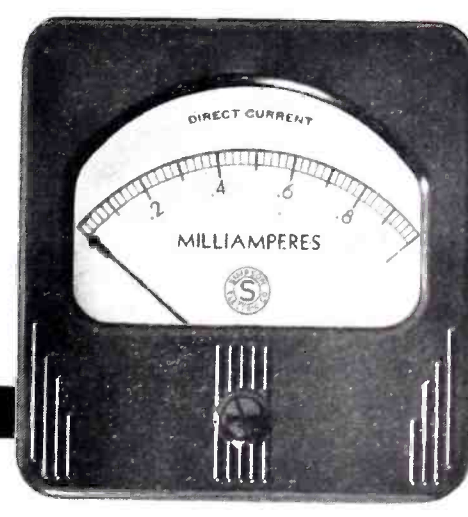
AMPLIFIERS—Battery of 24 reflection-type seismographic amplifiers

and have a stable sensitivity, important features of all instruments used in geophysical exploration work. The seismic pickups shown are of the variable-reluctance type. The coil is designed to work into a low-impedance winding of the input transformer of the amplifier. Some idea of the necessary sensitivity may be obtained from measurements made on this type of pick-up.

The frequencies of the reflections vary from about 20 cycles up to around 80 cycles, depending to some extent on the elastic properties of the deep formations and to a greater extent on the properties of the formation in which the explosion occurs and on which the seismic pickups are located. The frequencies of the direct waves are in general lower than the reflection frequencies, and the frequencies of the extraneous disturbances caused by wind and



DIRECT CURRENT
100
200
300
MILLIAMPERES



DIRECT CURRENT
.2
.4
.6
.8
MILLIAMPERES

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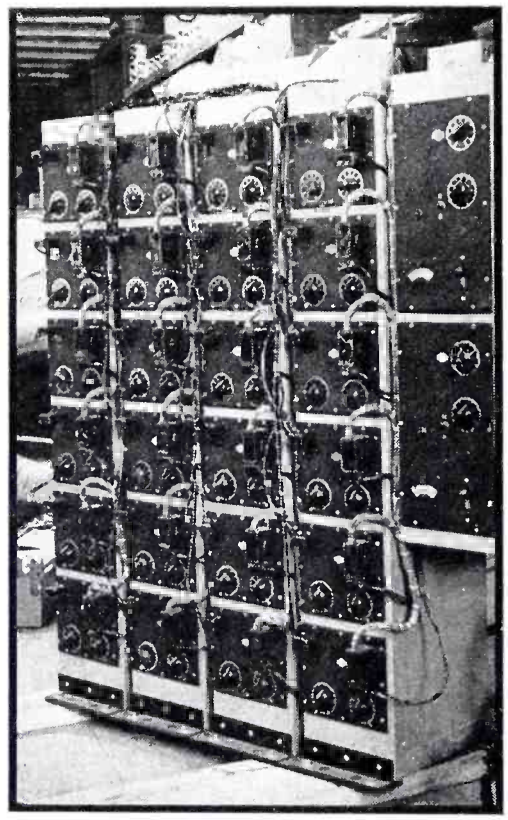

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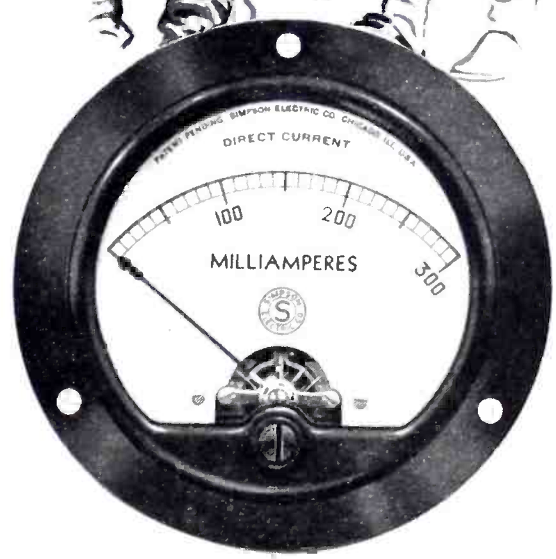
TOUGH CUSTOMERS

These men who fight for America . . . we knew them as just boys a few months ago. Now they're the toughest fighting men in the world. Call it the American love of freedom and justice, if you will, that makes them fighting mad. Or let's say simply that they don't like bullies. This much you can count on—they're going to drive a hard bargain with America's enemies.

For the big job they've got to do, they deserve the finest tools that American skill and ingenuity can contrive. We at Simpson are proud and glad to give our best . . . to match their fight with work . . . to produce Simpson Instruments in unprecedented numbers . . . and to wish them Godspeed with every working hour.



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Simpson

INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory

from this sudden break of the cap current is impressed on the modulating section of the transmitter and a signal is emitted at the instant of explosion. This signal is in turn received at the recording truck and recorded by a moving-coil galvanometer in the recording unit. Voice, C.W. and I.C.W. modulation are used for communication purposes.

Electronics Employed in Drilling and Analysis

In addition to the use of electronic equipment by the exploration group for locating a likely place in which to drill the well, it is used by the production group while drilling and completing the oil well. The vacuum tube and electronic circuit technique are indispensable in the recently developed gamma-ray electrical well logging method; also in other well logging methods where measurements are made of the electrical, acoustical or other physical properties of the earth formations treversed by bore holes. Electronic apparatus is also used in modern mud-logging equipment. While the oil well is being drilled, continuous analysis of some of the chemical and physical properties of the mud used as the drilling fluid is made possible by the application of electronic control equipment especially designed for this purpose. Data obtained enable the geologist and petroleum engineer to arrive at a clearer understanding of the conditions in the bore hole and aid in the final completion of the oil well.

Electronic equipment plays an important part in talk-back systems used on the drilling rig. Talk-back systems that supply the means for intelligible communication from the fourble board near the derrick's top to the noisy derrick floor decrease the hazards and help co-ordinate efforts in handling heavy drill pipe.

Modern radio transmitting and receiving equipment is used at some of the oil well drilling rigs located in the swamps and other isolated areas. The use of radio in this manner brings the facilities of the telephone system to the oil well derrick floor.

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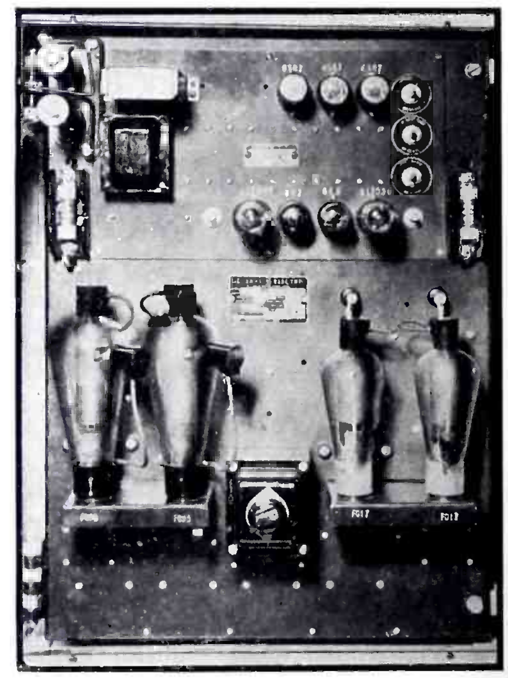
Motor Control

(*Continued from page* 139)

widely, but because the development of versatile electronic controls now makes it possible to obtain all of the advantages inherent in d-c motor applications, a tremendous extension in the application of d-c motors can be expected.

The future of the electronic drive is well reflected by its many advantages shown in the accompanying table.

Thus far, the full automatic electronic motor controls have been confined to motors of relatively small size. Fundamentally, however, there is no reason why similar controls cannot be applied to motors of any size so long as suitable tube combinations are available for handling them. When the limit of the thyratron tube has been reached, it will undoubtedly be possible to employ the pool-type ignitron tubes in suitable circuits.



PACKAGED—Typical electronic control unit for d-c motor.

Since motors may be considered one of the bread-and-butter items of industry, and since the electronic motor control makes possible still greater advantages than can be obtained with conventional equipment, it appears evident that the electronic motor control is destined to be a very important factor in the growing industrial electronic business and that past applications are but indications of the future possibilities of electronic drives.

Medical Science

(*Continued from page* 145)

duced by these screens adds to the effect of x-rays on the emulsion.

When x-rays strike the body, secondary rays are produced. These radiate in all directions, and have a tendency to fog the film. An ingenious device for the prevention of this effect is the Potter-Bucky diaphragm, which consists of alternate thin laminations of lead and wood. They are so placed that they are perpendicular to the film. The diaphragm is moved constantly during the exposure, so that no shadows of the lead strips are visible.

One of the more recent applications of electronics to roentgenographic technique is the photoelectric exposure control, which automatically ends the exposure after the proper amount of radiation reaches the film.[1] It operates by means of a multiplier-type phototube (RCA 931) connected to the grid circuit of a thyratron, with a condenser in parallel. The x-rays are changed into light by a fluorescent screen placed near the phototube.

In 1898, three years after the discovery of the rays, they were used to observe the movement of the stomach in the dog, followed shortly by their application to man. Bismuth paste was used, which when ingested made the gastro-intestinal tract opaque to x-rays. Barium sulphate is now used, because of its lesser toxicity. The movements and outlines of the human stomach could then be observed and photographed. This was of inestimable value in the early diagnosis of various abdominal conditions, the nature of which could otherwise be determined only by an exploratory operation.

Since that early day many new techniques have been devised, based on the development of non-toxic opaque materials, so that it is now possible to inject contrast media into the urinary bladder and kidney pelvis, into the spinal canal and the ventricles of the brain, and it is even possible to radiograph the blood vessels and the cavities of the heart. The location of clots in the veins of the leg may be accurately determined, and removed surgically if necessary.

In cases of sterility, lipiodol may

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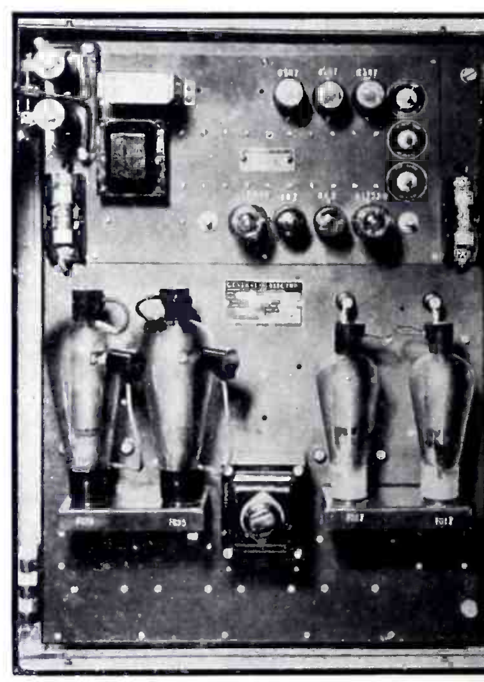

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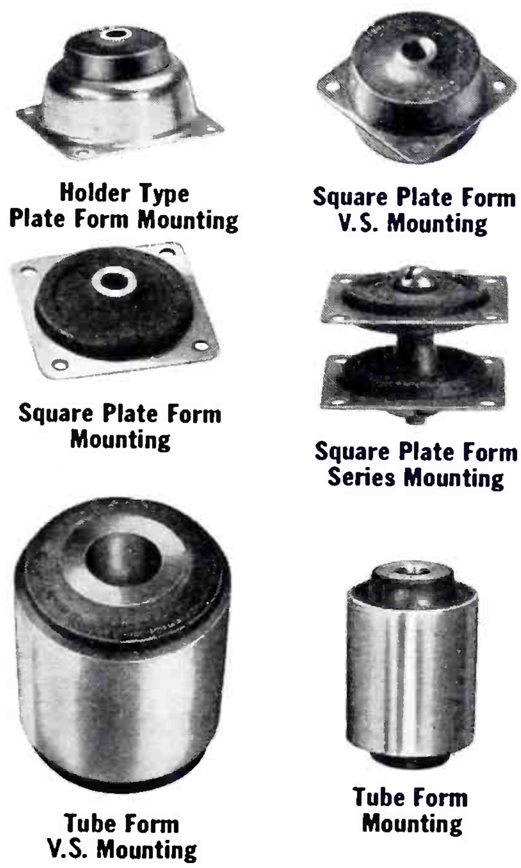
LORD BONDED RUBBER MOUNTINGS

Isolate Vibration in the WORLD OF ELECTRONICS

LORD STANDARD MOUNTINGS



MILLIONS of Lord Mountings are at work today in the electronic industry—protecting all manner of electronic devices from their worst enemy—vibration. The transmission of unbalanced forces causing vibration is reduced to a minimum by means of Lord Mountings, with the result that, in any electronic device, operating characteristics are improved and functional life is increased.

The principal characteristic of any Lord Mounting is the strong bond between the rubber and metal—a distinctive feature which makes possible the design and manufacture of *Shear Type* mountings that are rugged, simple, compact, and easy to install.

Standard Lord Mountings are made in two main types—Plate Form and Tube Form—in various shapes and sizes, with snubbing and non-snubbing features, and in load capacities ranging from a few ounces to 1500 pounds.

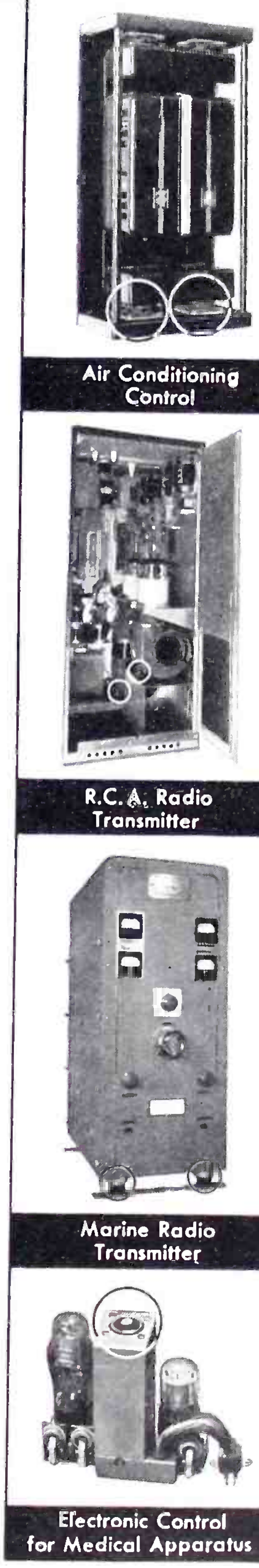
The first step in the selection of mountings is to determine the actual static load to be carried and the nature and direction of the disturbing frequency. When loaded so that the disturbance is in the direction of the main axis of the mounting, the mounting deflects readily and the rubber is permitted to operate in full shear freedom, with ample stability in other directions. This action results in a considerable reduction of the natural frequency of the mounted system with a consequent great reduction in the vibratory forces transmitted through the mounting. All Lord Mountings will withstand momentary overloads due to shock greatly in excess of static loadings.

Where equipment may be subjected to frequent, sudden load shocks . . . where movement is to be held to a minimum . . . or where the resonant range is frequently encountered, Lord Vertical Snubbing Mountings are recommended.

The exclusive features of Lord Bonded Rubber Mountings make them particularly adaptable for use on any type of electronic assembly or electronic controlled equipment—from light, delicate instruments to heavy, massive machinery.

For complete information covering all Lord Mountings and an engineering discussion on vibration control, call in a Lord Vibration Engineer for consultation on your design problems or write for Bulletins 103 and 104. There is no obligation.

TYPICAL INSTALLATIONS



LORD MOUNTINGS

PROLONG EQUIPMENT LIFE by isolating vibration, which reduces metal fatigue and prevents mechanical failure.

INCREASE PRODUCTION by eliminating the necessity for close machining and precision alignment.

SAVE VITAL MATERIAL by reducing equipment weight; inertia masses of machinery bases can be reduced or eliminated.

INCREASE PERSONNEL EFFICIENCY by eliminating nerve wearing noise and vibration, translated through solid conduction.

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IT TAKES RUBBER *IN SHEAR* TO ABSORB VIBRATION

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Originators of Shear Type Bonded Rubber Mountings

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be injected into the uterus to test the potency of the Fallopian tubes. Various other iodine compounds have been developed, which may be given by mouth or injected intravenously, and which will be excreted into the gall bladder or urinary tract and permit their visualization without instrumentation.

X-ray has also been widely used in the treatment of various diseases, mostly dermatological conditions and tumors, which are more sensitive to the rays than normal tissues. Although surgery is the method of choice in the treatment of most malignant tumors, x-ray is an important adjunct used pre- and post-operatively. It is also a widely used and beneficial palliative measure.

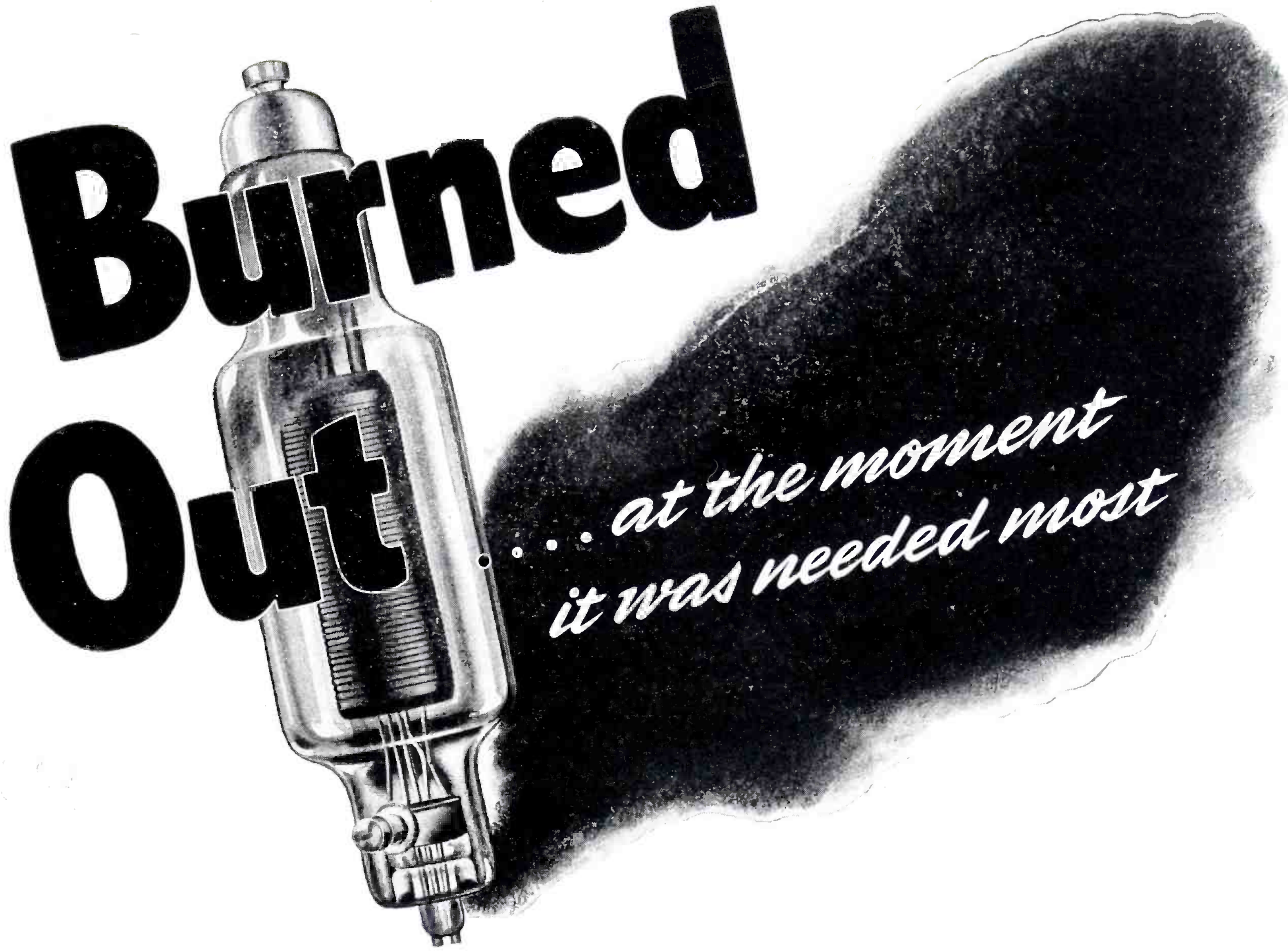
In general, higher voltages are used in therapy than in diagnosis. The high potential (above 100 kv) imparts to the electrons in the Coolidge tube an extremely high velocity, resulting in rays of short wavelength and great penetrating power. The rays are thus able to reach the tumor without being absorbed by the overlying tissue.

There has been considerable publicity about the potentialities as "cancer cures" of new high-voltage x-ray machines, and even more about the devices of the physicist which emit various sub-atomic particles. They are undoubtedly more effective than the lower-voltage devices, but it is very doubtful if they will actually cure any but the most superficial malignancies.

High-Frequency Heating Is New Medical Aid

The application of heat to an injured or diseased part of the body is one of the oldest forms of therapy, long recognized as of value in surface conditions, as well as aiding deep-seated inflammations. Its exact method of operation is not fully understood, but appears to be due to the direct effect of heat on the blood vessels of the injured tissue, producing dilatation and resulting in a greater flow of blood. Its effect on deeper tissues, to which the heat cannot penetrate, is reflex in nature, mediated by the nervous system. It follows logically from the above considerations that a method of applying the heat uniformly throughout the affected part would be of great value.

The natural scientists of the 19th



WITH CONSTANT VOLTAGE THIS MIGHT HAVE BEEN AVOIDED

This tube might have been transmitting orders to a battle fleet . . . or controlling some delicate operation in a war plant . . . or guiding an airliner through a storm "upstairs".

Then, a sudden surge of line voltage, a tiny filament gives way—and thousands of tons of fighting ships are out of contact with land . . . a whole production line has broken down . . . or a slender silver airliner lies wrecked against a peak.

Human lives and enterprises depend daily upon hundreds of functions controlled by electronic tubes. These tubes are delicate, precious, nowadays all but irreplaceable. Their priceless life *must* be kept safe.

In operation, rotate your tubes and spares. And *guard them against destructive voltage fluctuation* with SOLA CONSTANT VOLTAGE TRANSFORMERS. Sola "CV's" eliminate distortion, faulty emission, grid activation and filament failure due to voltage variation. They absorb line sags and surges up to 30% and still put out a constant filament voltage at rated level. Day and night, without supervision, they're on the job—instantaneous in action, without moving parts, self-protecting against short circuit.

Sola "CV's" are available in standard units with capacities from 10 VA to 15 KVA. Special units can be built to specification.

Note to Industrial Executives: *If you have a problem involving voltage control, no matter what its nature, Sola "CV" transformers can help you solve it. Ask for bulletin DCV-74.*

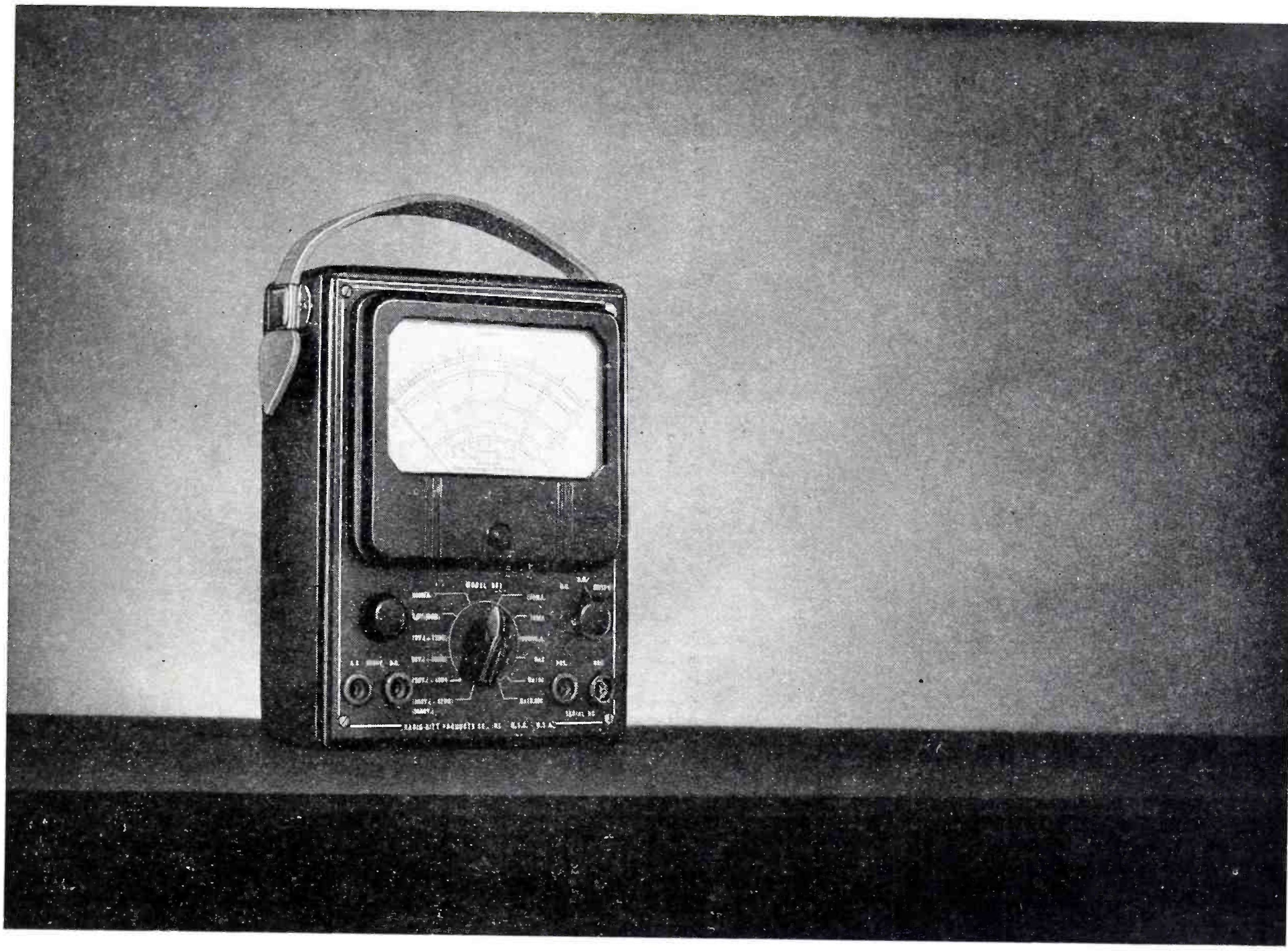
SOLA Constant Voltage Transformers

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago, Ill.**

century laid the ground-work for our present-day diathermy. Their results led to the work of Dr. d'Arsonval, who began about 1890 to conduct experiments on the biological effects of high frequency currents. He applied these currents to muscle, and found that the muscular response increased with increasing frequency up to about 5,000 cps, above which point the response decreased, and ceased altogether at about 10,000 cycles. Using frequencies as high as one megacycle, he was thus able to pass considerable current through his body with no subjective effect other than a feeling of warmth due to the ohmic resistance. He was the first man to pass the current for an electric light bulb through his body, a feat which was later duplicated by "renowned scientists" in every well equipped carnival. Apparatus of this type began to be used for the production of deep heating by the medical profession early in the present century, and the first World War provided an impetus to its more general use.

The use of higher frequencies was begun about 1925, with the development of large transmitting tubes. Vacuum tube oscillators have now almost entirely replaced the older spark-gap equipment. Most of the diathermy apparatus used at the present consists of self-rectifying push-pull oscillators with an output of 200 to 300 watts, at a wavelength of 6 to 12 meters. There are several methods of applying the current to the patient, depending on the area to be treated and the type of equipment available. The radio-frequency high potential may be applied to metal plates, which are either held firmly to the skin of the patient or held a centimeter or so away from the skin by rubber pads. Because of the high frequencies used the latter method is almost as efficient as the former. Another widely used technique is to place a coil through which the r-f current is flowing around the part to be treated. In this case the effect is due to a combination of capacitive and inductive heating.

The use of malarial therapy for syphilis had been shown to be moderately successful, and Whitney of General Electric conceived the idea of using diathermy to raise the temperature of the entire body. The cabinet designed by him consists of



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Sensitivity of 20,000 ohms per volt on all D.C. measurements results in negligible loading of delicate circuits. Wide scale, 4½" rectangular meter used, with a movement of 50 microamperes. Readings as low as 1 microampere can be made on the 100 microampere scale.

A.C. voltmeter sensitivity is 1,000 ohms per volt. Meter movement is 2% accurate. Shunts and matched pair metallized voltage multipliers accurate to within 1%. A suppressor type copper oxide rectifier is used.

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D.C. voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
A.C. voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
Output voltmeter:	0-2.5-10-50-250-1,000-5,000 volts.
D.C. microammeter:	0-100 microamps.
D.C. milliammeter:	0-10-100-500 milliamps.
Ohmmeter:	0-1,000-100,000 ohms; 10 megohms.
db meter:	minus 10 to plus 55.

Over all dimensions of the model 461 are 7" x 5½" x 3". Complete with self-contained battery supply and convenient leather handle . . . net 34^{50}

Other instruments in the complete line of R.C.P. electronic and electrical instruments described in Catalog No. 126. If you have an unusual test problem — either for production or laboratory work—our engineers will be happy to cooperate in finding the most efficient solution.

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a horizontal box in which the patient is placed, having a coil around it to which the current is applied. Only an ordinary oscillator need be used, as a sufficiently high temperature is maintained around the patient to prevent loss of heat, and it is comparatively easy under such conditions to reach the desired temperature (about 106° F) with minimum power. Excellent results have been obtained by a combination of chemotherapy with hyperpyrexia, but such treatment is not without danger, and the popular accounts written by non-medical men should be discounted considerably.

The "Radio Knife" Cuts and Cauterizes in Surgery

One of the most useful applications of diathermy is in surgery. In medical diathermy the current flows in a wide area, producing moderate heating. In surgical diathermy, the so-called radio knife, a large indifferent electrode is placed on the patient's back and the current passes from a small electrode to the tissue, producing a high temperature in a small area. This current may be varied in its characteristics so that it will have a predominant coagulative or cutting effect. Surgical diathermy has revolutionized neuro-surgery by making possible rapid hemostasis in friable brain tissue, where the slow and laborious application of silver clips was previously necessary. It has also made possible the modern transurethral prostatectomy, as the coagulating power is little impaired by operation under water.

Electrocardiograph Records Potentials of Heart

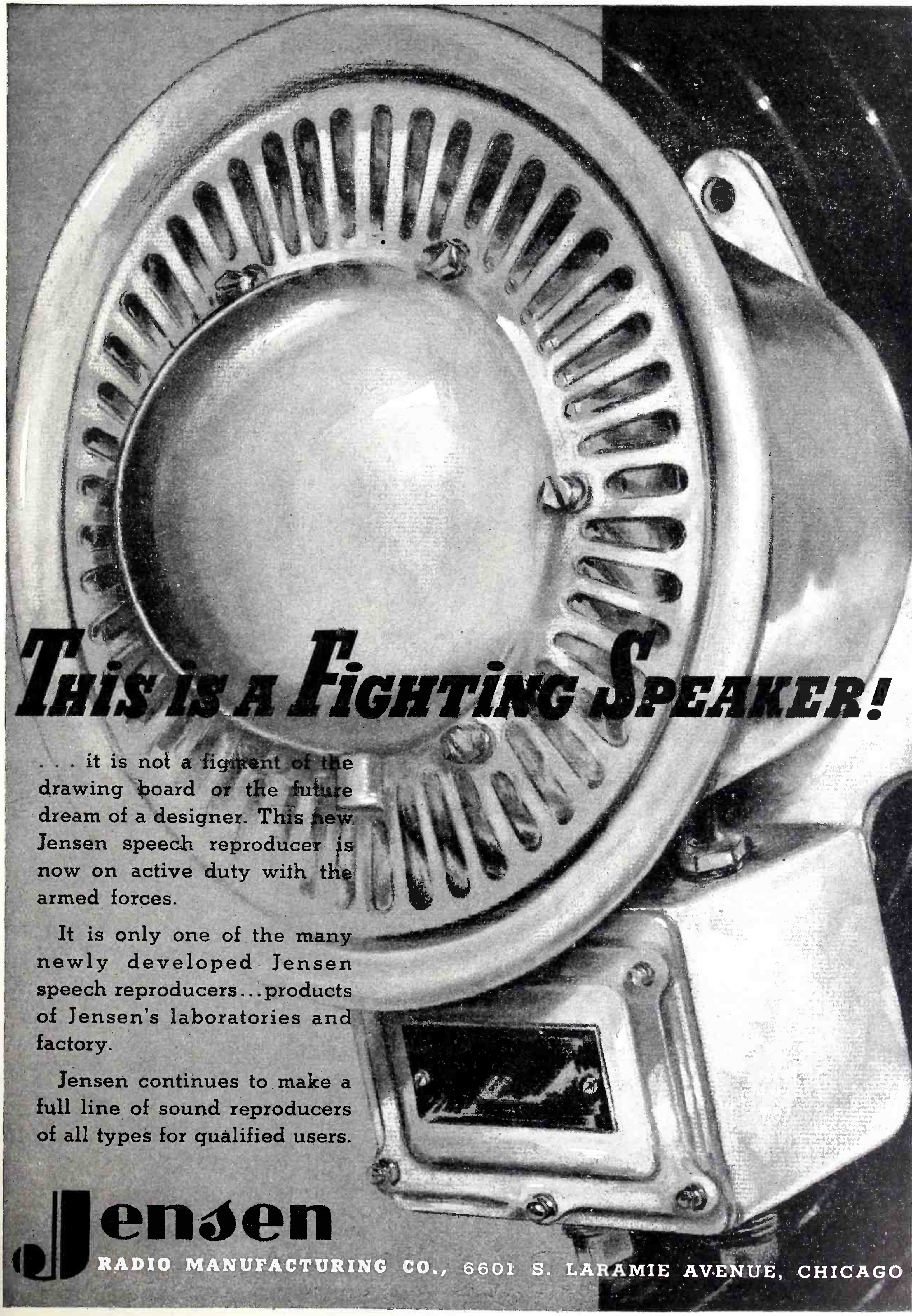
The electrocardiograph is a device sufficiently familiar to the patient so that if he is worried about his heart he will usually ask his doctor about taking an electrocardiogram. The fact that a difference of potential is produced on the surface of the heart during contraction was first discovered in 1856, and in 1887 Waller showed that the potential could be led from two parts of the body which had the heart between them, using the capillary electrometer as the indicating device. This ingenious but rather primitive device could not accurately record the rapidly changing cardiac potentials.

Einthoven first described the string galvanometer in 1903, and in 1906 published the results of the first clinical studies.[2] Three leads or points of obtaining the potentials were ordinarily used—between the two arms, between the left leg and the right arm, and between the left leg and the left arm. The peak voltage so obtained is of the order of one millivolt. It is interesting to note that Einthoven often had a pair of wires over a mile long between his patient and his recording equipment. The amount of 60-cycle pickup which would be obtained under these circumstances today can easily be imagined.

By 1913 the use of the string galvanometer in recording the electrocardiogram had spread to this country, and became in a few years a highly useful clinical tool. The string galvanometer has an input resistance of about 3,000 ohms, and thus the potential recorded is to some extent dependent on skin resistance. This difficulty is not present in modern electrocardiographs, which consist of mirror-type galvanometers preceded by several stages of vacuum tube amplification. Large coupling condensers must be used to reproduce the long slow injury potentials obtained in coronary disease. For research involving potentials obtained directly from the heart, direct-coupled amplifiers must be used, mainly in order to show shifting of the baseline.[3]

The general nature of the electrocardiogram and its changes in most of the diseases of the heart were rapidly determined empirically, but the fundamental basis of the electrocardiogram still remains comparatively unknown and a fertile ground for research. The situation was considerably obfuscated by the assumption of early experimenters that injuring a region of the heart made that region incapable of producing an action potential, and that it could thus be used as an "indifferent" electrode with respect to other regions of the heart. To anyone with the slightest practical knowledge of electricity this is manifestly absurd, because even if the region did not produce a potential it would act as a saline bridge to the surrounding uninjured muscle.

What actually happens is that there is a large prolonged positivity of the injured muscle with respect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. . . it is not a figment of the drawing board or the future dream of a designer. This new Jensen speech reproducer is now on active duty with the armed forces.
It is only one of the many newly developed Jensen speech reproducers...products of Jensen's laboratories and factory.
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to the uninjured muscle during contraction, as shown at the Wisconsin laboratories in 1938.[4] This would of course give a record indistinguishable from a negative change under the uninjured lead, and it was so interpreted erroneously by practically all investigators. This agreed with their preconceived idea that a negative state was synchronous with contraction of the cardiac muscle, and many present-day electro-physiologists have blindly accepted this classic dictum and interpreted their own results in the light of this supposed "fact".

The part of the heart which is beginning contraction is usually somewhere near zero potential, between a highly positive and highly negative area, and its potential is usually changing rapidly. Contraction may be preceded by either a positive or negative potential, and there are some parts of the heart which are never negative.

Many naive attempts have been made to explain the electrocardiogram as composed of two parts, an upstroke from one ventricle and a downstroke from the other. The electrocardiogram is, in fact, the result of a highly complex charge distribution on the surface of the heart, affecting the peripheral leads according to well defined laws of potential distribution in a volume conductor. It is to be hoped that in another decade enough will have been learned about the electrophysiology of the heart so that physiologists may propound intelligently a theory or theories explaining satisfactorily the phenomena observed.

Electronics in Study of Brain

A more recently developed clinical use of action potential recording is the electroencephalogram. It has been known for many years that when an impulse travels along a nerve, an action potential is produced. That such a potential is present in the brain was first shown by Caton, an Englishman, working on the cortex of rabbits in 1875. In 1924 Hans Berger successfully recorded and analyzed the potentials from the human brain, using needles extending through the scalp to the outer surface of the skull, and published his results in 1929. He later used electrodes on the surface of the

Recently a new type cathode-ray tube was called for by our armed forces. Just an idea—something rising out of new conditions—not yet reduced to actual ractice—and of course far from production.

pinion generally was that this new tube might require onths to develop, design, produce. Yet DuMont, with s exceptionally close coordination of experimental be work and actual production, was actually shipping that very tube in quantities within 10 days.

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scalp, which is now the method generally employed. His analysis revealed that in the normal brain the output consisted of: (1) the alpha waves, frequency about 10 cps, and an amplitude of 25 to 150 microvolts, and (2) the beta waves, frequency 15 to 60 cps, amplitude 10 to 15 microvolts. There are other components, probably artefacts, with frequencies up to about 125 cps.

Various types of mechanical-optical oscillographs were used by the early workers, being superseded by the cathode-ray oscillograph for the most refined work, and by the ink-writing oscillograph developed by Tonnies. The ink writer had the advantage that an immediate and very cheap record is obtained, which is extremely important because of the long records which must often be taken while waiting for an intermittently appearing abnormality to manifest itself. In abnormal conditions large slow waves are frequently found, 1 to 6 cps, with an amplitude up to 300 microvolts. Such waves, and variants of them, are frequently found in various types of epilepsy and in brain tumors. In the latter case they appear to be caused by pressure on the cortex, and may possibly be analogous to the injury potentials found under similar conditions in the heart.

It is interesting to note that the appearance of the normal alpha waves is possible only when the mind is moderately free from thought, and when few optic stimuli are allowed to reach the brain. This circumstance is explained rather plausibly by the hypothesis that these slow waves are due to the automatic and synchronous discharge of the cortical neurons, and that the rhythmic simultaneity of discharge is broken up by mental activity. This general principle has been used in the recently reported application of electroencephalography to lie detection.

From the above considerations it would appear that it would be necessary that the recording equipment have a frequency response from 3 to about 100 cps, but as a matter of fact the frequencies above 45 are of little importance from a diagnostic standpoint. This simplifies design problems, as the amplification of stray 60-cycle fields which will be picked up even in a screened room may be reduced considerably. Noise

from thermal agitation in resistors and shot noises in tubes is spread over the audio frequency range, and cutting off all but a band from 3 to 45 cycles is highly effective in reducing noise. This is especially important because of the extremely low potentials which must be amplified, necessitating a noise level of about 2 microvolts or less.

Other Medical Applications

Besides the applications discussed, electronics is used in practical medicine in other ways too numerous for detailed discussion. Ultraviolet rays are used for the irradiation of milk and other substances to produce vitamin D, for the sterilization of air, and for the treatment and prevention of disease. Several mining companies are trying irradiation of their workers as they leave the mines, traveling on a moving belt under mercury vapor lamps.

A very familiar device is the hearing aid, the most recent of which consists of a crystal microphone with a three-stage vacuum tube amplifier, feeding into a crystal earphone especially designed to fit into the ear. A more complete discussion of hearing aid design may be found in an article which appeared previously in this journal.[5]

One of the most widely publicized electronic devices which have appeared recently is the Berman-Moorhead metal locator, for use in removing shrapnel and similar material from the tissues. After further clinical trial and modification of the instrument, it should prove to be a device of great value to the military surgeon. Details of this device are not as yet available to the public.

A tremendous number of electronic devices are used in medical research, among which are the electron microscope, stimulators,[6] pH meters,[7] colorimeters, etc. A recently developed device measures continuously the oxygen saturation of arterial blood in man, by sending a beam of colored light through the ear to a photocell.[8] Other devices of possible interest are an apparatus for recording systolic blood pressure,[9] and an electronic device for testing fatigue by the flicker fusion method.[10] In previous issues of ELECTRONICS I have described an automatic blood pres-


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Vital applications in the Signal Corps, Navy and Air Forces are proving the axiom that difficult tasks are those which can be done immediately . . . and impossible ones being those taking a little longer.
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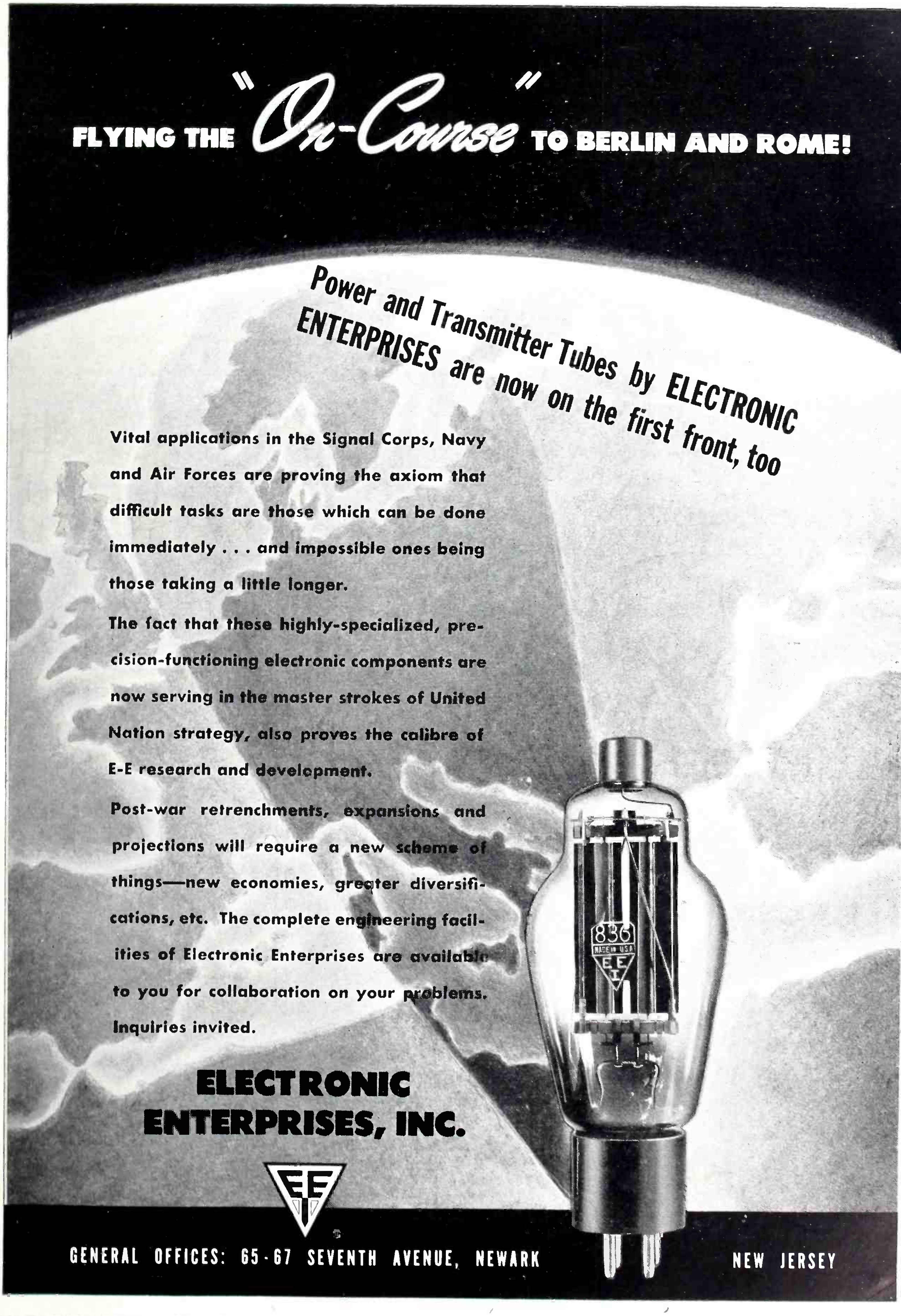
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sure recorder (May 1942), an oscilloscope (Dec. 1941), a delayed sweep circuit (March 1942), a photoelectric membrane manometer, an electronic relay, a precedence indicator, and a photoelectric myograph (Jan. 1943).

The end of the war will result in the publication of many electronic devices which are now military secrets. The war has done much to stimulate development of apparatus for the study of military physiology, but has to some extent impeded fundamental research. The application of this newly developed apparatus to basic problems should, however, solve many instrumental difficulties which previously impeded the experimentalist.

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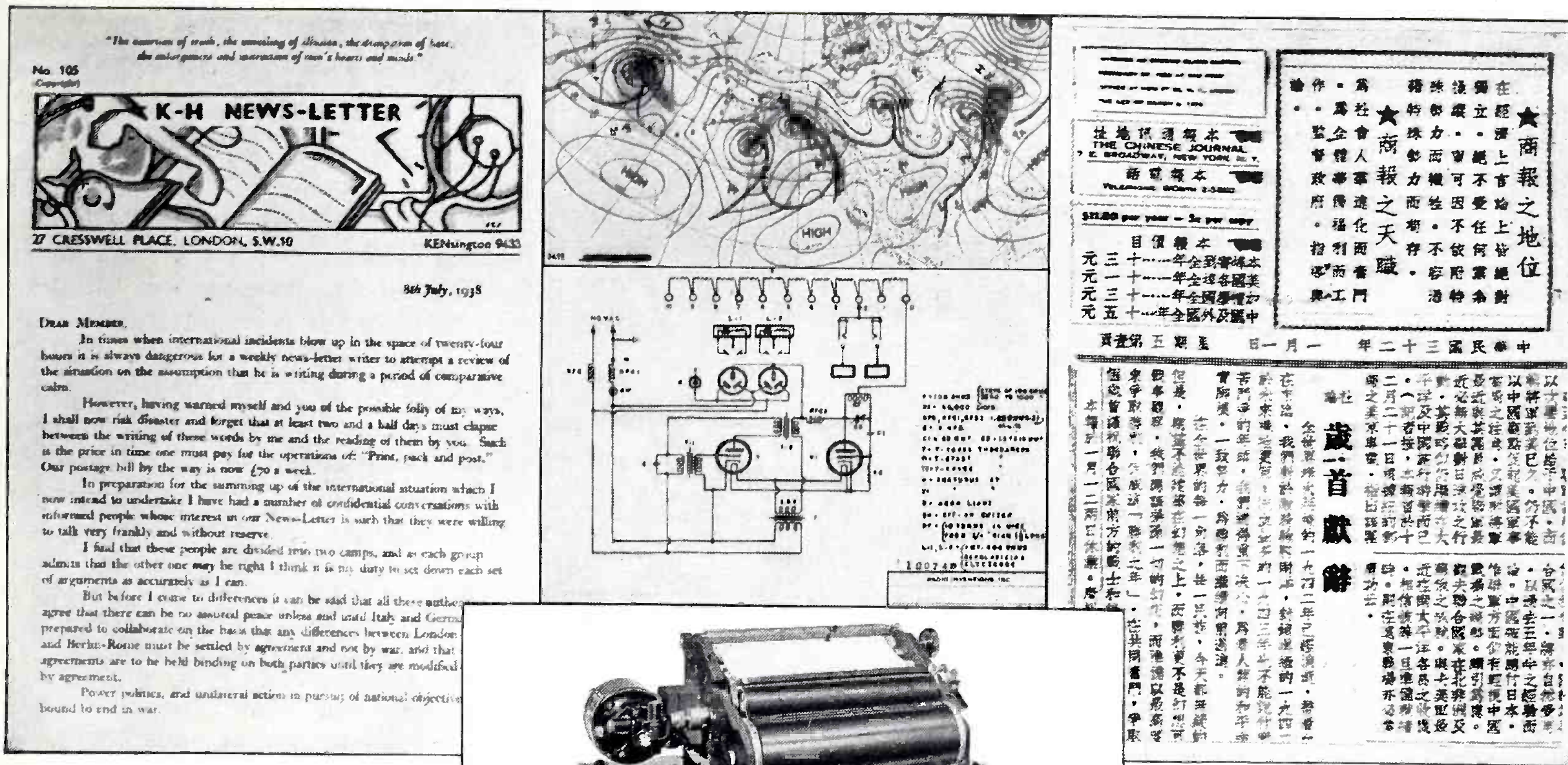
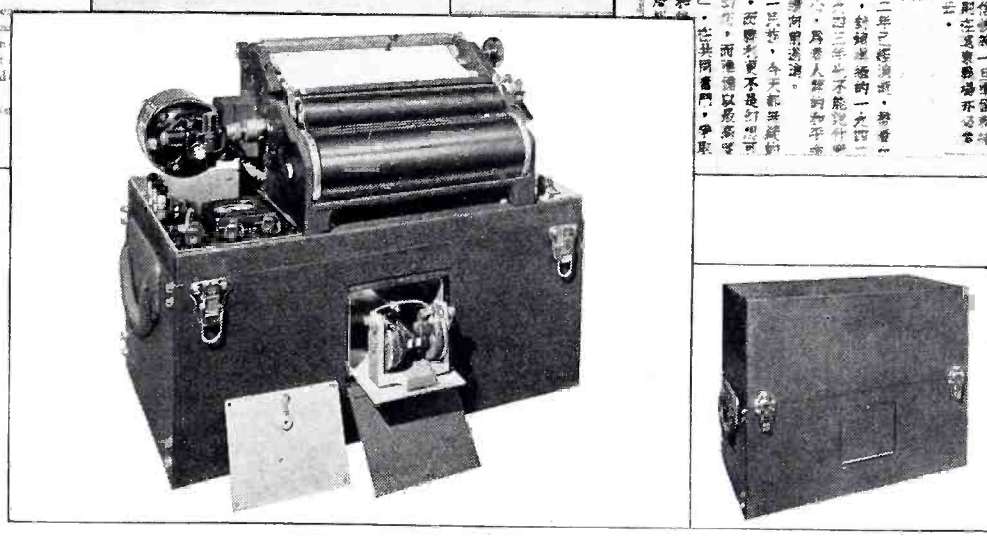
CANCER TUBE

The world's most powerful x-ray tube for the treatment of cancer has been installed in a cancer research and treatment center in Los Angeles. It has been designed to carry on the research which was conducted at the California Institute of Technology by Dr. Seeley Mudd and Dr. Clyde K. Emery from 1930 to 1938 with the first 1,000,000-volt x-ray. Shown here is the control desk for the tube, of 2,000,000 volts, and four other less powerful tubes. The control desk has a two-way communication system which can be plugged into the treatment rooms





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Electron Microscope

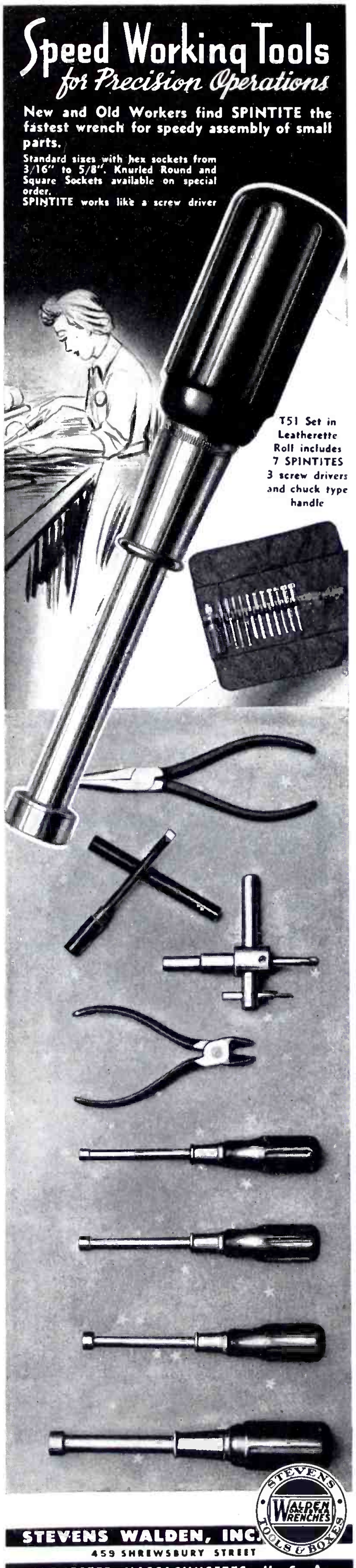
(Continued from page 147)

scope, interests metallurgists greatly. Serious obstacles to its use in this field have been overcome by the development of the replica technique in which an extremely thin plastic mould is made of the surface and viewed in the electron microscope. In one year this technique has developed into one of the major applications of the electron microscope. Its extreme importance in the war effort is obvious.

Future Microscopes and Future Uses

As electrical lenses are improved the resolving power of electron microscopes may be extended to 1000 times that afforded by the light microscope, still further extending the vision of the research workers. Atoms and molecules and the more intimate structures of large molecules and viruses will all become visible. The transition between the realms of living and non-living will be put under close observation. The gap between the elemental building blocks of matter, studied so carefully by the indirect methods of physics and chemistry, and the gross structures of every day life will then be completely filled.

The trend of future development of the electron microscope itself is also becoming apparent. The present overloading of all the instruments already in use indicates the need for a much wider distribution in the future. On the other hand the complexity and cost of the present apparatus is an important hindrance to such a wide distribution. With this in mind, the electron microscope has already undergone a complete redevelopment that has resulted in successful instruments much smaller and simpler in structure than previous instruments. This has been done by sacrificing versatility, convenience and the possibility of modernization of installed instruments and not by sacrificing performance. This new development should greatly increase the number of electron microscopes available and hence add to their value, simply as a result of the more rapid accumulation and distribution of the information which they give.



Promise of Tomorrow

(*Continued from page 155*)

able to believe that the cathode-ray tube may form a nucleus for some new and unforeseen developments, probably in connection with the ultrahigh frequencies. At best, however, these will probably come slowly at the start.

Electronic Calculators. In the past few years, personal living as well as business procedures seem to have become involved in a multitude of new uses of printed forms, tabulations, and miscellaneous paper work. The time is ripe for machinery and appliances to simplify this expansion in the requirements for routine hand work. One can be very sure that once this subject is successfully attacked for one application, its use will spread rapidly and it is also almost certain that electron tubes and their circuits will be somewhere in the picture.

Other Possibilities. The routine clerical details attending such simple procedures as a purchase in a department store, the buying of a railroad ticket, the sorting and distribution of mail, and payroll accounting, as well as a host of other routine clerical operations, will readily come to mind. The routine drudgery and exasperating delays associated with such procedures are certain to be a great stimulus to their simplification, minimizing, or elimination. The principle of scanning that is used in television may very well find application in some other field such, for instance, as photoelectric methods to enable the blind to read a printed page. Industry as well as the entertainment field may obviously use television principles.

The important thing to be kept in mind in all of our plans for the future is the stern necessity of having each electronic development economically sound from a fundamental viewpoint.

New devices must be pieces of equipment that people are willing to buy and to use on the basis of what they will do better or faster or easier or cheaper than non-electronic equipment. No amount of "glamour" will cover up or take the place of these two fundamentals.

Wire Telegraphy

(*Continued from page* 166)

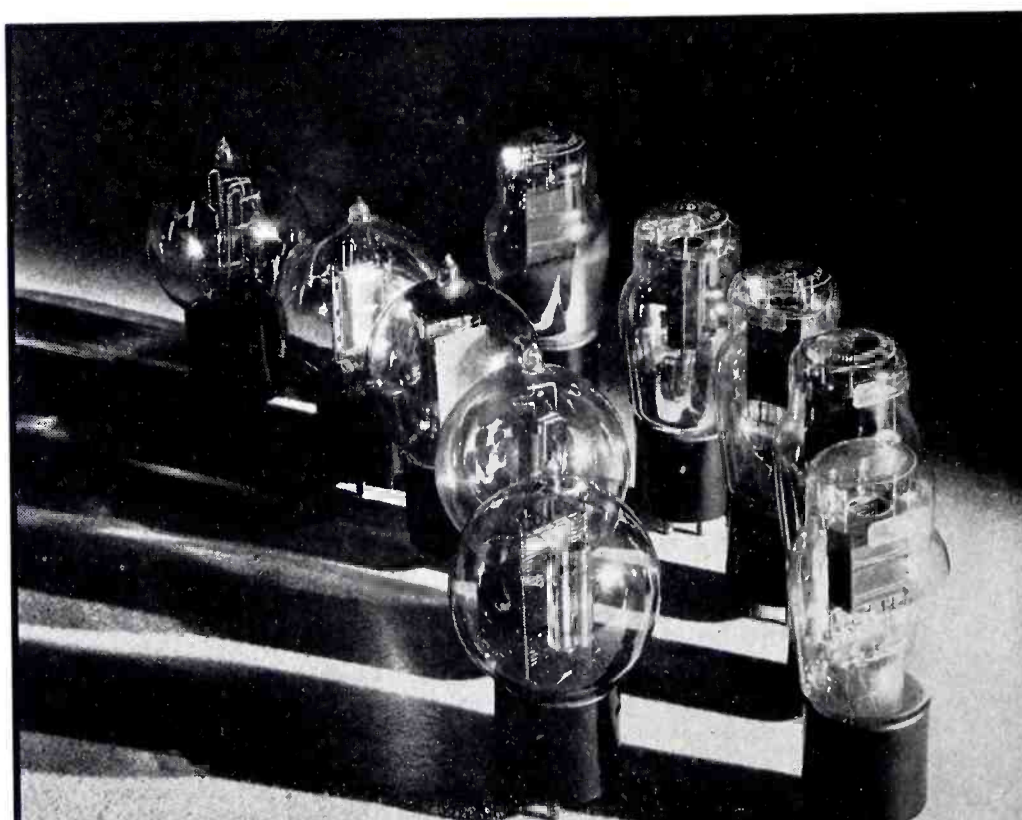
the problem of attaining a duplex balance.

In addition to the high-quality metallic telegraph circuit just described, a grounded telegraph circuit commonly known as a "gimplex" is operated over the same pair of wires. The pair of wires in the metallic loop circuit is bridged at each end of the line with a center-tapped 3000 ohm resistor. The center-tapped point is connected to a regular grounded duplex telegraph set. To improve transmission each half of the 3000-ohm resistor is shunted by a 4 microfarad capacitor. The derived ground-return telegraph circuit thus obtained is slightly inferior to an ordinary grounded telegraph circuit.

Postal Telegraph has a large number of metallic circuits in regular operation. A typical example would be one of the New York-Chicago circuits. This is a 3-channel multiplex circuit. Repeaters are located at Elmira, N. Y., Meadville, Pa., and at Fostoria, Ohio in the order named. When the circuit was operated single-wire with ground return the repeater at Meadville was of the rotary regenerative type. After the circuit was made fully metallic it was possible to dispense with the rotary repeater and replace it with the simpler non-regenerative repeater. A recent check-up of operating margins on this circuit at a speed of 61 words per minute per channel after a routine lineup showed a loss of only one percent in signal length distortion (non-duplex) after passing through the three repeaters and four line sections. The accumulative signal distortion caused by irregularities in the duplex balance was four percent. The total signal distortion was only five percent which is remarkably small when compared to earth-return operation. It is likely that six-channel equipment, not at present available, could be satisfactorily operated over these circuits.

The foregoing is a brief description of the part played by vacuum tubes in the Postal Telegraph System. Particular emphasis has been placed on the new metallic telegraph system in which tubes play a vital part.

It is felt that only the surface has been scratched, in utilizing vacuum tubes in wire telegraph systems and the future will show an ever increasing use of electronic devices.



TELEPHONE TUBES—Characteristic vacuum tubes employed by the Bell System. Those on the left have the same physical form as tubes used during the last war (VT-2); those on the right represent more recent structures

Wire Telegraphy

(*Continued from page* 166)

the problem of attaining a duplex balance.

In addition to the high-quality metallic telegraph circuit just described, a grounded telegraph circuit commonly known as a "gimplex" is operated over the same pair of wires. The pair of wires in the metallic loop circuit is bridged at each end of the line with a center-tapped 3000 ohm resistor. The center-tapped point is connected to a regular grounded duplex telegraph set. To improve transmission each half of the 3000-ohm resistor is shunted by a 4 microfarad capacitor. The derived ground-return telegraph circuit thus obtained is slightly inferior to an ordinary grounded telegraph circuit.

Postal Telegraph has a large number of metallic circuits in regular operation. A typical example would be one of the New York-Chicago circuits. This is a 3-channel multiplex circuit. Repeaters are located at Elmira, N. Y., Meadville, Pa., and at Fostoria, Ohio in the order named. When the circuit was operated single-wire with ground return the repeater at Meadville was of the rotary regenerative type. After the circuit was made fully metallic it was possible to dispense with the rotary repeater and replace it with the simpler non-regenerative repeater. A recent check-up of operating margins on this circuit at a speed of 61 words per minute per channel after a routine lineup showed a loss of only one percent in signal length distortion (non-duplex) after passing through the three repeaters and four line sections. The accumulative signal distortion caused by irregularities in the duplex balance was four percent. The total signal distortion was only five percent which is remarkably small when compared to earth-return operation. It is likely that six-channel equipment, not at present available, could be satisfactorily operated over these circuits.

The foregoing is a brief description of the part played by vacuum tubes in the Postal Telegraph System. Particular emphasis has been placed on the new metallic telegraph system in which tubes play a vital part.

It is felt that only the surface has been scratched, in utilizing vacuum tubes in wire telegraph systems and the future will show an ever increasing use of electronic devices.

TELEPHONE TUBES—Characteristic vacuum tubes employed by the Bell System. Those on the left have the same physical form as tubes used during the last war (VT-2); those on the right represent more recent structures

Wire Telegraphy

(Continued from page 166)

the problem of attaining a duplex balance.

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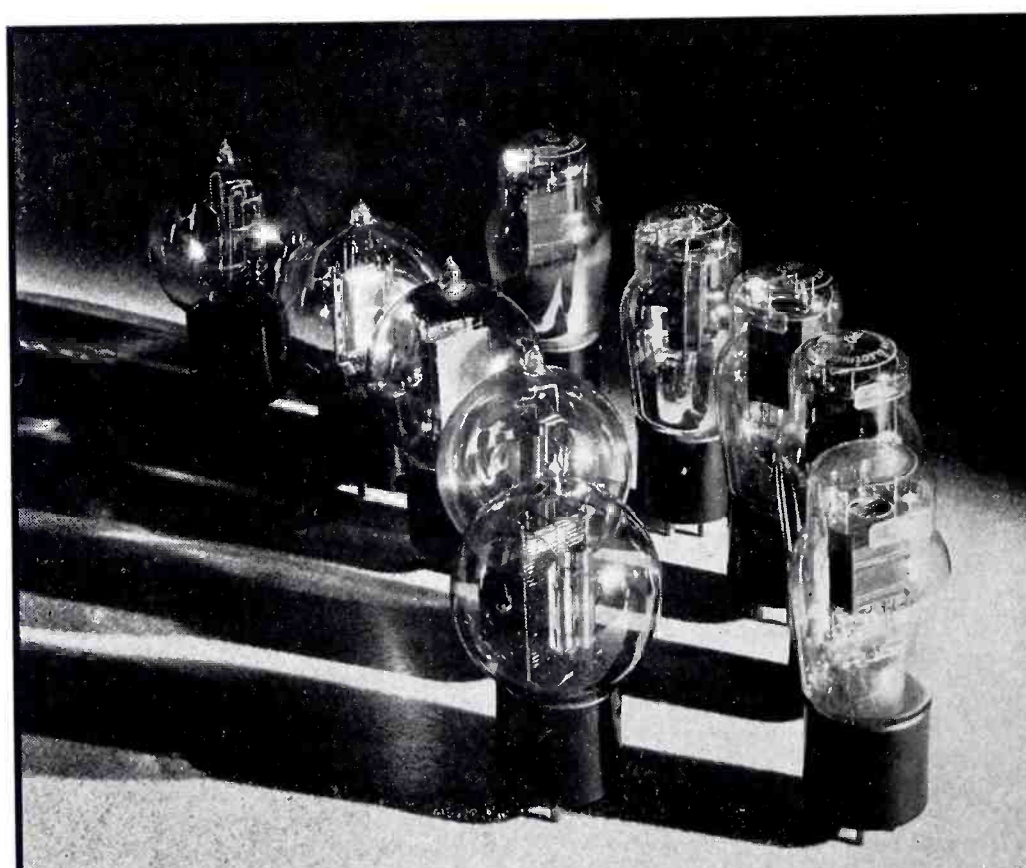

TELEPHONE TUBES—Characteristic vacuum tubes employed by the Bell System. Those on the left have the same physical form as tubes used during the last war (VT-2); those on the right represent more recent structures

Behavior of Wave Guides

(*Continued from page* 80)

for much greater convenience.

Circular guides have advantages and disadvantages in practical use, but their principle of operation is the same as that of the rectangular guide: the metal wall must always hold electric charge to terminate the electric field, or carry current to serve as boundary for the magnetic field, or both. In no other guide, however, is it as easy to recognize component plane waves as in the guide of rectangular cross section, and that is why most of this article has been devoted to rectangular guides. Almost all that has been said, however, can be extended to guides of other shape.

A circular guide with a simple wave pattern is shown in Fig. 8. It is easy to see that this is similar to the wave of Fig. 6. Indeed, if a wave of this type passed from a circular guide into a rectangular guide, through a proper transition section, it would travel on down the rectangular guide.

Two-Surface Guides

There are two fundamental kinds of guides with metal walls: those consisting of only one continuous metal surface, like the rectangular and circular guides we have been discussing, and those consisting of two separate metal surfaces. A concentric transmission line is of the latter type. So is a parallel-wire transmission line. So is a twisted pair of wires. So is any other electric circuit, if one wishes to make the most of this point of view.

Conductors Only Provide Boundaries. From the wave-guide point of view, the conductors in any circuit exist for the sole purpose of serving as boundaries to the electric and magnetic fields. This may seem an extreme view to take of the fifty feet of bell wire between your front door and your kitchen, yet it is the magnetic field in the transformer that provides the energy, the electric and magnetic fields about the wires that carry the energy, and the magnetic field in the box on the kitchen wall that rings the bell. There is, of course, a flow of current in the wires,

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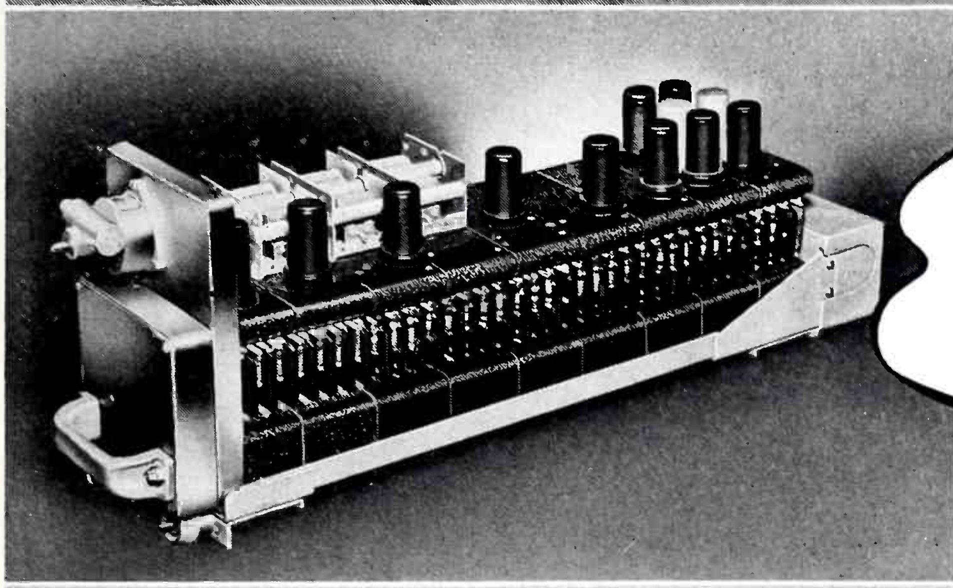
feature



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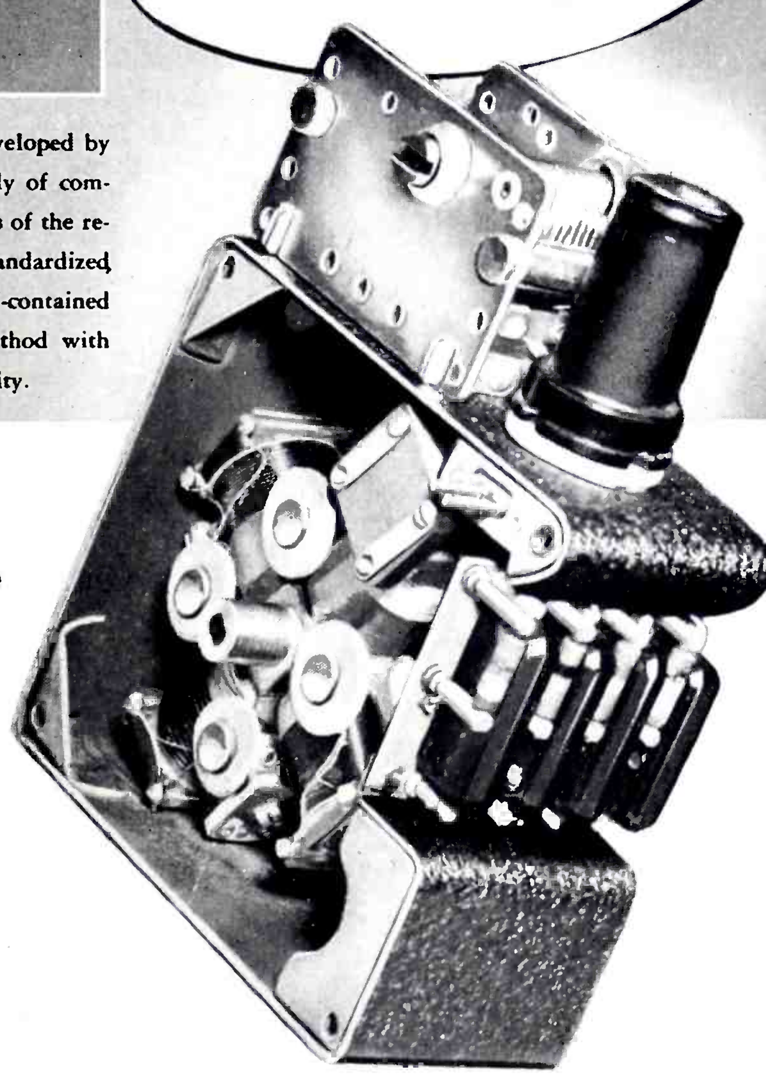

Cell-unit construction creates new standards in radio performance

The R. F. Amplifier cell, shown at the right, is typical of Harvey "Unitized" construction. The standardized case supports the variable tuning condenser and a remote cut-off high-mu pentode tube. The rotary turret coil assembly is mounted on a hollow trunnion, and the R. F. transformers are rotated by a band change control, which connects the desired coil to the fixed components of the circuit.

L/C ratios of the R. F. circuit are greatly improved by the Harvey turret coil which provides up to 40% less minimum circuit capacitance than is found with conventional band switch methods. The exceptionally high Q of Harvey R. F. circuits is due to coil design and use of low-loss coil forms, minimum contact resistance between a coil and the circuit through use of solid silver contactors provided with wiping action, and efficient shielding. Such features assure performance from Harvey multi-band receivers equal to the finest single-band receivers with comparable tuning ranges.

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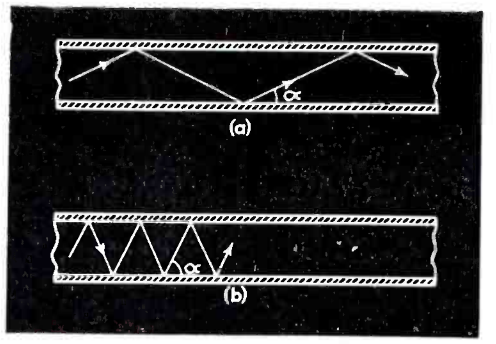

Fig. 7—The speed at which a wave travels through a wave guide depends upon the path which the wave takes, and this in turn depends upon the width of the guide and the frequency of the wave. At (a) the speed will be relatively high since there are few reflections in a given length of wave guide. At (b) there are more reflections per unit length, and the speed is correspondingly decreased

but that is merely incidental and neither wires nor current serve any useful purpose except to guide the electromagnetic fields into the little box in the kitchen. It is freely admitted that this concept would not be of much service to the electric repair man, but it is absolutely necessary for the ultra-high-frequency engineer.

Wave Guides Can be Curved

A hollow wave guide can be used to carry a wave from one place to another as a speaking-tube carries sound. Although we have spoken of straight guides, a guide may be curved if the bends are not too sharp. There are practical applications for such guides only at very high frequencies, for unless the wavelength is of the order of magnitude of a few centimeters the wave guide must be prohibitively large.

Hollow vs. Concentric Guides. Even with centimeter waves the hollow guide must meet the competition of the concentric line. The outstanding advantage of the hollow guide is that it requires no insulation, while a concentric line must necessarily have the inner conductor supported by some solid material; there is appreciable loss of energy in even the best of insulators in an ultra-high-frequency field, and in an extreme case the strong electric field near the small inner conductor of a concentric line may cause dielectric breakdown of the insulating material, or of the air itself.

The most suitable type of transmission line or wave guide to use for a particular application depends on many factors, and most particu-

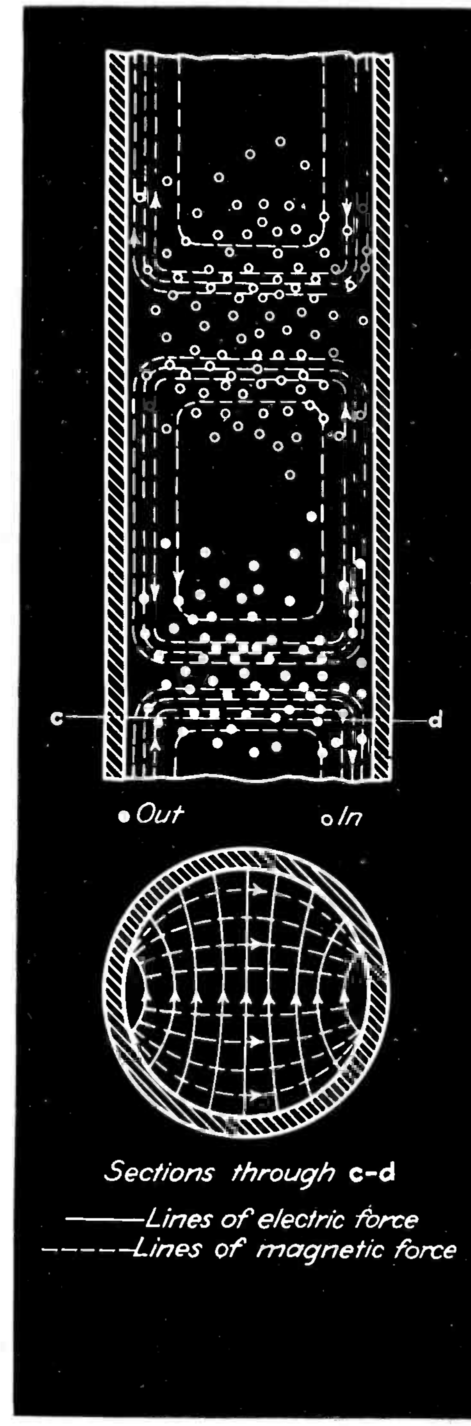

Fig. 8—Plan and cross-section views of the electric and magnetic fields in a circular wave guide for one mode of oscillation

larly on the frequency. Hollow guides are at their best at the highest frequencies.

Hollow guides are also very valuable as resonators. Cut off a section of the guide of Fig. 6, or the guide of Fig. 8, and close each end with a flat plate of metal. The result will be an *electromagnetic cavity resonator.* If a wave guide is like a speaking-tube, a resonator is like an organ pipe. A standing wave may be produced inside it by repeated reflections, back and forth from end to end, at one specific frequency. There can also be other modes of electromagnetic standing waves in a cavity resonator, with various patterns of the electric and magnetic fields. In one of the most usual modes the elec-

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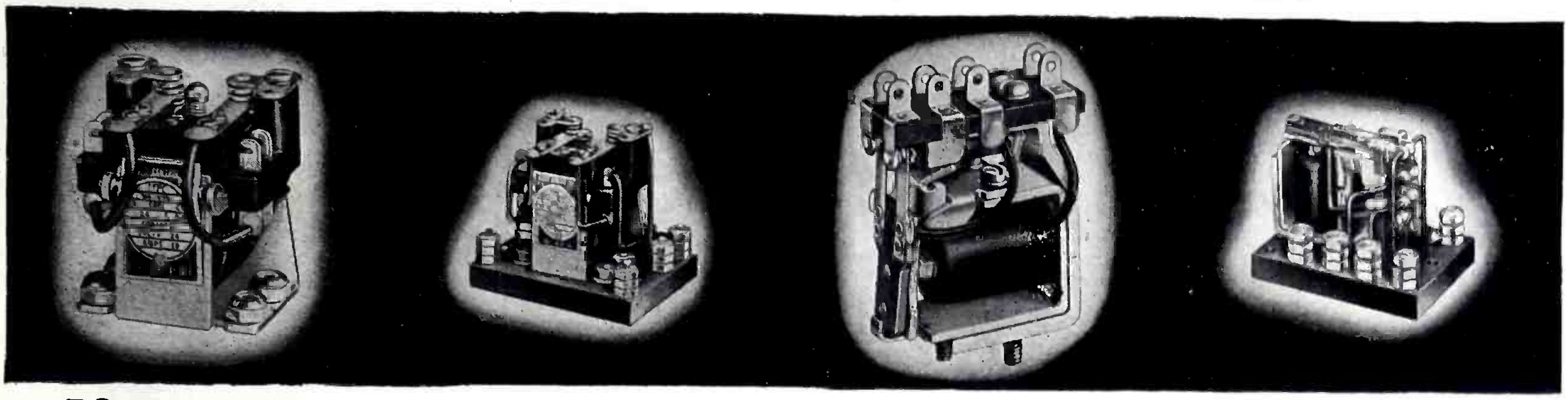
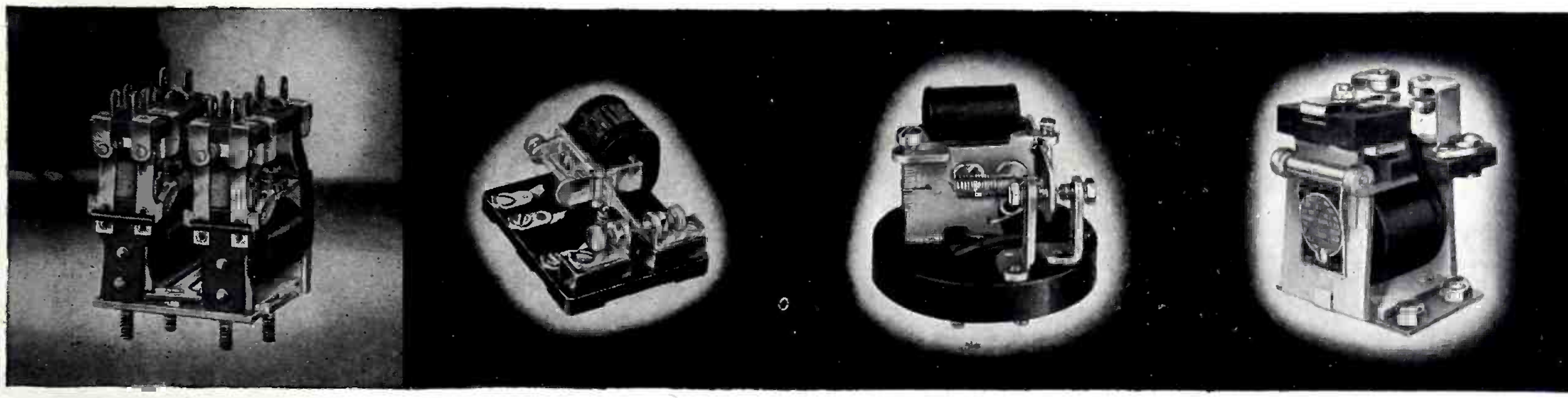


BO *a compactly designed 2½ watt relay, rated 15 amperes at 24 volts DC or 110 volts AC, standard is double pole double throw and also made in 3 and 4 pole double throw — (model BOB when mounted on Bakelite Base).*

BJ *a small compactly designed 2 watt relay, rated 5 amperes at 24 volts DC or 110 volts AC, standard is double pole double throw — (model BJB when mounted on Bakelite Base).*

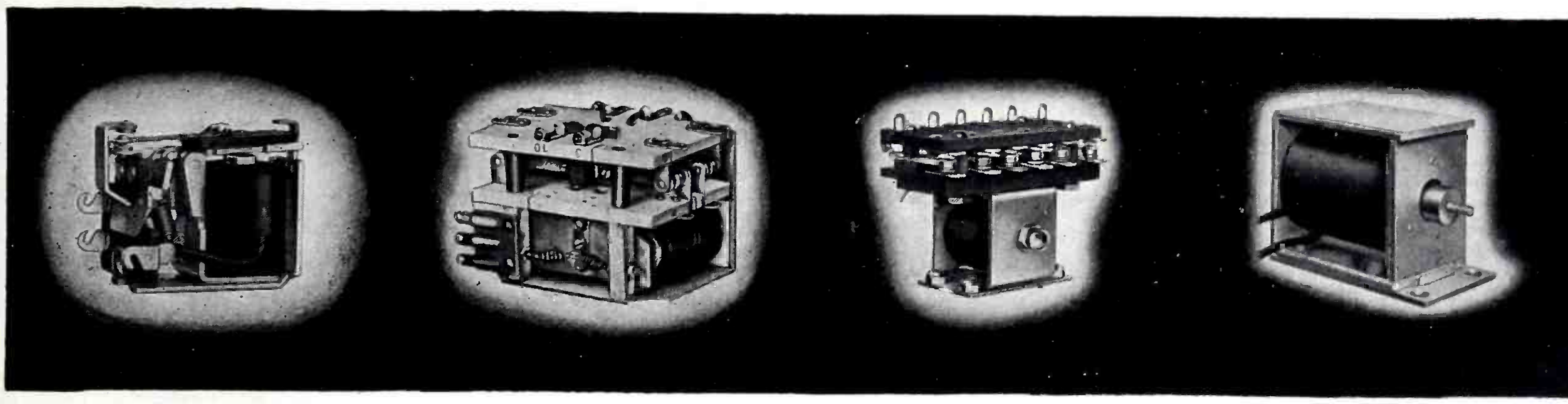


BJU *a latching relay for aircraft; maximum rating 5 amperes per contact, non-inductive.*

B *a sensitive relay operating at. 0.012 watts*

G *a sensitive relay operating at 0.05 watts*

AN *a power relay handling up to 75 amperes at 24 volts DC*



AR *a featherweight relay with 5 ampere contacts and weighing 50 grams*

AK *a high speed Keying Relay, 20 cycles per second . . Contact rating 1000 volts at 30,000 ft . 20 megacycles . . 4 pole double throw*

BN *a multiple contact relay, 6 pole double throw handling 10 amperes at 24 volts DC*

Solenoid AP *capable of 3 to 5 pounds pull at ¼" stroke*

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tric field extends from one flat side to the other of a chamber shaped like a tin can.

Resonant Characteristics. A resonator serves the same purpose at ultra-high frequency as a tuned circuit at moderate radio frequency, and does it better. It is more highly resonant, more able to discriminate frequency, and has higher Q than the best of tuned circuits. It is rather analogous to a half-wavelength of concentric transmission line used as a resonant circuit. A resonator, or a pair of resonators, may be built in as part of an ultra-high frequency vacuum tube, as in the Klystron; the resonators then serve instead of tuned circuits to determine the frequency generated.

Solid dielectric Guides

Another possible type of wave guide is not made of metal but of dielectric material. Instead of being a copper pipe it may be a solid rod of, let us say, glass. Reflection of electromagnetic waves takes place from a surface between glass and air. Light, for example, is reflected at such a surface, and may be totally reflected if attempting to pass too obliquely from glass into air.

Somewhat similarly, if an electromagnetic wave of sufficiently high frequency is sent into the end of a dielectric rod it will be guided to the other end of the rod because of its inability to leave the dielectric material. The practical difficulty with such a wave guide is that all dielectric materials have high energy loss in a high-frequency electric field, and the propagated wave is attenuated too rapidly. In other words, all dielectric material is somewhat opaque at ultra-high frequency.

Starting the Wave

There is no doubt about how to start a wave on a two-wire transmission line, or even a concentric line. Connections are merely made to its two terminals. But it is by no means obvious how a wave is to be started traveling along a hollow-pipe guide. One cannot make connections to its two terminals because it does not have two terminals. So the usual expedient is to use a small antenna within the wave guide, and simply radiate waves down the pipe.

The shape of the little antenna is selected to suit the type of wave to

TEST EQUIPMENT

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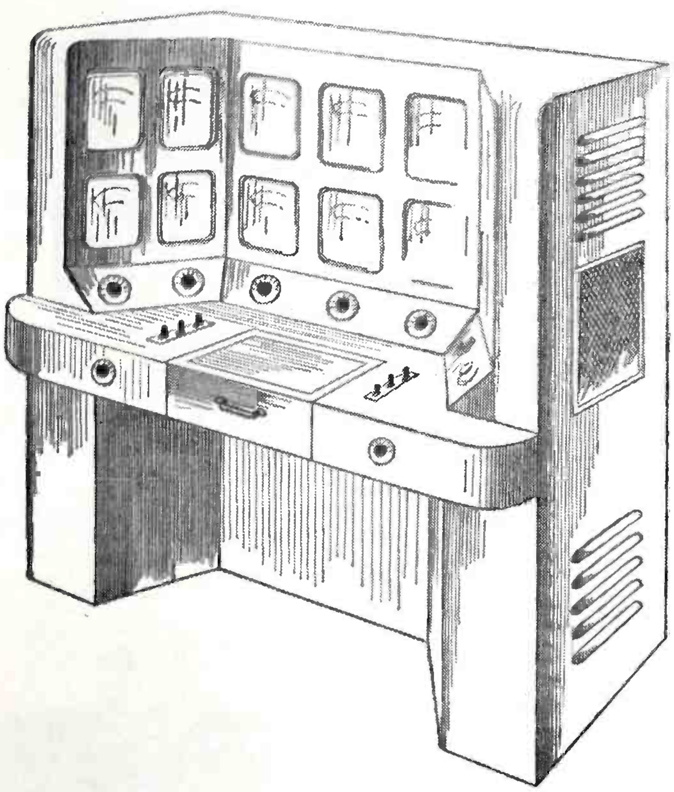

For military reasons the test set shown is not a new development.

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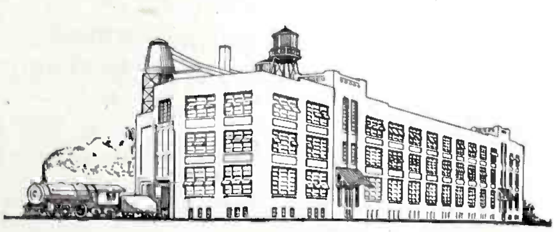

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ELECTRONIC DIVISION

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1201 FLUSHING AVENUE ~ BROOKLYN ~ NEW YORK be propagated. For instance, in the guide of Fig. 6 the antenna could be a short, straight rod projecting in through one of the walls of the guide and parallel to the lines of electric flux. The electric and magnetic fields around such an antenna would roughly approximate those of the wave that is propagated along the guide. At least, the magnetic field would be similar to that desired, and the electric field of the antenna would have its principal component parallel to the electric field of the desired wave.

An inserted rod antenna would produce complicated disturbances in the wave guide, but the guide is able to carry only certain relatively simple types of waves. As a result all the undesired components of the fields about the antenna would fail to propagate, and only the proper kind of wave would go on down the guide. It is probably desired to transmit only one way along the guide from the antenna, so a short distance upstream from the antenna the pipe would be closed with a flat metal plate. By properly adjusting the distance from the antenna to the reflecting metal plate the closed end of the guide may be made to act somewhat as a resonator and the strength of the transmitted wave will be enhanced.

To obtain other wave patterns within the guide, other types of antennas are used. A small loop may be used for some purposes, and for others an axial rod is used instead of a transverse rod.

Terminations

At the other end of the guide, energy is received on an antenna similar to the transmitting antenna. If an antenna is good for transmitting, it is equally good for receiving. From the receiving antenna energy may be carried by two wires, or, better, by a concentric line, to wherever it is to be used or detected.

If, however, the energy is to be radiated into space as a free radio wave it may simply be allowed to pass outward from the opend end of the wave guide. This is a possible means of radiating, but not a good one, for the wave guide is not well matched to open space and the wave cannot get out freely.

Radiation is greatly improved if the end of the guide is belled out as in a horn. Then the larger the horn,

the more efficient the radiation; the horn acts as a megaphone. A large horn on the end of a hollow guide produces a highly directive beam of radiation, and the wider the mouth of the horn the sharper the beam that it radiates. It is one of the great advantages of centimeter waves that they are easily directed by a horn, by a parabolic reflector, or by various other directional devices.

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See also the above references.

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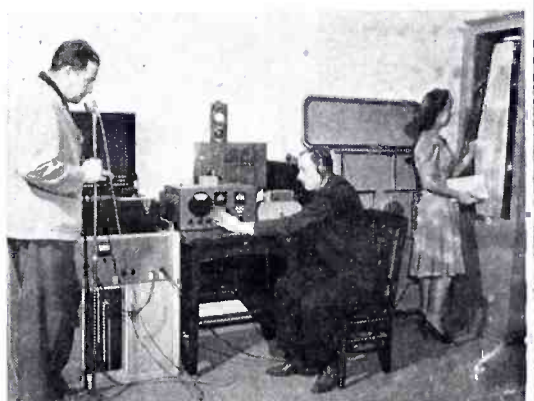
TEST FLIGHT RECORDER



New radio test flight recorder perfected by engineers of the Vultee Aircraft Corp., checks all reactions of an airplane during its test flight and radios them to recording devices on the ground. Harvey Giffen, (center) the inventor, and his assistants are shown at the Vultee plant checking the progress of a new fighting plane in flight 100 miles from the laboratory


Electronics

I.R.E.-AIEE War Conference

(*Continued from page* 157)

members from London by shortwave radio circuit. The technical difficulties under which broadcasting service is maintained in Great Britain under conditions of actual bombing and of air raid alarms were outlined in this address.

Through the facilities of the Columbia Broadcasting System, a nationwide radio network linked the New York meeting with the I.R.E. Section banquet held simultaneously at Washington D. C., in which L. P. Wheeler and A. F. Van Dyck took part. A feature of this broadcast was an address by James Lawrence Fly, chairman of the Board of War Communications and of the Federal Communications Commission.

Increasing Tube Life

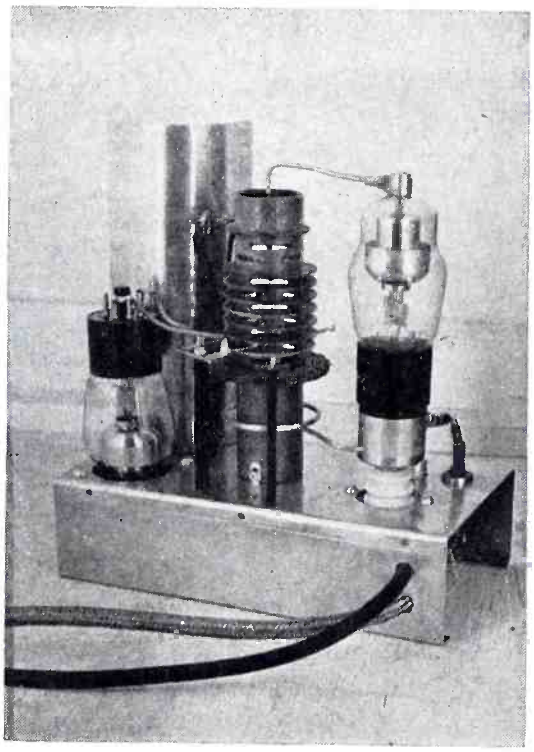
On Wednesday afternoon a conference on "Getting the Most Out of Electronic Tubes in Wartime" was led by D. W. Jenks, E. E. Spitzer, C. C. Herskind, G. H. Rockwood, and S. B. Ingram.

Not only the tube designer, but the equipment designer and tube user have a responsibility in obtaining maximum tube life. Much effort is spent by manufacturers to assure long life, but this can be achieved only if tube is used in accordance with the manufacturer's instructions. The user is the loser if these instructions go unheeded. Maintaining filament voltage at specified values, and providing adequate cooling, with filters when forced draft is used are the greatest aids to prolonging tube life. Mercury vapor tubes should be handled in such a manner that splashing of mercury is avoided. If tubes are water cooled, the water supply should be analyzed to ascertain that no harmful ingredients are present. The water supply should be filtered.

In certain cases possible "salvage" operations may extend the life of the tube, but increased emission by raising the filament voltage or reactivation should be employed only as a last resort. It was shown that life may be lengthened by operating tubes below normal filament voltage during short periods of stand-by operation instead of turning them off.

The morning technical session was opened by Otto H. Schade who

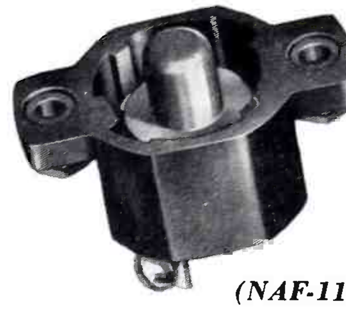
spoke on "Radio-Frequency-Operated High-Voltage Supplies for Cathode-ray Tubes." The operation of such tubes requires a power source providing high potential direct current ratings from 1 to 30 kilovolts or perhaps higher, but the current requirements are seldom in excess of one or two milliamperes. Suitable power supplies in the past have customarily been obtained through the use of high-voltage transformers operating from a 60-cycle power line, used in conjunction with suitable rectifiers and filtering circuits. Such practice requires comparatively bulky equipment and is potentially if not actually, dangerous to personnel since the power capabilities of



High voltage high frequency power supply for cathode-ray tubes, described by Mr. Schade

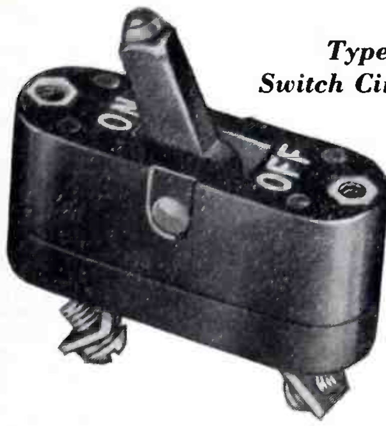
such a system usually exceed those required by the cathode-ray tube. The use of high-frequency power sources instead of the 60-cycle power line permits a substantial reduction in size and weight of the component parts of the power supply system. In addition the limited input power, generated by vacuum tube oscillators, permits the construction of relatively safe power supplies when the current requirements are low.

Mr. Schade described several types of high-voltage power supplies in which power was obtained from an oscillator operating at a frequency of approximately 100 kilocycles. One of the power supplies developed 1,000 volts at 0.3 milliampere. A larger supply developed from 10,000 to 12,-



Type PM
(NAF-1131) Circuit Breaker

Type B3120
Crystal Dew Point Control



Type C-6363
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FOR A CLEAN BREAK OR A SOLID MAKE...

Use Klixon Snap Acting Controls

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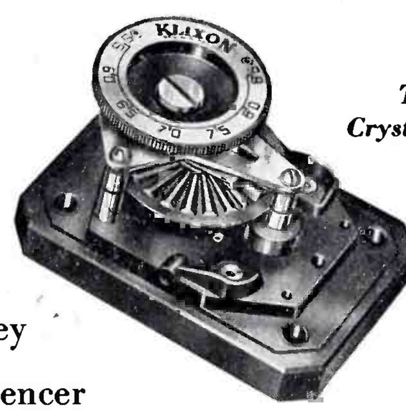

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There's no arcing or flutter action with Klixon Thermostatic controls. For these small, simple and foolproof controls are snap-acting. They contain no fussy parts—no magnets, toggles, etc. They are operated entirely by a scientifically calibrated Spencer Thermostatic disc. They are extremely resistant to shock, vibration, high altitude or motion regardless of position of mounting. And they are non-radio interfering.

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Type C4351 Series
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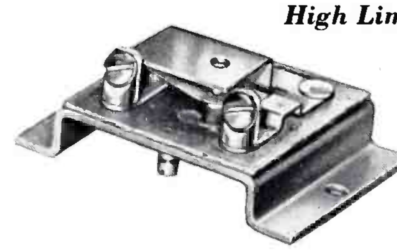

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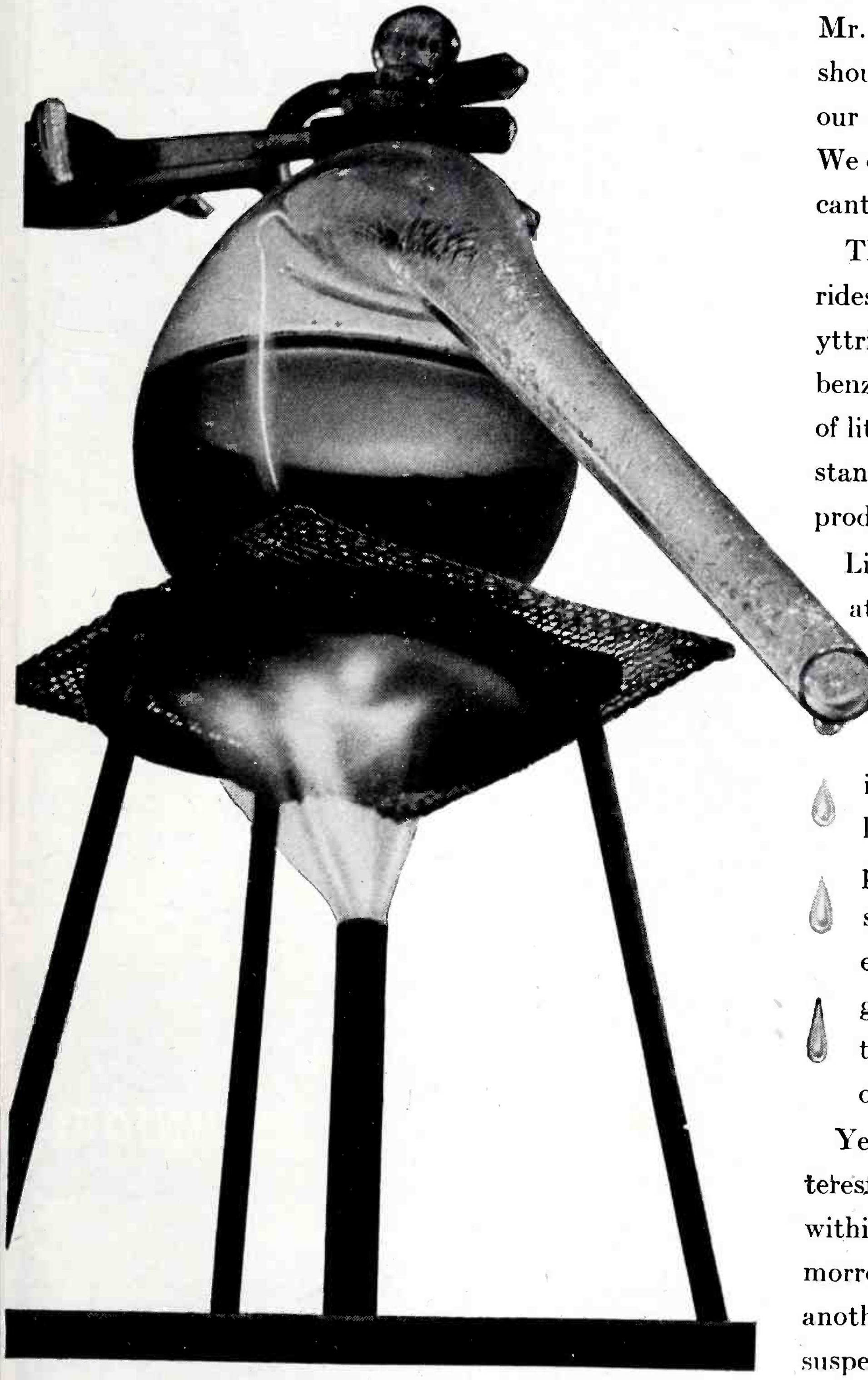
000 volts at approximately double the current.

For obtaining high efficiency, the tuned r-f step-up transformer windings must have high impedance and a low power factor. They should likewise have a minimum capacitance to ground. When used in a self-oscillating circuit, primary and secondary tuned circuits must be overcoupled to obtain efficient energy transfer. The circuit has then a double coupled tuning characteristic requiring that the oscillator frequency be stabilized at one of the peaks by feedback from the secondary winding. The radio frequency transformer from which the high frequency output was obtained consisted of a grid coil of 70 turns, and a plate coil of 55 turns. Interposed between the two coils was the high voltage winding of 1,400 turns divided into a number of pie sections in order to reduce distributed capacitance. All three windings were reasonably well coupled together and were wound on a coil form approximately 1½ inches in diameter. In order that losses in the coil form at high frequency may be reduced to a minimum, losses were reduced through the use of extremely high quality dielectric tubing, from which sections of the tubing, not required for mechanical rigidity, were cut. The output of the high-voltage winding is fed to any of the conventional rectifier circuits. Because of the high frequency involved, only a simple filter is required to obtain satisfactorily constant direct current and voltage. Where high voltages are required, voltage doubling circuits are employed.

Power loss is proportional to the capacitance of the high-voltage circuit which is to be minimized by suitable design. The design of optimum high-voltage winding with low self-capacitance and maximum impedance is, therefore, of great importance and governs the operating frequency of the particular unit.

The physical construction and electrical performance of several developmental high-voltage supplies were discussed and illustrated. It was clearly demonstrated that one of the difficulties with such a high-voltage supply is that of corona discharges which result from excessive voltage gradient. To obviate these difficulties, sharp points or corners are to be avoided. One way of ac-

Is this the beginning of a miracle?



Mr. Ernest G. Enck, our technical director, thinks we should put greater emphasis in our advertising on our sizing and beneficiation of ores and minerals. We do, he emphatically reminds us, prepare a significant list of chemicals from these ores and minerals.

There are, for instance, the carbonates and chlorides of lithium and strontium; the nitrates of lithium, yttrium, caesium, thallium and zirconium; and the benzoate, chloride, hydroxide, fluoride, and stearate of lithium . . . to mention only a few. A better understanding of these underemployed chemicals is already producing startling discoveries.

Lithium stearate is a case in point. Lithium stearate or "metal soap", was just what petroleum researchers needed to compound for our fighting planes *one* grease which tames the biting cold of Reykjavik as easily as it does the scorching heat of Tunisia. Will the automobile industry look into the post-war possibilities of this Foote patented product? Probably! Another example is strontium. Strontium salts, now vital to the war effort, are intriguing the interest of ceramic engineers and, after the war, may well influence the making of whiteware, glazes, lustres and optical glasses.

Yet, this is only a beginning. Much of our most interesting exploratory work is still quietly bubbling within the retorts of our laboratory. Today or tomorrow it is just possible we may help you achieve another miracle of chemistry, or to start one. If you suspect we can help you now, please write us.

FOOTE DUCTILE ZIRCONIUM NOW IN PRODUCTION!

Here is real news for every one of you in the radio and electronics industries, news we have been waiting to give you for months. *We are now in production on ductile zirconium.*

You are, of course, well acquainted with zirconium metal powder and its advantages for vacuum tubes. Ductile zirconium, like the powder, is an active "getter" at elevated temperatures. However, ductile zirconium is doubly useful, since—because of its structural strength—it may be shaped into vacuum tube elements. In fact, the metal may be spot-welded, butt-welded or machined. Experimental quantities are available as wire, sheet, rod, and woven screen. Other special forms can be made on request. Your inquiries are invited.

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complishing this in practice is to use conductor tubes of appreciable diameter rather than wires of small size. To keep the voltage gradient to a suitably low value, a wire diameter of at least 10 mills for every 1,000 volts is desirable.

"Transmission-Line Charts" was the title of an interesting talk delivered by R. S. Julian, and illustrated with slides. Since the analytical approach to transmission line problems is usually rather tedious, time-consuming and unwieldy, recourse can be made, with considerable advantage, to the use of transmission line charts. A wide variety of charts has been devised for determining the voltage and current distribution along transmission lines or for determining the peak and power in the line. These charts may take any one of a wide variety of graphical forms, but all represent essentially the same data. The differences in the various types of charts result from the selection of the most convenient, coordinate axis, and this in turn, depends largely upon the type of problem to be solved.

It was shown that all of the characteristics of a transmission line could be plotted on a spherical surface. The various transmission line charts customarily employed in engineering work may then be obtained by suitable projection on to a plane surface from the various coordinate grid systems plotted on the spherical surface. The problem is analogous to that of drawing a plane map of the world; the various projections being given by various methods of projection whose utility is best suited to a particular purpose.

The very extensive use which Mr. Julian made of graphical methods and three dimensional models illustrating the various types of projection, make it impossible to do a very adequate job of reporting his paper. This is the type of paper which can be appreciated only by visual examination of the illustrative material presented. But Mr. Julian has made a big stride forward in showing the relationship between the various types of transmission charts, in indicating the maximum sphere of utility for the various types, and in outlining the manner in which one is related to another.

Polydirectional microphones, consisting of a single ribbon, the back of which is coupled to a damped

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.... Yet
MOISTUREPROOF
BAKELITE RESINOID IMPREGNATED
BAKELITE CEMENT SEALED
A proud achievement . . . . after years of research for a small moisture-proof paper capacitor . . . . Dumont engineers have scored a signal victory by perfecting a water-tight seal that is definitely moisture-proof. Conclusive tests of many samples show LESS THAN 1% CHANGE IN LEAKAGE RESISTANCE after 150 hours in water.
• Dumont moisture-proof capacitors, in all types of radio construction, are being used in radio equipment serving our armed forces and governmental agencies here and over there.
Samples on Request
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folded pipe, and an inertia in the form of an aperture was described by H. F. Olson in a talk on "Polydirectional Microphones." Dr. Olson's paper was primarily a report of progress which has been made in the development of directional microphones within the last few years and up to our entrance into the war. several directional characteristics, of the microphones described have been made possible through the use of improved magnetic materials which made possible a considerable reduction in size with consequent reduction of diffraction effects at high frequency.

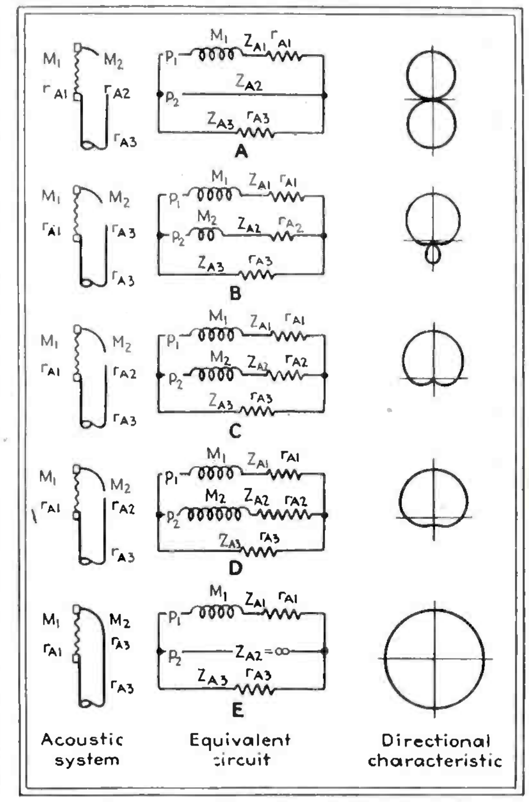
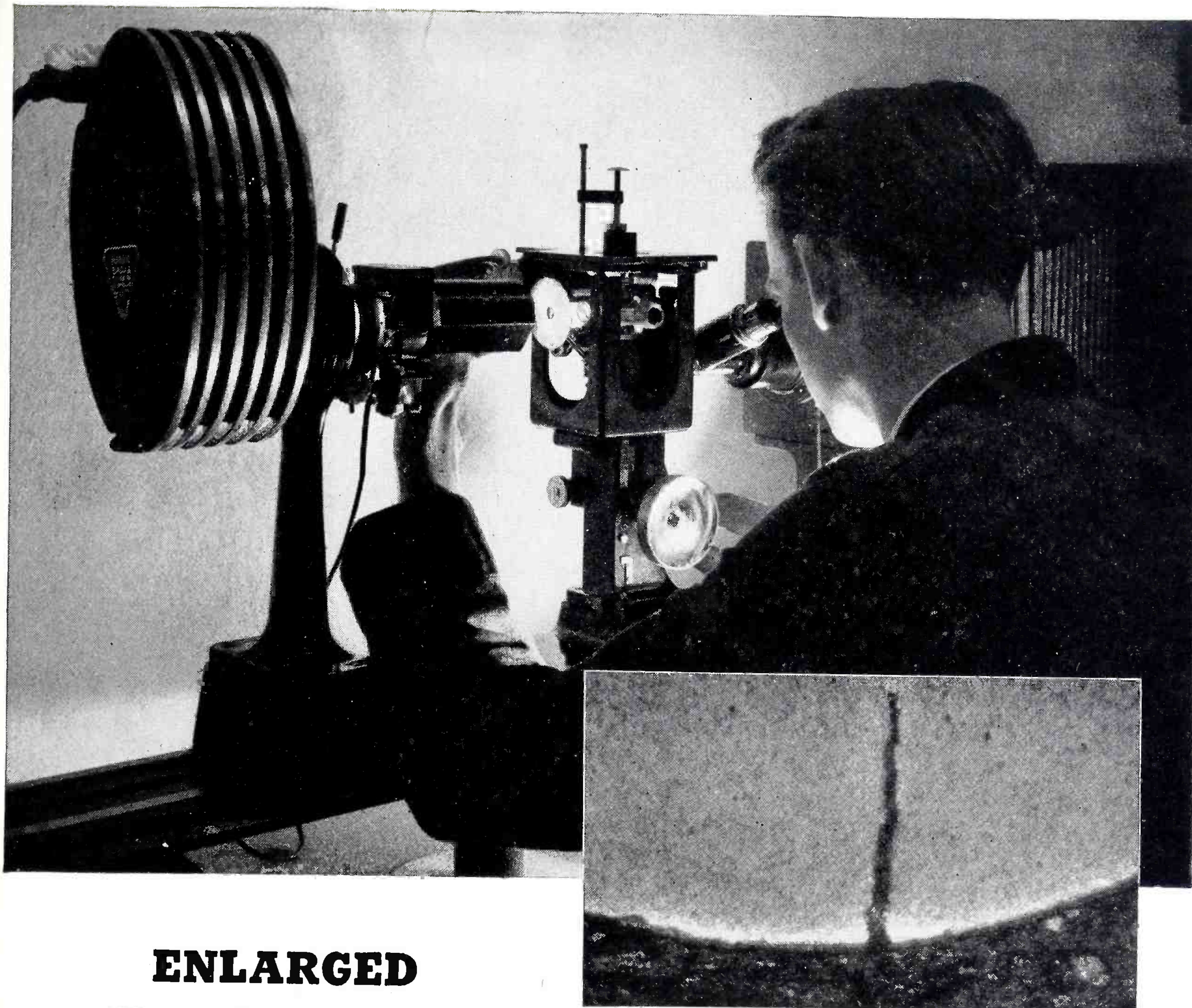


Diagram of directional microphone (left) with equivalent circuit (center) and pattern of directivity (right) discussed by Mr. Olson

The development of the directional microphone was carried out largely through an analysis of the equivalent acoustical circuit, shown for several directional characteristics, on the attached diagram. This procedure illustrates the increasing use of acoustic networks for solving acoustic problems of vibrating systems. From the practical point of view, the advantage of these microphones lies in the fact that a single infinity of directional characteristics, ranging from bidirectional, through all variations of unidirectional to non-directional, may be obtained simply by varying the size of the aperture in the back of the microphone.



ENLARGED 3,000 TIMES TO PREVENT SPRING FAILURE

Spring material must be as near perfect as possible. That's why Muehlhausen engineers use the Metallograph, illustrated above—to detect minute flaws.

Wire used in the Muehlhausen plant must undergo this test. A section of wire is mounted in a plastic mold and then polished. This specimen mount is placed in the Metallograph and photographed under high magnification. The developed print reveals the slightest interior fissure or surface crack.

This is only one of many tests customarily made by Muehlhausen engineers to insure quality in the art of spring making. Check with Muehlhausen on the design of any type spring—compression, extension, torsion or flat—hot or cold formed.

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MUEHLHAUSEN SPRINGS

EVERY TYPE AND SIZE

FREE! SEND FOR INFORMATION

- New Die Spring Bulletin illustrates, describes 206 sizes and types of die springs.
- New Armament Bulletin shows importance of springs for many types of war equipment.

H. W. Leverenz spoke on "Phosphors and the Periodic System of the Elements." By way of introduction it was stated that luminous materials or phosphors, may be classified as fluorescent materials or phosphorous materials. A fluorescent material is one providing an output of radiant energy only so long as it is excited by radiant energy falling upon the luminescent material. As shown in the accompanying illustration the rise and decay characteristics are practically instantaneous with the application and removal of the excitation. On the other hand, phosphorescent materials show a decided lag in the energy output after excitation is applied or removed. This characteristic results in the emission of light from the phosphorous material for several seconds and in some cases even for several minutes after the removal of the ultraviolet light or other excitation. In the demonstration it was shown that whereas ultraviolet light is usually the most effective radiation for exciting luminescent materials, then the effectiveness of the luminous material depends to a large extent upon the wavelength of the incident radiation. This is not the case when luminescent materials are excited by cathode-rays, since such rays excite all frequencies.

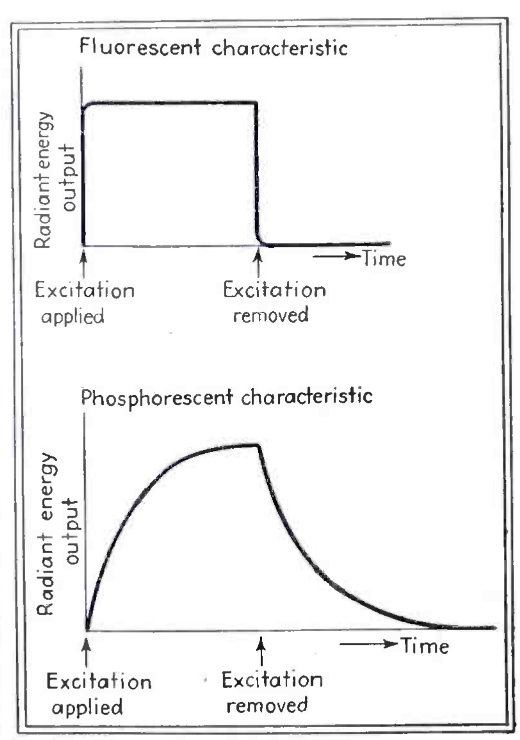
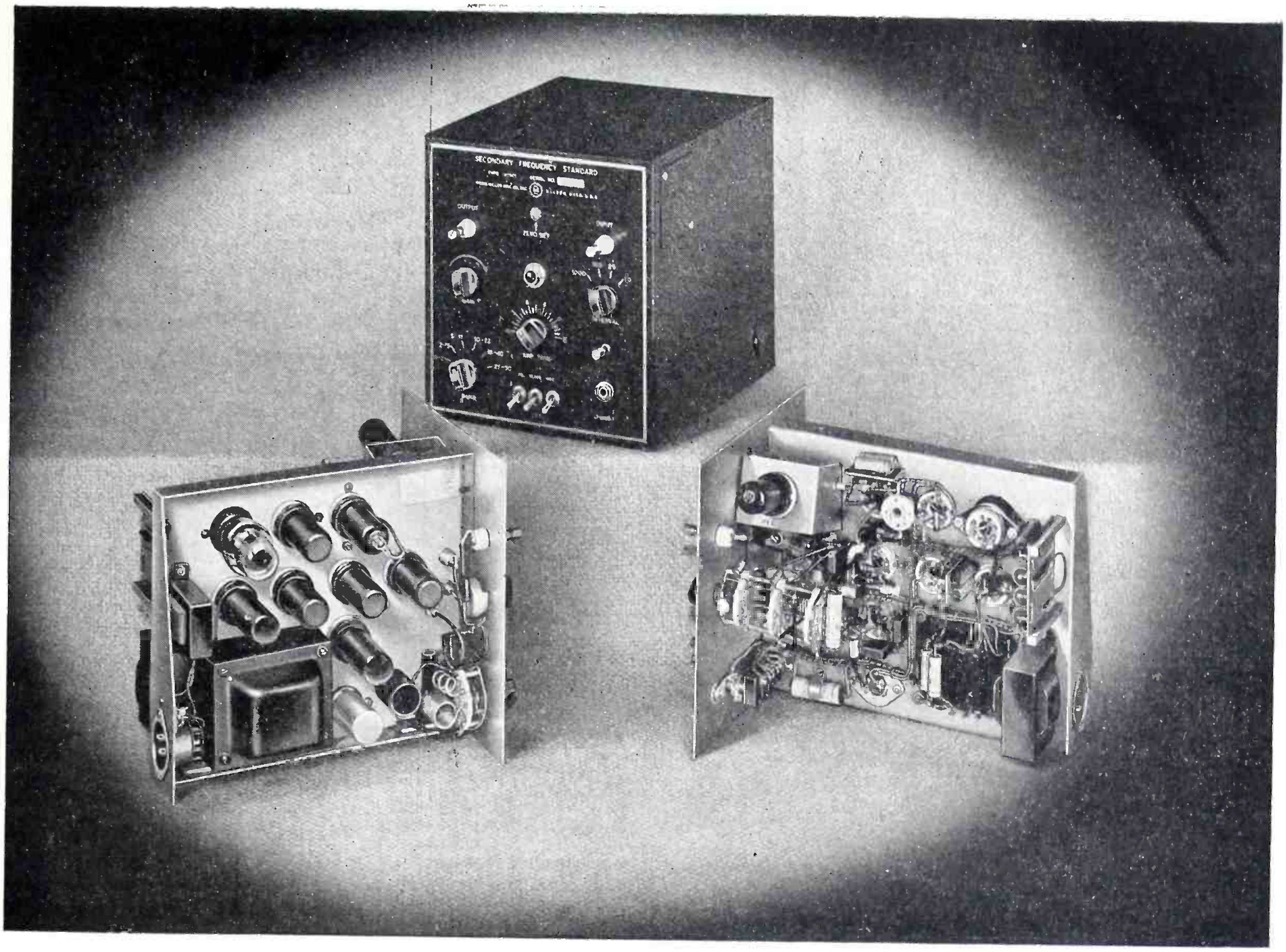


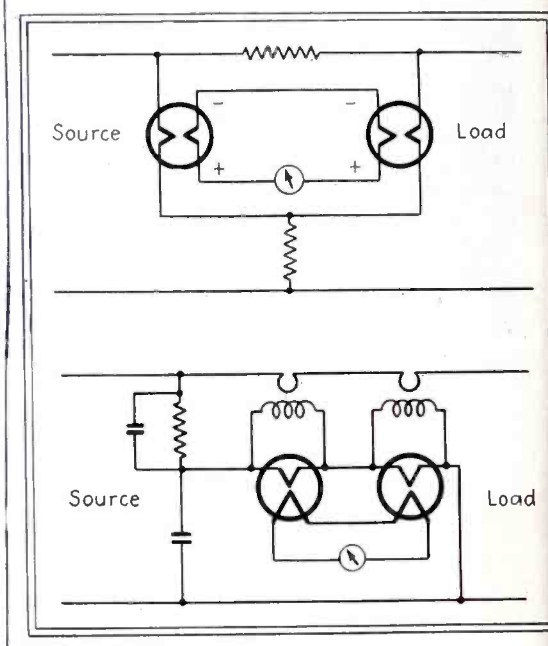
Diagram illustrating the differences between fluorescent materials (above) and phosphorescent materials

It has been suggested that the fluorescent and phosphorescent characteristics of various phosphors


SECONDARY FREQUENCY STANDARD

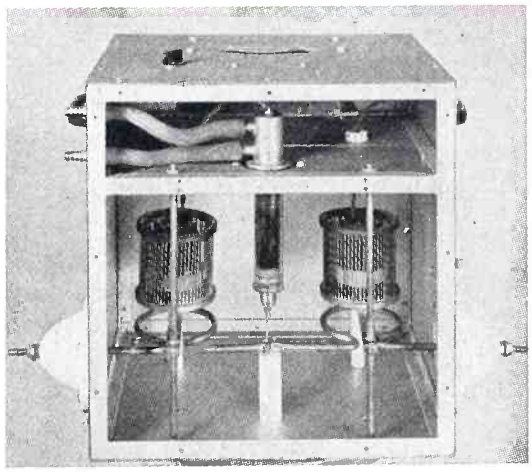
might be related to the composition of the luminescent material. The results of many tests on some seven thousand luminous materials show that this assumption is too naive to warrant substantiation. Undoubtedly, the complex nature of the phosphors, together with the changes in activity resulting from processing conditions are of sufficient importance to mask any effect which may lead to a correlation between a wavelength of maximum radiation of the phosphors and the position of the phosphor materials in the periodic table of the elements.

Certain applications of luminescent materials, not only in television where its application is obvious, but also for obtaining dramatic effects, and as a means of illumination were mentioned.



Schematic diagram of basic circuit for radio frequency wattmeter (above) with improved circuit employed in practice (below)

Not included in the initial announcement of the program was a paper by Brown, Epstein and Peterson, entitled "Direct Reading Wattmeters for Radio Frequencies" and delivered by Dr. G. H. Brown. The wattmeter described uses two thermocouples connected in voltage opposition so that the current read by the microammeter is the difference in current produced by the two thermocouples. The simple circuit shown in the attached diagram suffers from several defects which prevent it from being a commercially satisfactory instrument. The improved and modified circuit is also shown. It will be seen that voltages are induced across the heaters by means of air core transformers



Photograph of the interior construction of the radio frequency wattmeter

rather than by means of a dropping resistor as in the first case. This materially reduces the voltage drop in the meter which is particularly important where high powers are involved.

Instruments using this basic design were illustrated and their use in high frequency broadcasting stations outlined. Wattmeters suitable for operation over a wide range of power factors and from frequencies from 200 to 2,000 kilocycles have been constructed.

Emphasis on Production

Following the business meeting in the afternoon, a number of papers, mostly devoted to production activities, were delivered, although one of these was a broad-gage address dealing with general developments in the communication field.

Lloyd Espenschied, in a paper "Electric Communications—the Past and Present Illuminate the Future," gave a rather unusual historical development and outlook concerning radio communication. It was shown that through the use of modern communication facilities based on the application of the electron tube, limitations of space or distance were greatly diminished. In attempting to hint at some of the possible developments of the future, Mr. Espenschied devoted a considerable portion of his talk to a discussion of the developments, on a frequency basis, of electrical communication during the past century. Manually-operated telegraphy required frequency bands of about 10 cps but this was extended to approximately 2,500 or 3,000 cycles with the invention of the telephone. Vast new frequency bands were opened with the discovery of electric oscillation

of short waves by Hertz which led to the development of commercial radio communication. Whereas the short waves of Hertz were gradually increased in length to lower frequencies, the introduction of carrier telegraphy and telephony increased the frequency range beyond that normally required for telephone service until ultimately the two bands merged or overlapped. Recent extension of frequency utilization into the ultrahigh frequency and microwave region would appear to indicate that by the time the war is over, methods will have been devised to open up for effective utilization, the entire frequency spectrum up to and including visible light. At least it is becoming evident that the frequency spectrum normally used for communication, and in which oscillations are intentionally generated by man-made machines, will converge to that region of the spectrum in which oscillation occurs as a result of the motion of atomic or interatomic elements. What the opening of these vast and frequency bands infers can only be surmised at the present time. Certainly the possibility is open for communication services of a type not now employed.

"Radio Production for the Armed Forces," was the title of a paper prepared by, but read in the absence of, Rear Admiral Stanford C. Hooper. Under the compulsion of war improvements which were long sought by the armed services are being achieved, but the manufacturing processes of radio concerns must be altered to meet the requirements of military equipment and this is achieved through the establishment of suitable specifications. "These new specifications reflect the demand for perfect performance; perfect reception by plane flying at 20,000 feet, battling ice and sleet, as well as the enemy; perfect reception by pitching tanks, hurtling debris and jolting through shell holes in the heat of the African desert; perfect reception for all our mobile equipment, whether it be in the Battle of Midway, the Aleutians, or the green steaming jungles in the Solomons.

"These specifications call for equipment that must stand up with full efficiency under all conditions—tropical and arctic temperatures, rapid changes in altitude, varying humidities, salt spray, hot sun and desert sands. It must be unaffected by the

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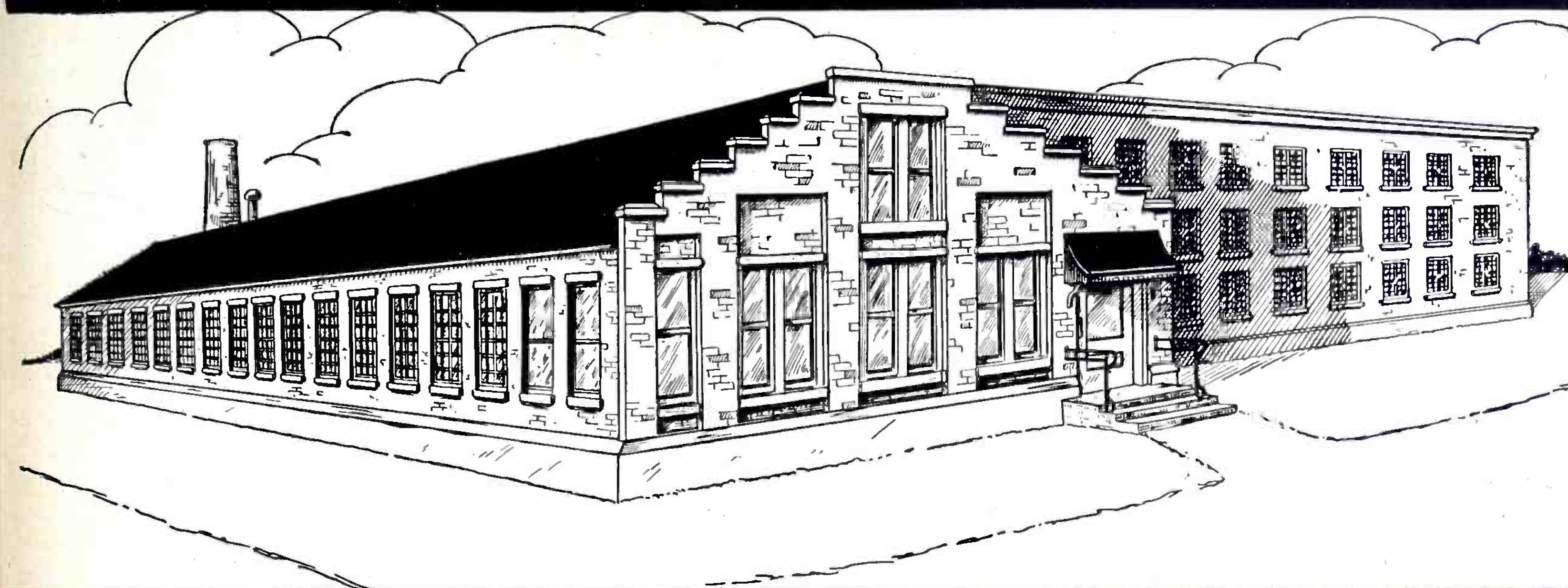
is solving new VOLTAGE CONTROL problems



SECO'S LARGER PLANT OPENED FEBRUARY FIRST

This plant is entirely devoted to engineering, manufacturing and development of...

POWERSTAT VARIABLE TRANSFORMERS

AIR COOLED

STANDARD TYPE POWERSTAT VARIABLE TRANSFORMERS are available in capacities up to 75 KVA for single or polyphase operation on 115, 230 or 440 volt circuits. Where necessary specially designed units can be built to specifications.

OIL COOLED

COMPLETE ENCLOSURE WITH INCREASED KVA CAPACITY is available in oil cooled POWERSTATS. Many wartime applications require these features in single and polyphase types. These units are manufactured for manual operation or motor drive.

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STANDARD AIR COOLED MOTOR DRIVEN POWERSTATS are made in capacities up to 75 KVA for single or polyphase circuits of 115, 230 or 440 volts. Units of this type are ideally suited for continuous and distortionless control of *large amounts of power.* The driving motor is designed for slow speed, eliminating complicated gearing. Applications of these devices range from *push button type control* of voltage and power in electronic, heating, plating and other fields —to *automatic correction* of voltage and power output when the device is actuated from special control circuits.

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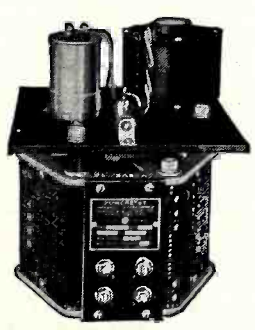

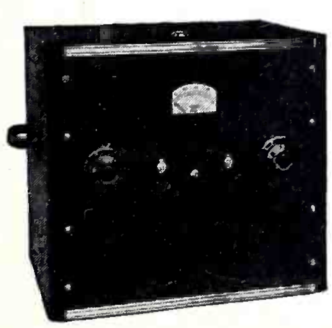

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SECO IMPROVED AUTOMATIC VOLTAGE REGULATORS deliver constant output voltage with variations of applied voltage or load. This design has features of wide range, correction, high efficiency, freedom from mechanical adjustments, zero wave from distortion, low cost per KVA and operation is unaffected by load power factor. Send for bulletin #163.

CRITICAL CIRCUITS, radio, other electronic devices and technical processes REQUIRE a.c. voltage and power control.

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motion of motorized units, ships and aircraft, and the jar and vibration due to gunfire and shell attacks. It must be fireproof, especially from the instantaneous hot flames which follow a bomb explosion, or in proximity to hot metal surfaces. It must be rugged to withstand mishandling and operation by inexperienced personnel, and jars due to handling in transit. It must be designed to compromise ruggedness and extreme sensitivity. It must be capable of being operated adjacent to various other transmitters and receivers in the roar of battle, to electrical and other noises of ships and planes, and radio jamming. The radiation of tubes must not divulge presence to an enemy. It must be flexible in frequency shifting and power variation in order that shifts from one command or information channel to any other may be accomplished as required, and instantaneously. It must be constructed for installation in most limited space, with minimum weight and convenience or operation. It must be instantaneously ready for operation at all times, exactly on the prescribed frequency and accessible for adjustment and quick repair. Danger of accident due to electric shocks to personnel must be prevented. These are but a few examples to show the need of specifications more elaborate than those governing the design of commercial equipment."

Because of the constant shifting of units from one location to another, the standardization of component parts going into military equipment is vitally important. Spare parts from various widely separated shore bases which may be constantly changing, should be available for use in ships, planes, tanks or submarines if required. The variety of spare parts should be kept to a minimum and "special" components should be used only when there is no general-purpose substitute which will meet the requirements.

"The Army-Navy Electronics Production Agency" was the topic of a talk by F. R. Lack, director of this agency. The Army-Navy Electronics Production Agency abbreviated ANEPA has the services of forty-four officers and 900 civilians for the express purpose of expediting production for the armed services. ANEPA is divided into two broad

divisions, production expediting and production control and analysis. Mr. Lack pointed out that troubles are few and far between if all orders are made on time and more than 250 expediters of ANEPA are available for assistance on this problem. The snowballing of orders has also resulted in difficulties in the past and the agency has had as one of its functions the tracing out of such "safe guards".

Ray C. Ellis, WPB spoke on "The Functions of the War Production Board in Radio." A portion of this talk was devoted to a resume of the conditions resulting in the formation of the War Production Board. The following abstract, however, deals in practical terms with the present and future which must be faced by those in the electronic industry.

"For the producer of electronic equipment, the major problem for this year lies in finding the engineer, the chemist, and the key production supervisor in sufficient numbers. It is true that the universities have trimmed their liberal arts courses, and that the youth are learning one or another of the physical sciences. However, while many of these young men are studying Maxwell's equations, while they are observing the ways and foibles of the electron, they are also dreaming of themselves in uniform. How many will come to our laboratories and plants? How many will be permitted to stay?

"In general, then, the problem of war production—in radio as elsewhere—is to keep output in line with the requirements of war. That involves the synchronizing of various kinds of output. It requires that the factors of production, namely, facilities, materials, manpower—be available where needed. The WPB, in cooperation with the armed services, are endeavoring to minimize these problems."

Within the radio division there are three groups to handle the three major problems of war production. There is a Program Group which keeps abreast of the requirements for military electronic equipment. Another group, primarily working with the B-1 component, sees to it that critical materials are delivered at the right time and delivered to the right place. A Resources Group makes certain that equipment and facilities of the industry are adequate to meet the schedules which

have been set. There is a separate group in full charge of the maintenance of our civilian radio equipment. Finally, there is a new "Radio Field Operations Section" working within the WPB Regional Office, which assists the manufacturers and their plants, helping to solve their specific problems outside of Washington.

"An Engineering Advisory Section closely watches the development going on in the laboratories in order that when new devices reach the production stage, there be facilities to undertake the production swiftly; and also that the new designs use the minimum critical materials and components."

The place which standardization is playing in the role of wartime production was outlined in an address "Radio Standards Go to War," by Harold P. Westman, Secretary, War Committee on Radio, American Standards Association. It was pointed out that the aim and function of standards during wartime are quite different from those carried out during times of peace. During peacetime, important standardization may be accomplished on definitions of technical terms, letter and graphical symbols, methods of testing and rating components and equipment, and physical dimensions of equipment.

Wartime standardization must deal primarily with the simplification of practices and the standardization of physical equipment to the aim that the maximum production may be effected. The War Committee on Radio, which is charged with preparing standards for radio components for use in equipment for our armed services, consists of a group of individuals and representatives of the armed services who are skilled in the production processes and requirements for such radio equipment. The drafting of standards is carried out by relatively small groups or committees charged with the responsibility of preparing the proposed standards. Usually a series of drafts are made, each based on criticisms of a previous one. As each draft is completed, it is sent to all known interested groups and individuals with requests for comments. The last draft is circulated in printed form and is made as nearly like the final copy as knowledge at that stage of the work permits.

The following subjects are now on the agenda for standardization:

(a) Components
- Fixed capacitors
- Fixed resistors
- Variable resistors
- Dynamotors
- Tube Sockets
- Crystals and holders
- Vibrators
- Dry batteries

(b) Materials
- Insulating material

(c) Processes
- Soldering metallic surface coatings
- Organic surface coatings

The objective of the foregoing is to produce a series of specifications to provide a range of components suitable for practically all normal designs of radio and electronic equipment for use by the armed services. Additional factors which must be taken into account in any completely successful standardization program include (a) interchangeability of parts among all branches of the armed services, (b) increased production, (c) reduced weight of materials, critical or otherwise, (d) conservation of labor time, and (e) clarity of presentation to avoid unnecessary difficulties between manufacturing and inspection personnel.

Every effort is being made to develop specifications for components which are suitable for operation anywhere on the surface of the earth, below the sea or in the sky above. Any component which is limited to one extreme service as in the arctics or the tropics, presents a serious problem, since such equipment must be earmarked for that particular climate and must be found to be unsatisfactory for replacement use in some other locality.

Of interest to all readers of ELECTRONICS is the final paper of the afternoon session delivered by Kirk Miles, National Roster of Scientific and Specialized Personnel of the War Manpower Commission. The title of Mr. Miles' paper was "The Engineer's Position in the Manpower Program."

Mr. Miles stated that "a number of regulations providing for the deferment of 'necessary men' have been issued by Selective Service. To be classed as a 'necessary man' and thus be eligible for deferment an individual must meet three criteria: (1) He must be engaged in war production or in activities supporting the war effort, (2) he must be in a critical occupation or, in other words, there must be a shortage of personnel of the qualifications and training that if he were removed he could not be replaced, (3) his removal would cause a loss of effectiveness in the activities in which he was engaged."

Through its Military Advisory Section, the National Roster has been giving advice to the Selective Service Board concerning the professional qualifications of its male registrants. If upon consideration of an individual case the Military Advisory Section believes that an individual should be classed as a necessary man, the local draft board is notified of this fact. But this advice is in no way binding upon the local board and serves merely to inform them. The qualifications unit of the National Roster attempts to fill job requests for scientific and specialized personnel that it may receive. It is estimated that since the inception of the Roster some 20,000 to 25,000 positions have been filled in this manner. Although the services of the Roster are available to all, industry has not made as much use of the available service as has the government agencies. It must be understood, however, that with the shortages of skilled personnel, it is by no means possible for the National Roster to be used to find personnel for all jobs which may exist.

Dr. Southworth Speaks on Ultrahigh Frequencies

From many points of view the most interesting address of the I.R.E. Conference was that, held jointly with the American Institute of Electrical Engineers on Thursday evening, at which Dr. George C. Southworth spoke on the subject, "Beyond the Ultra Shorts." In spite of the fact that none of Dr. Southworth's comments revealed any developments subsequent to September, 1939, his able presentation made the subject fascinating to all those who were fortunate enough to attend.

Based on a chart shown on page 157, Dr. Southworth traced the means of developing electromagnetic radiation in various portions of the spectrum from the early works of Hertz throughout the past four or five decades. Progress was rapid from about 1887 to about 1895, after which almost thirty years elapsed before any further significant developments in the generation of short electromagnetic waves was made. While radio physicists were developing generators for shorter and shorter waves, physicists working in the infrared region of the spectrum were developing generators for longer wavelengths until finally about 1923 the spectrum was closed in so far as the physicists were concerned.

But while the physicists may be regarded as the pioneers in developing the need for producing electromagnetic waves of various lengths, the engineers may be regarded as the homesteader since it is its function to occupy and make use of these frequencies. The equipment which the physicists use is not particularly well suited for the engineer's "homesteading activities" and refined apparatus is required. Dr. Southworth traced out the development of continuous wave generating equipment for short waves beginning with the 6 meter oscillator devised about 1916 by W. C. White and extending down to slightly less than 10 centimeters at the time of the European war. In addition to the negative grid oscillator, Barkhausen and magnetron oscillators were also developed and applied in the ultra-short and microwave region.

Another interesting slide shown by Dr. Southworth was one illustrating the transfer of electromagnetic energy from the source to the sink. At commercial power frequencies or even audio frequencies, an ion-core transformer serves the purpose admirably. As the frequency is increased, coupled tuned circuits perform the same function, but with increasing the physical dimensions of the tuned circuits become sufficiently small that ultimately they disappear completely. However, before this stage is reached Lecher wire systems making use of distributed capacitance and inductance may be used to transfer the energy from source to sink. The sending waves on such a wire system may be regarded as representing the impedance of the circuit and hence the analogy to the transformer is complete. As the frequency is still further increased, undesired radiation takes place from the Lecher wires. To eliminate this, one of the conductors may be rotated or generated about the other so that a coaxial transmission line is the next step. As the frequency is still further increased, the inner conductor becomes unnecessary and hollow wave guides (or wave guides with solid dielectric material) becomes practical. To carry out the analogy still farther, Dr. Southworth showed the generation and absorption of visible light by means of an optical system with an ordinary lens acting as the conversion element.

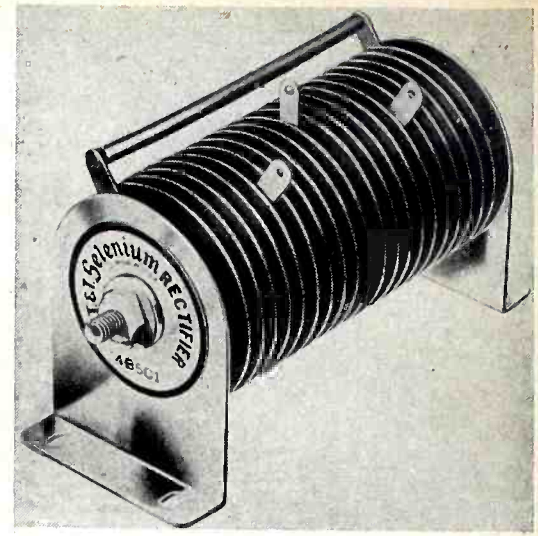
Discussion was also given to the properties and characteristics of hollow wave guides independently and simultaneously developed by Dr. Southworth and by Dr. W. L. Barrow of M.I.T.

In concluding his very interesting address, Dr. Southworth could, of course, only conjecture as to the probable trend of developments. In spite of a lack of new material, even those whose work led them directly into this highly specialized field agree that Dr. Southworth's address was a very lucid and laudable contribution to the complete and thorough understanding of some of the problems "beyond the ultra-shorts."

• • •

ENGINEERS RECEIVE AWARDS

At the meeting of the American Institute of Engineers, held in New York, these three from General Electric Co. were awarded prizes. Left to right, Dr. Geo. W. Dunlap, winner of the Alfred Noble prize; Gerard Swope, president of the company, winner of the Hoover medal; Dr. Willis R. Whitney, first director of the Research Lab., winner of the John Fritz medal. Dr. Dunlap is shown demonstrating the voltage analyzer on which he based his prize-winning paper



possible by a special assembly which lends itself more readily to moisture-proofing. Standard brass contact washers and pressure-limiting fibre washers are not used. Instead, a single metal washer is employed which makes it possible to apply the protective coating to all exposed surfaces.

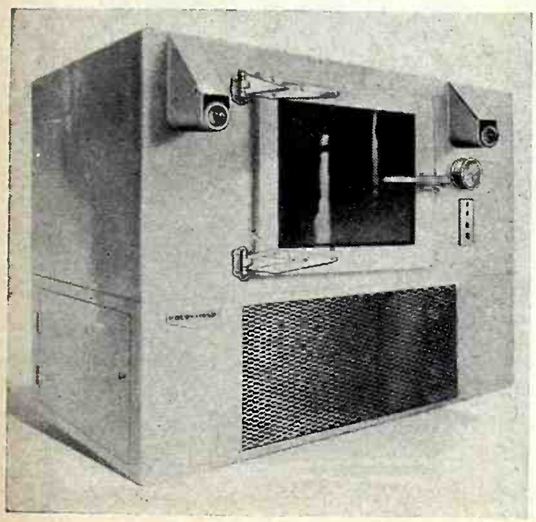
International Telephone and Telegraph Corp., 67 Broad Street, New York, N. Y.

Industrial Sub-Zero Machine

ILLUSTRATED IS basic Model 3600HL (designated as "Hi-Low") machine which is available in three temperature ranges for testing aircraft instruments, batteries, wire, metals and various devices. The machine provides the conditions which are required for testing under certain stringent aircraft inspection and testing specifications.

Temperature ranges available are from −60 deg. F. to +170 deg. F., from −80 deg. F. to +170 deg. F., and from −90 deg. F. to +170 deg. F. In Model 3600HL90 "Hi-Low" machine, for example a temperature drop from ambient of +80 deg. F. to −60 deg. F. can be accomplished in 45 minutes; to −70 deg. F. in 1 hour; to −80 deg. F. in 85 minutes, and to −90 deg. F. in 140 minutes. Also, heating to +170 deg. F. from −90 deg. F. takes 90 minutes; −80 deg. F. takes 85 minutes; −70 deg. F. takes 80 minutes, and from −60 deg. F. takes 75 minutes. The machine itself is entirely self-contained, and requires only a source of electrical power.

Outside dimensions of the "Hi-Low" machine are: height, 84 inches, depth, 52 inches, and length 94 inches. The net clear usable working space is 46×36×36 inches. Constructions inside and out is of 16-gauge steel, welded and chemically treated for paint adhesion. Insulation is 8 inches of Fiberglas in the sides, top and bottom. For the "Hi" side of the machine, strip heaters are located in the air stream for defrosting and rapid heating. For the "Low" side, finned type coils are used. The forced convection air distribution provides a high degree of air circulation in working space for rapid heat transfer. The condensing unit is 4, 7½ or 10 hp, 2-stage, air-cooled, "Freon-12 or 22 inch machine



as specified. Temperature recording and controlling instruments are provided to meet usage requirements. The door as illustrated is standard, though several variations in size and location may be obtained as specified. Interior is lighted by two 40-watt Lumiline lamps, one on each side of the door, and controlled from a switch on the right-hand side of the door.

The Kold-Hold Mfg. Co., Lansing, Mich.

Boundary Protection Equipment

A BALANCED CAPACITANCE-operated alarm device called Browning Signal System is designed for use outdoors on property lines either with or without existing fences. A protective curtain is laid down so that any penetration of this curtain sets off an alarm.

Browning Laboratories, Inc., 750 Main Street, Winchester, Mass.

Black Baking Varnish

SYNTHITE PX-5 BLACK baking varnish is one of the newer polymerizing varnishes which is for use on stationary and revolving units constructed with Class "B" insulating materials. The varnish possesses essential bonding properties which will hold modern types of magnet wire and insulating materials intact under the high centrifugal force developed by high speed unit windings.

Test specimens prepared by the manufacturer under ASTM procedures indicated very high, dry and wet dielectric strengths, and good resistance to water, acids and alkali. Thoroughly dried coatings are oilproof and highly resistant to abrasives and carbon tracking.

John C. Dolph Co., 168 Emmett St., Newark, N. J.

Reactance Slide Rule

A HANDY NEW REACTANCE slide rule is available for electronic and electrical engineers, physicists, radio service men, radio amateurs, teachers and students. It saves time solving resonant frequency problems, capacitive reactance problems, inductive reactance problems, Q problems, etc.

On one side of this slide rule, resonant frequency problems are solved with one setting of the slide, using

$$\omega^2 LC = 1$$

with ranges of 5 cycles to 500 Mc, 0.001 $\mu\mu$f to 1,000 mf, and 0.00001 mh to 10,000 henries.

On the other side of the slide rule, reactance, dissipation factor and coil Q problems are solved with one setting of the slide, using the following formulae:

$$X_C = \frac{1}{2\pi fC}$$
$$X_L = 2\pi fL$$
$$Q = \frac{2\pi fL}{R}$$
$$D = 2\pi fCR$$

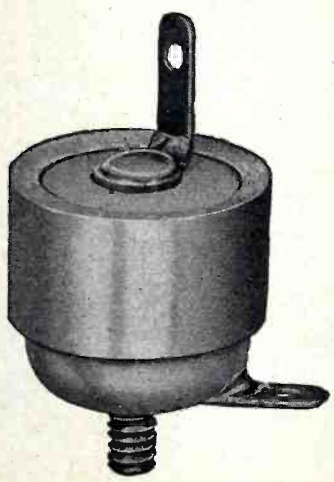
The ranges on this side are 0.1 cycle to 10,000 Mc, 1 $\mu\mu$f to 100 mf, and 0.001 mh to 100 henries.

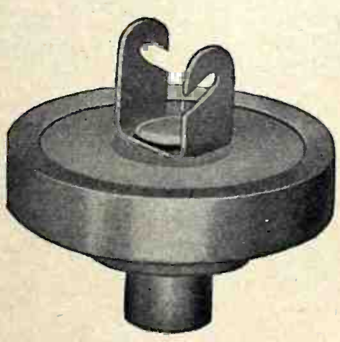
This slide rule is available at a nominal charge of ten cents in coin or stamps to cover the cost of handling and mailing. All inquiries should be addressed to Shure Brothers, 225 West Huron St., Chicago, Ill.

Ceramic Condensers

Two new types of ceramic condensers, called Disc Ceramicons, have been announced. Basic Type 1770 is $\frac{3}{4}$ inch in diameter, and basic Type 170 is $\frac{15}{16}$ inch in diameter. The height of the units varies in accordance to capacity (the maximum height, excluding mounting stud and terminal, is $\frac{3}{4}$ inch). A wide variety of mounting studs and terminals are available. Both types are hermetically sealed to provide protection against humidity.

Type 1770 is rated at 500 volts d-c working, and is available in any standard temperature coefficient from ± 120 (P120) to -750 parts





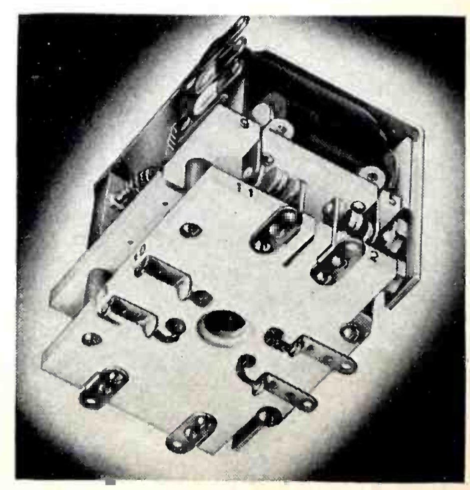
per million per deg. C. (N750). Maximum capacity at zero temperature coefficient (NPO) is 1,000 μ and is approximately 7,000 μ in N750.

Type 170 is rated at 1500 volts, d-c working. Maximum capacity in NPO is 400 μ, and 1750 μ in N750.

The manufacturer states that the design of these condensers is such that their resonant frequency is considerably higher than that of conventional condensers and therefore are especially applicable for ultrahigh frequency applications. Copies of a data sheet showing various styles of available mounting studs and giving electrical characteristics of the Ceramicons can be secured from the manufacturer, Erie Resistor Corp., Erie, Pa.

Keying and Break-In Relay

MODEL AK RELAY is a high speed keying and break-in relay for aircraft radio equipment. It is compactly designed for high voltage, high speed and resistance to vibration. Its push-pull magnetic arrangement provides magnetic holding pressure on both transmit and receive contacts. One pole is equipped with two windings, one of which is a holding winding connected directly across the battery supply. The other winding is connected in series with the single winding on the other pole and polarized so that when the circuit is completed through the key, the flux is neutralized on the hold-



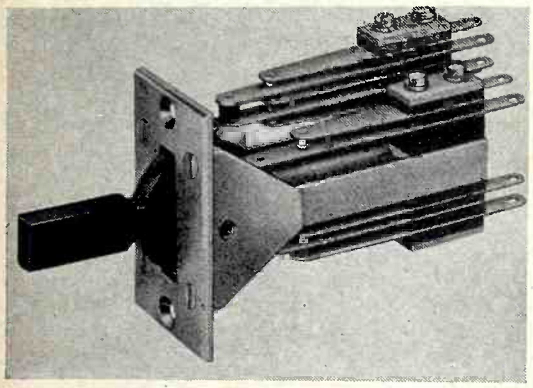
ing or receive position pole and the armature pulls up to the transmit position. Opening the key cuts off the bucking flux and the holding flux pulls the armature back to receive position. The relay is completely balanced.

Other specifications include: Arms which are equipped with anti-bounce features; it is magnetically held in both positions and does not rely on back spring pressure; it keys at 20 cps; its contact rating is 1,000 volts at 30,000 feet, 20 Mc; 4-pole, double-throw; it is insulated to sustain 10,000 volts at sea level; its standard models are in 12 and 24 volts d.c.; its wattage consumption is 5.5 in first position and 17.0 in second position; it withstands vibratory motion to better than 20G.; its dimensions are $2\frac{7}{16} \times 3\frac{1}{2} \times 2\frac{1}{4}$ inches; its weight is 17 ounces.

Allied Control Co., Inc., 227 Fulton St., New York, N. Y.

Lever Switch

MODEL 0-42 LEVER switch is primarily designed for use in aircraft, radio, communications, annunciator and fire alarm systems, testing apparatus, and other industrial applications. It is available in an unlimited series of combinations of contact assemblies. Contacts, pile-ups and lever action are assembled to meet specific requirements. The switch is a rugged, positive action switch, and is light in weight. It has positive action locking, non-



locking (spring return to neutral position) and no-throw stops. A large handle permits a firm grip by a gloved hand. Maximum rating (recommended by the manufacturer) is 5 amps, 110 volts, a-c, non-inductive.

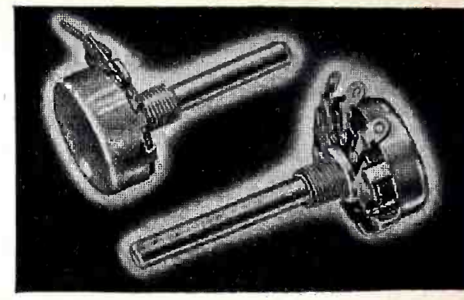
Diagrams and complete information is given in General Data Bulletin No. 82 available from the manufacturer, Donald P. Mossman, Inc., 6133 North Northwest Highway, Chicago, Ill.

Sealed Variable Resistors

TWO NEW CLOSED-COVER, sealed variable resistors, designed to give good performance under humid or dusty conditions, are available for either standard radio or high-frequency equipment.

Type MG resistor is designed for use under conditions of extreme humidity or salt spray, and where internal and external leakage must be held to a minimum. The resistor has a leakage resistance on the order of 300 megohms after 48 hours in 95 percent humidity at 40 deg. C. Spacing of current-carrying parts is greater, and the surface insulation of the molded base is several times that of previous laminated-base units.

Type LP is furnished with a dust-proof cover and is effectively



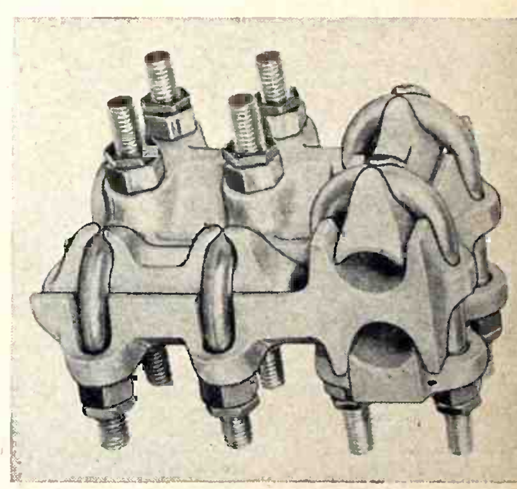
sealed with a special compound to the point where resistivity from current-carrying parts after 48 hours of 95 percent humidity at 40 deg. C. is five times that of the previous open construction units.

Both of the new units have spiral connectors (which give noise-free contact between contacting head and center terminal), as well as a double-fingered element contacting member of special design.

Engineering Bulletin No. 6 describing these variable resistors in greater detail are available from the manufacturer, Stackpole Carbon Co., St. Marys, Pa.

Multiple Cable Connectors

THESE MULTIPLE CABLE connectors have been designed for use wherever cable connectors may be used in place of critical material shortages or to speed up construction work. To provide facilities for connecting and terminating multiple cables, these high compression solderless cable fit-



tings are available in tees, straight connectors, and cable to flat bars, or tubing types. Illustrated is a tee connector for 2-500,000 CM cables on both main and tap. All standard cable sizes can be accommodated up to 1,000,000 CM.

Delta Star Electric Co., Chicago, Ill.

Literature

Story of Conversion. In this twenty-page booklet, the steps that were taken to convert five automotive plants to airplane manufacturing plants, are given. Some 104 General Motors plants are now engaged in war work and are producing tanks, airplanes, airplane engines, Diesel engines, trucks, guns, shell cases and many other war products. Booklet is available from Dept. of Public Relations, General Motors, 1775 Broadway, New York, N. Y.

References on Aluminum. *Aluminum Service Bulletin*, No. 4, October 1, 1942, contains a selection of references on aluminum. They contain the name of the article, the author, publication it appeared in and the date of publication. Several of the references are available upon request, others may be found at technical libraries. Aluminum Company of America, 2195 Gulf Bldg., Pittsburgh, Pa.

Marking Machines. Advanced marking methods are fully described in an illustrated 8-page folder. Marking machines for informative designations on vari-shaped surfaces; designations on flat surfaces and objects and designations by simultaneous indenting and coloring are included. These machines may be used for marking any size, shape or type of material, such as glass, wood, plastic, metal, cloth, paper, painted surfaces, rubber sheets, abrasives, etc. Markem Machine Co., Keene, N. H.

Electrical Contacts Manual. This booklet (32 pages) has been made-up to be helpful to designers of electrical equipment and appliances. Practical notes on design for better contact performance, descriptions of contact metals, alloys and powder metallurgy compositions and a Contact Selector Chart help in the choice of contact material for a given application. Solid and composite rivets, screws, disks with projection backs for welding, plain and solder flushed disks and segments, bimetals and special service contacts are illustrated and listed in convenient catalog form. Fansteel Metallurgical Corp., N. Chicago, Ill.

Melting and Alloying Furnaces. Bulletin No. 500 on magnesium melting, holding and alloying furnaces covers the various types and sizes of furnaces available. The latest furnace added to the line is model MAH with 2000 to 4400 pound capacities in magnesium. Bulletin 500 available from Fisher Furnace Co., 5535 N. Wolcott Ave., Chicago, Ill.

Vacuum Pumps. Faster methods of chucking and handling metals, papers, plastics, wood and other materials is described in a four-page folder. Vacuum pumps, air motors, continuous feed sand blasts and dust collectors are illustrated. Available from Leiman Bros., Inc., Christie St., Newark, N. J.

Sound Devices. The recording of sound for industrial and military purposes is described in this booklet. Details of operation of the different models are included. Described and illustrated are: Type JVC, Type AZ, Type 1K, Type JVD, Type 2VD, Type VA, Type HBK, Type CD and several other models. Available from Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.

Circuit Breakers. Booklet DD-29-060 describes Nofuse "De-ion" circuit breakers. Breakers are available for panelboards, switchboards, built-in applications, individual mountings and separate enclosures. Special attachments are described and pertinent facts on design and operation of each breaker is given. The booklet also explains how to select the circuit breaker best suited for the application. Diagrams with exact dimensions of each breaker are included. Available from Westinghouse Elect. and Mfg. Co., E. Pittsburgh, Pa.

Speed Reducers. Bulletin 22–27, which supersedes 22–25C, describes speed reducers for 1/50 to 10 hp motors and speeds from 0.08 to 1140 rpm. The applications, dimensions, electrical modifications, frame sizes, formulas, mechanical modifications and price list are included in this 100 page bulletin. Available from Janette Mfg. Co., 556–558 W. Monroe St., Chicago, Ill.

Plastics. "Designing Molded Plastics Parts" is a technical booklet intended for product engineers. This booklet is an enlarged edition of an 8-page booklet issued last year. Data is given on inserts, shrinkage, tolerances, wall thickness, holes, undercuts, ribs, bosses, fillets, threads, assembly devices, materials, physical properties, chemical, thermal and electrical properties. Available from General Electric's Plastics Dept., Pittsfield, Mass.

Metal Duplicating. Catalog No. 43-4 describes the Di-Acro system of metal duplicating without dies. An outline of the system is given with illustrations. Di-Acro shear No. 1, 2 and 3, Di-Acro brake No. 1, 2 and 3 Di-Acro bender No. 1 and 2 are described and illustrated. The representative parts made with the above are illustrated. Catalog No. 43-4 available from O'Neil-Irwin Mfg. Co., Minneapolis, Minn.

Metal Bellows. A new thirty-two page book covers the Cook "Spring-Life" metal bellows. The book is printed in two colors, complete with blueprints, examples of bellows now in use and specification form. These metal bellows are constructed of individually fabricated diaphragms which are joined alternately at inside and outside peripheries. The construction, advantages, characteristics, applications, data enabling the correct selection of a bellows are included. Available from Cook Electric Co., Chicago, Ill.

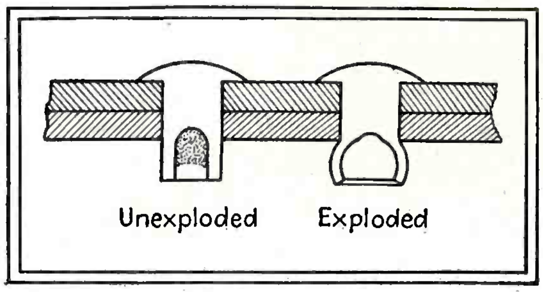
Media for Draftsman. A booklet which describes a new kind of drafting material for engineers. Engineer's-Glass is plate glass on which drawing paper has been cemented. Drawings can be drafted to permanent charts called Engineer's-Transparencies. These transparencies are scratchproof images on plate glass. As many duplicates as desired can be made from the original design. Booklet available from Industrial Engineers Specialties Division, The Universal Engraving & Colorplate Co., Buffalo, N. Y.

TUBES AT WORK

Radio Frequency Heating Tool Fires Explosive Rivets

AN R-F OSCILLATOR capable of firing as many as twenty explosive rivets a minute has been developed by RCA engineers to speed up aircraft assembly. The oscillator is used with a special applicator designed to concentrate radio waves directly in the head of the rivet. The resulting heat due to generation of eddy currents in the rivet is transmitted to the charge of high explosive secreted in a cavity at the end of the rivet shank, firing the explosive and thereby expanding the inaccessible end of the rivet.

The importance of being able to set rivets from outside is evident from the fact that all-metal pursuit planes have as many as 800 fastening points which are accessible only from one side, and the largest bombers have about 10,000 of these points.



Application of the newly developed RCA radio frequency rivet-firing tool to the head of an explosive rivet sets off the charge in a few seconds, expanding the inaccessible end of the rivet

Electronic or "radiothermic" detonation of explosive rivets is proving superior to the use of a soldering-iron type of rivet-firing tool because there is no warm-up time, and the power output control can be adjusted instantly to suit the requirements of different sizes of rivets. Any number of rivets can be put in place ahead of the riveter and held by scotch tape, since this tape does not interfere with r-f heating.

Balancing Machine Checks Rotating Parts in Production

UNBALANCE in rotating parts weighing up to 200 lbs. may be located and measured with the aid of a machine made by the Gisholt Machine Company. This machine, one of several available types, measures pure static and pure dynamic unbalance or the combined effect of both static and dynamic unbalance in two arbitrarily selected planes of correction.

Mechanical Analogy

The operating principle employed by the machine when making measurements in two planes is best described by using a mechanical analogy. Referring to Fig. 1, the part to be balanced is represented as a cylinder which is supported on flexibly mounted bearings *A* and *B* and

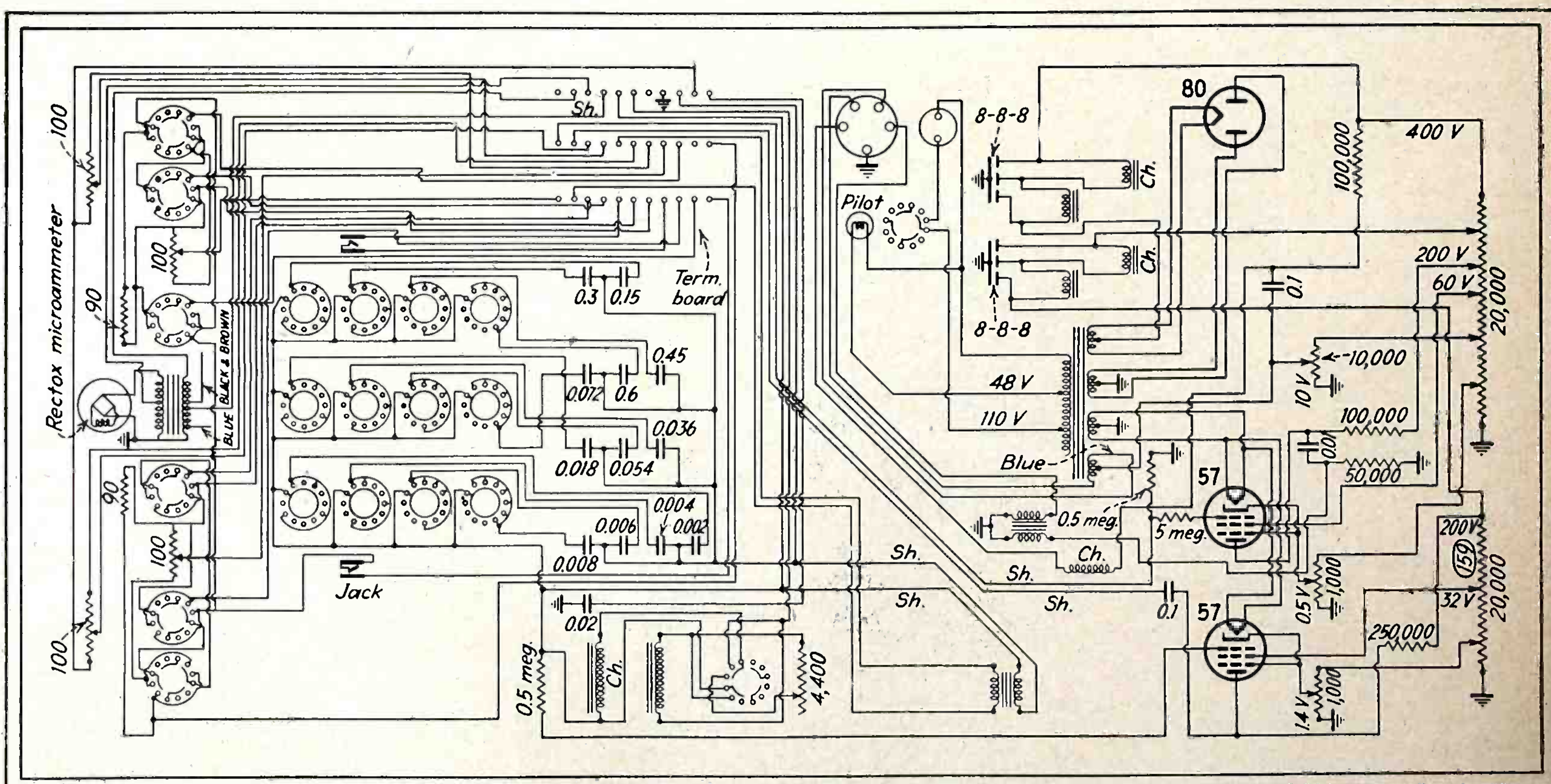
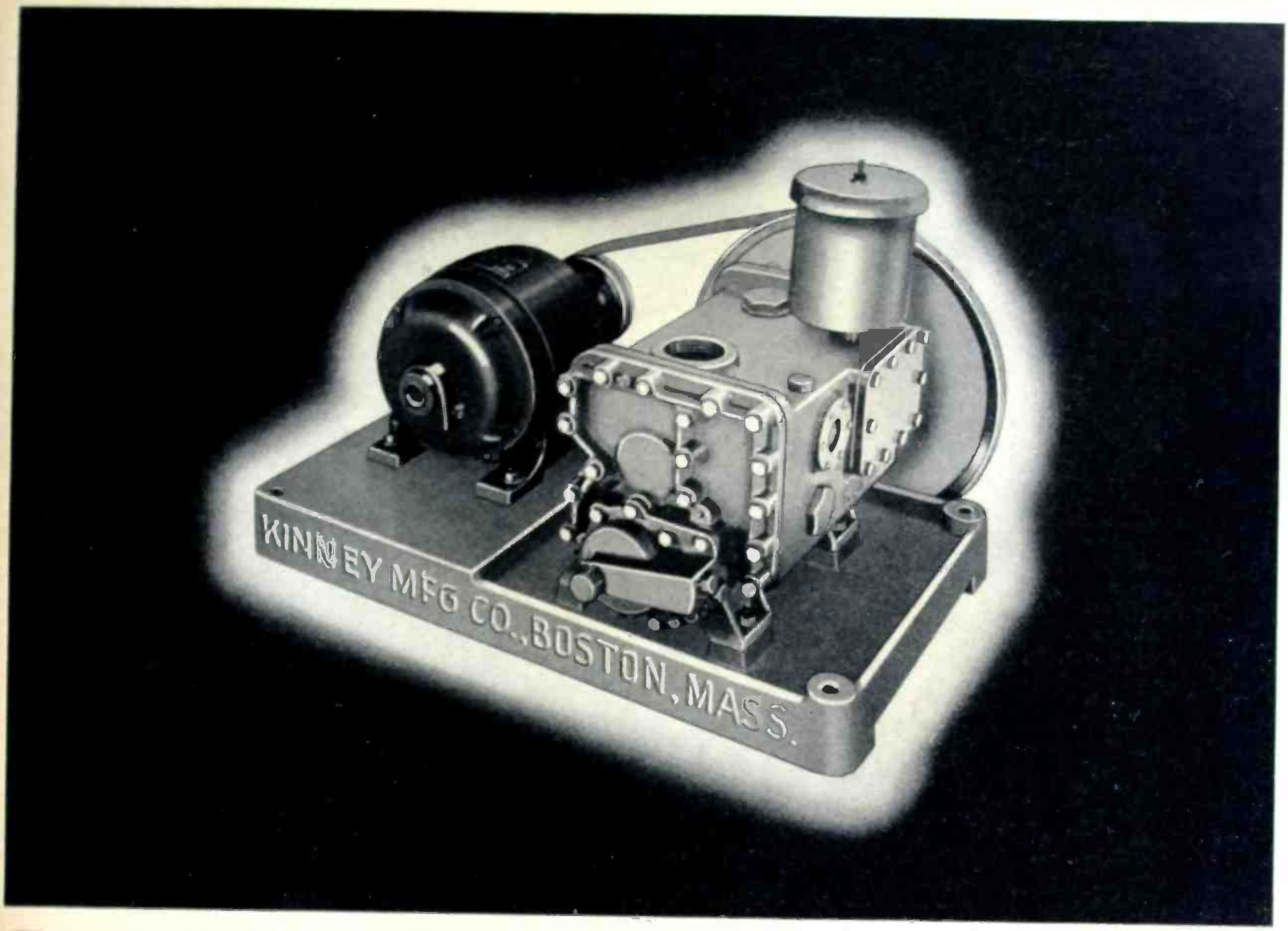


Fig. 4—Detailed circuit diagram of Type S balancing machine whose operating principle is outlined in the accompanying text



The KINNEY Compound Vacuum Pump creates unusually high vacuums

The Kinney Model CVD Compound Vacuum Pump is not a new pump! It was brought out several years ago after extended experimentation and utilizes the working mechanism of the well known Kinney VSD and DVD Vacuum Pumps. To those experienced in the task of creating and maintaining high vacuums with mechanical pumps, the results claimed for this Kinney compound pump were astonishing. Laboratory readings, on an ionization gauge, of 0.5 microns (0.0005 mm.) are regularly obtained and tests have shown readings on the McLeod gauge of better than 0.1 micron.

Users report splendid results

Since first announced, the CVD pumps have been widely used and results in actual service in a wide variety of uses, especially in the lamp and tube field, have been excellent. For many services, the final vacuum produced by these pumps is so high that they have replaced mercury vapor pumps with gratifying results both as to production times and operating expense since cold traps are eliminated and the pumping system simplified.

Will produce high vacuums indefinitely

Because of the absence of mechanical contact between pistons and cylinder surfaces, these pumps maintain their ability to produce extremely low absolute vacuums over long periods without breakdowns or repairs.

Write for this real "tell-all" bulletin

Bulletin 18 contains complete descriptions, capacity and dimension tables, and efficiency curves covering all Kinney High Vacuum Pumps *plus* a valuable section giving formulae for determining correct pump sizes—address any office listed.

KINNEY MANUFACTURING COMPANY
3565 Washington St., Jamaica Plain, Boston, Mass.
BRANCH OFFICES: NEW YORK; 30 Church St. • CHICAGO; 59 E. Van Buren St. LOS ANGELES; 1333 Santa Fe Ave. • PHILADELPHIA; 725 Commercial Trust Bldg. SAN FRANCISCO; 55 New Montgomery St.

SINGLE STAGE • KINNEY HIGH VACUUM PUMPS • COMPOUND

rotated by a motor. The transverse planes 1–1 and 2–2 represent arbitrarily selected planes where corrections may be conveniently made. To correctly measure the unbalance W_1 in plane 1–1 by noting the movement of the supports A and B the portion of movement of these supports caused by unbalance W_2 in plane 2–2 must be eliminated.

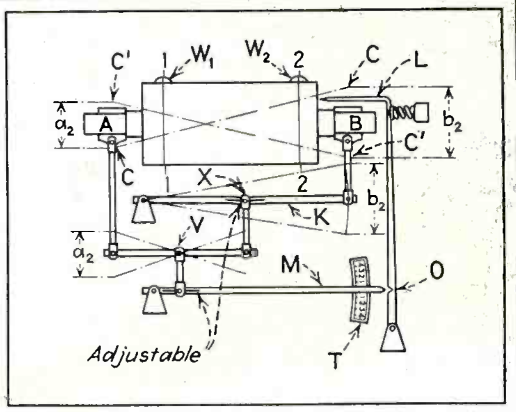


Fig. 1—Mechanical analogy showing method by which Type S Gisholt "Dynetric" machine checks unbalance in two planes and gives independent quantitative data concerning each of the planes

First, assume that the cylinder is balanced. Then insert unbalance W_2 in plane 2. Under rotation, due to the presence of unbalance W_2, the axis of the cylinder will oscillate bebetween lines C–C and C'–C'. The vibration or movement b_2 of support B will be greater than movement a_2 of support A. The vibration or movement of each support will be proportional to the unbalance W_2 and the direction of motion of support A will be opposite to the motion of support B.

Assume that there is a lever K pivoted at one end and attached to support B at the other end so that it will oscillate from the motion of the support. There will then be a point X on lever K which will have the same amount of movement as support A but opposite in direction. The lever V is provided to combine the motion of lever K and support A. One end of the lever V is attached by means of a link to point X on lever K. The other end of lever V is attached by means of a link to support A. Therefore, the ends of lever V have the same amount of motion but in opposite directions. The mid-point of this lever will have no motion even though supports A and B are vibrating due to the effect of unbalance W_2 in plane 2–2.

Now, if an unbalance W_1 is inserted in plane 1–1 there will be a large vibration of support A and of the end of lever V connected to this support. The motion of support B due to unbalance W_1 will be small and the motion of the end of V which is connected through lever K to support B will be extremely small. Therefore, the mid-point of lever V will have a definite amount of motion which will be proportional to the unbalance W_1 and will not be affected by the unbalance W_2. With two such lever systems (one for each end) the exact unbalance in any two selected planes can be accurately determined and the indications for each plane will be true and free from the effect of any unbalance in the other plane.

The motion of the mid-point of lever V is greatly amplified by lever M and the amount of this amplified motion may be read on scale T. This will give an accurate indication of the amount of unbalance W_1 without any influence from the unbalance W_2. As the amount of amplification may be varied by changing the length of lever M, the value of the units on scale T could be adjusted to read in practical correction units.

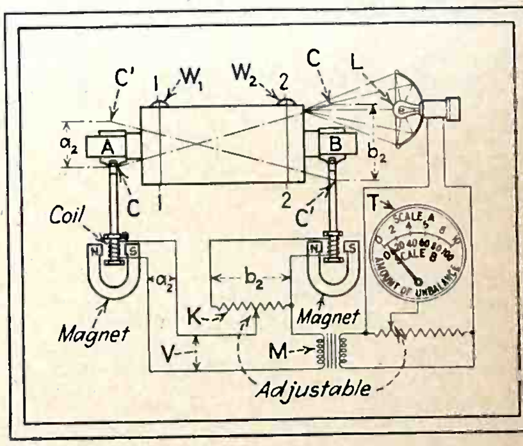


Fig. 2—Elementary circuit of Type S balancing machine, indicating method of employing electronic rather than mechanical components to increase sensitivity and accuracy

The angular location of unbalance W_1 is recorded on the work by means of the centerpunch L, attached to the end of a long, vertical spring-loaded lever which continuously tends to force the center-punch into the work. At the mid-point of the movement of level M its point enters a vee notch O, permitting the center-punch L to strike the work at two points 180 deg. apart and record the exact angular location of unbalance W_1, thus indicating the points where weight is to be added or removed to obtain balance. When the amount of unbalance indicated on scale T is applied in plane 1—1 at the angular indication given by center-punch L the part will be in balance except for unbalance W_2.

Electronic Counterpart

A functional diagram of the electronic means of locating and measuring unbalance is shown at Fig. 2. Here the work-piece is again represented as a cylinder which is carried

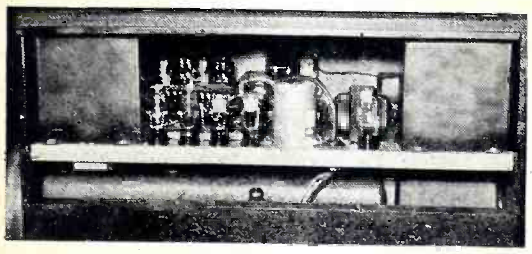


Fig. 3—Photo of back of Type U machine, showing most of the electronic components

in flexible supports at A and B. Attached to supports A and B are coils which are in the fields of permanent magnets. The vibration of the supports due to unbalance causes voltages a_2 and b_2 to be generated in the coils. The voltages thus generated are proportional to the vibrations of supports A and B.

Again assume that the only unbalance in the work-piece is the unbalance W_2. When the work is rotated, the unbalance W_2 will cause a large motion of the support B and will generate a correspondingly large voltage b_2 in the coil connected to support B. The lesser motion of support A will cause a smaller voltage a_2 to be generated at the left-hand coil. By means of the voltage-divider K a portion of b_2 may be chosen which will be equal to a_2 but opposite in value so that the resultant voltage V will be zero due to unbalances of any magnitude in plane 2.

An unbalance W_1 in plane 1 will produce large motion of support A, correspondingly large voltage a_2, small motion of support B and small voltage b_2. Now, if the voltage a_2 and a small part of the voltage b_2 is added, there will be a definite voltage V due to unbalance W_1 with no effect from unbalance W_2. This voltage V may be amplified in the Type S machine as much as 1,600,000 times by electronic means at M. The resulting voltage, or any desired portion of it, is applied to an "amount" meter which indicates the amount of unbalance in the work. The amplication used is determined by practical requirements. The meter reading may indicate, for example, the depth in $\frac{1}{64}$ in. units for a given size of drill, or the number of $\frac{1}{32}$ in. lengths of $\frac{1}{8}$ in. diameter solder, required for balancing the rotating part under test.

The angular location of unbalance W_1 is determined by means of Stroboglow lamp L. This lamp is caused to flash for ten millionths of a second each time the voltage generated in the pickup coils changes polarity. The flashing of the lamp at each revolution of the work-piece causes one point on the periphery of the work-piece to apparently stand still. If numerals are placed on the work-piece the numeral which apparently stands still due to stroboscopic effect may be made to indicate the angular rotation of the unbalance correction.

Fig. 3 is a photograph of the back of one of the Gisholt balancing machines (Type U), showing most of the strictly electronic components.

• • •

Speedy Analyzer Checks Wiring in Republic's "Thunderbolt"

PRECIOUS MINUTES are being saved in testing wiring and electrical equipment in the powerful Thunderbolt high-altitude pursuit plane through use of an electrical aircraft analyzer. This instrument, designed by Republic Aviation Corp. engineers and described in the *Ohmite News*, makes it possible to determine the exact location of a wiring error in the plane, and also permits adjustments of electrical equipment prior to final assembly. Missing circuits or loads are duplicated by means of a voltage control arrangement which can be varied from 0 to 50 volts and can deliver up to 50 amps. The analyzer operates from 120-volt a-c lines, and is mounted on a roller cabinet for portability.

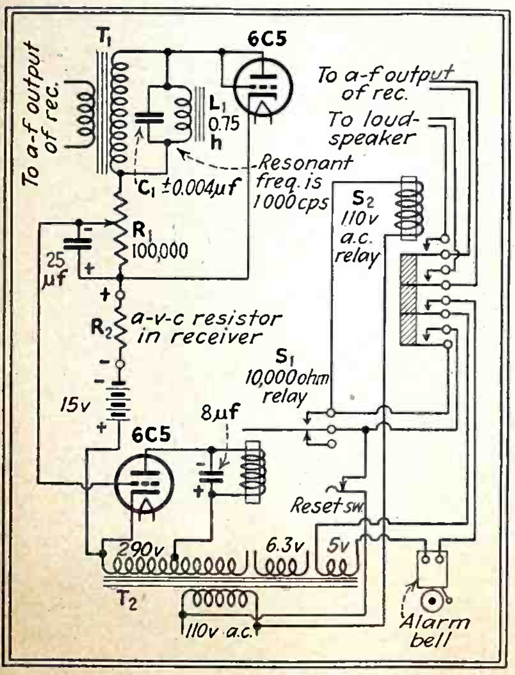
Simplified Carrier-Failure and Tone Alarm System

By JOSEPH HEROLD

Radio Station WOW

THIS TWO-TUBE alarm system for broadcast stations will cause an alarm bell to sound if the carrier is cut off for any reason or if the standard 1000-cycle alarm tone is received.

The entire system can be built from common radio parts which are usually at hand in any broadcast station. It requires connections to only two points in the monitor receiver at the station. One set of connections is made across the a-v-c resistor in



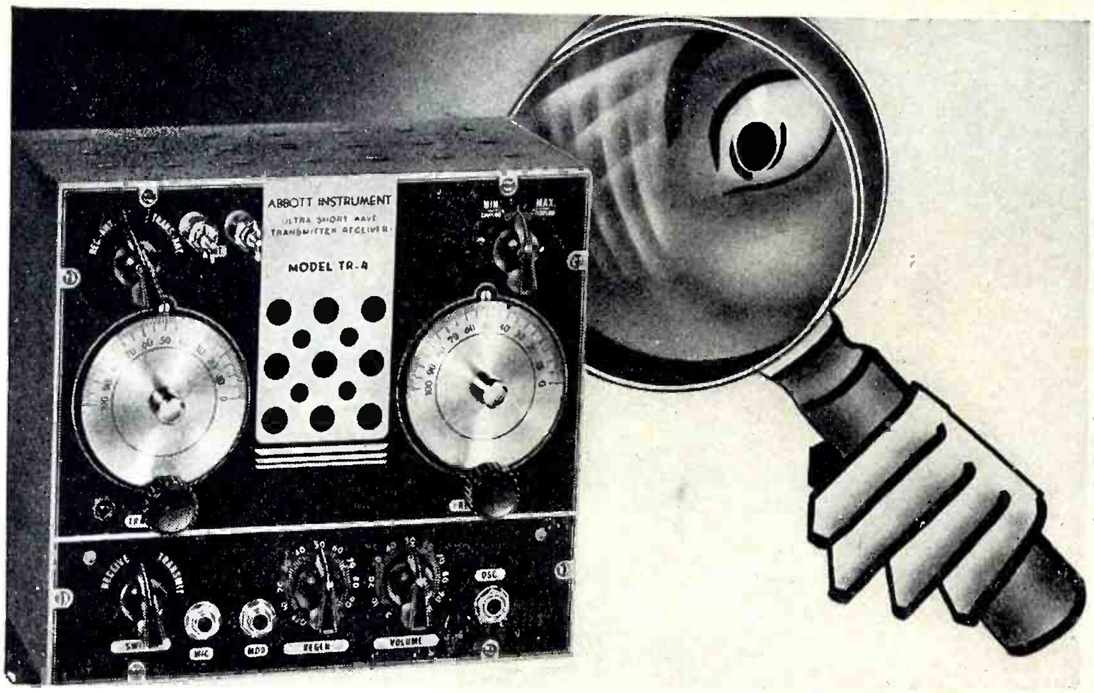
Complete circuit diagram for a carrier-failure and tone alarm system suitable for use at broadcast stations

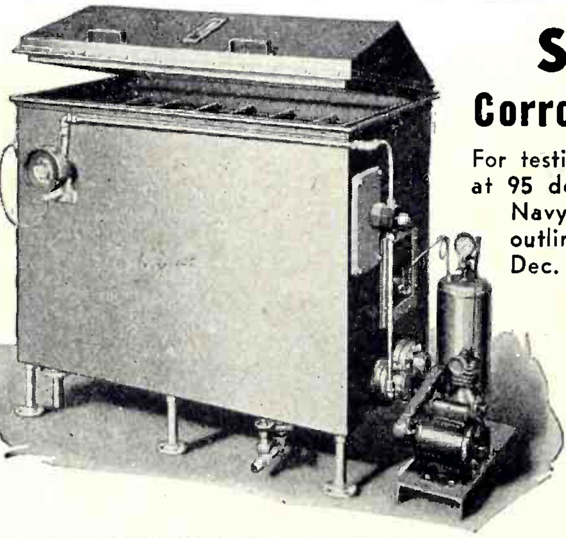
the receiver, and the other is made to the a-f output of the receiver, as shown in the circuit diagram. When the alarm is set off for any reason, the loudspeaker is automatically connected to the output of the receiver for aural monitoring until such time as the alarm system is reset by means of the reset switch.

The alarm bell circuit is closed by relay S_2 when relay S_1 releases. Relay S_1 is energized by the plate current of the lower 6C5 tube in the diagram, and this current in turn is determined by the net C bias voltage of the tube. Three distinct voltages in series determine the C bias:

(1) A fixed d-c voltage of 15 volts obtained from a C battery, making the grid negative with respect to the cathode.

(2) The d-c voltage across the a.v.c. resistor (R_2) in the monitor





receiver, utilized in such a way that it opposes the C battery voltage. When the carrier signal is present, the resulting voltage across R_1 lowers the net C bias voltage, allowing enough plate current to flow through relay S_1 to energize this relay and keep the alarm circuit open. Conversely, failure of the carrier opens relay S_1 and closes the alarm circuit.

(3) The d-c voltage across the lower portion of potentiometer R_1, utilized in such a way that it aids the C battery voltage. When a 1000-cycle tone signal is received, it is rectified by the upper 6C5 tube acting as a diode detector, producing a d-c voltage across R_1. This voltage aids the C battery voltage, increasing the net C bias and lowering the plate current of the lower tube, so that arrival of the 1000-cycle tone releases relay S_1 and sets off the alarm.

Parallel resonant circuit L_1-C_1 is tuned to 1000 cycles, and hence this stage accepts only this one frequency. A 25 μf electrolytic condenser across the lower portion of R_1 provides a time delay of about 5 seconds at this frequency, thus preventing strong 1000-cycle components in a program from setting off the alarm.

The parallel resonant circuit should be tuned quite accurately. This can be done by connecting a d.c. voltmeter across R_1, feeding a 1000-cycle tone to the input of the upper 6C5 stage, and adjusting the value of C_1 above and below 0.004 μf with small mica condensers until a maximum voltmeter reading is obtained.

An ordinary plate-to-grid audio transformer is used for T_1, and T_2 is a standard replacement power transformer providing the indicated voltages.

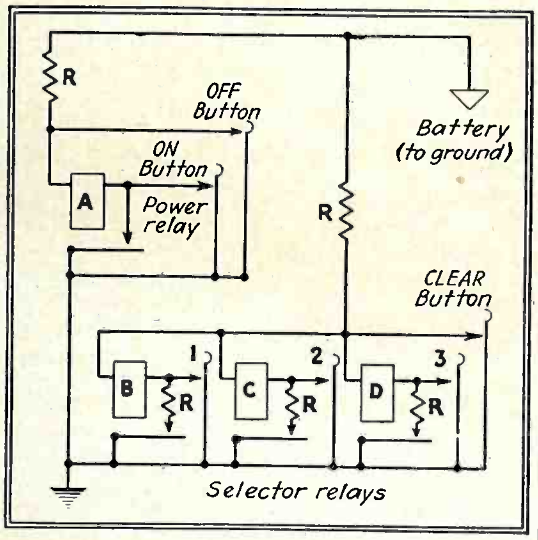
Relay S_1 can have a coil resistance of about 10,000 ohms, and should operate on a change of about 0.003 amp. Relay S_2 is a 110-volt a-c unit having a four-pole, single-throw contact arrangement.

Adjustment of the system is simple. With a carrier signal present and with the system connected to the receiver as shown in the diagram, turn up control R_1 until the alarm is set off by program peaks. Now lower the setting of this control a small amount and press the reset button, repeating the procedure until the alarm is no longer set off by program peaks.

Resistance Network Provides Interlock for Simple Relays

By JOHN H. MILLER

THE SIMPLE INTERLOCK circuit to be described has been used for some years in a pushbutton-operated remote receiver located in the basement of the writer's home. Only conventional d-c relays are needed, as interlock is obtained through the use of a resistance network.



Circuit arrangement for a remotely-controlled pushbutton tuning system which utilizes electrical interlock through resistors instead of conventional mechanical interlock

The diagram is shown above. When the ON button is pressed, power relay *A* picks up. The holding contact then keeps it closed, and other contacts on the relay (not shown) apply power to the receiver. Pressing the OFF button short-circuits the relay and releases the armature, thus turning off the receiver, and a resistor in the battery circuit limits battery current to a safe value during this operation.

After the power circuit of the receiver is closed by pressing the ON button, the button for the desired station is momentarily pressed. Assuming button 2 is chosen, it energizes relay *C*. The resistance in the holding circuit of this relay is low enough to keep the relay closed after the button is released. Other contacts on this relay (not shown) connect the correct padders across the tuning condensers for reception of the desired station.

If another station-selecting button is now pressed, such as button 3, the battery current will initially divide between relays *C* and *D*, with more current flowing through the newly-selected relay *D* since there is as yet no resistance in its circuit. The current through relay *C* and its holding-circuit resistor is lowered sufficiently for this relay to drop out. The holding circuit of relay *D* takes over after button 3 is released, and the new station is thus selected without any need for manual interlock.

The release of one station-selecting relay concurrently with selection of the next can best be explained by using actual values. Assume the resistance of each relay coil to be 10 ohms, assume that each resistor *R* in the network is 10 ohms, and assume that the battery or other voltage source provides 6 volts. Now, when button 2 is pressed, 0.3 amp flows through relay coil *C* and battery circuit resistor *R* initially. When the button is released, this current drops to 0.2 amp due to insertion of the holding resistor in the circuit, but this current is sufficient to keep relay *C* closed.

When button 3 is now pressed, 0.24 amp flows through relay *D* and pulls it up, while the current through relay *C* drops to 0.12 amp and it consequently drops out.

Under these conditions, the selector relays must be able to pick up on a current of 0.24 amp, must hold for 0.2 amp, and must drop out on 0.12 amp. This apparently is not a difficult specification to fill. If a lower drop-out current value must be used, the resistor values can be increased. The 10-ohm values mentioned above are those actually used in the installation mentioned.

The CLEAR button is provided to short out the last selector relay and deenergize it when the receiver is turned off. It should be pressed when the OFF button is pressed, for otherwise current would be drawn by one selector relay when the receiver is not in use.

Instead of a battery, the writer used an ordinary bell-ringing transformer acting through a small copper-oxide rectifier of the type found in trickle chargers. This permitted the use of ordinary d-c relays without attendant battery replacement problems.

The only difficulty encountered in several years of operation was dust in the padder contacts of the relays, causing noise in the receiver. Cleaning and adjusting of contacts about twice a year has proved sufficient.

(See opposite page)

NEW BOOKS

Radio Goes to War

By CHARLES J. ROLO, *G. P. Putnam's Sons, New York, 1942, 293 pages, price $2.75.*

TECHNICIANS IN ELECTRONICS are well acquainted with the military use of radio in the field, on ships and in planes. However, one very effective use of radio as an offensive weapon usually receives little or no attention. This use is on the propaganda front. This is the subject of Mr. Rolo's well-written book.

In twenty-three interesting chapters he tells how the enemy is using radio propaganda, how we have come to realize its importance, and hoy we are retaliating in kind. The reader is taken on a tour of the air waves to the various propaganda centers where "bombs for the mind" are being prepared and launched every day and every hour. The technique, (so potent in well-trained hands, as is exemplified by the collapse of propaganda ridden France) is explained and many interesting cases are cited.

Radio as a propaganda weapon is gaining in importance every day. This book tells how and why. It is heartily recommended. Mr. Rolo's informal style makes interesting reading. The chapter on secret radio stations is especially good.—E.E.G.

• • •

The Electrical Fundamentals of Communication

BY A. L. ALBERT, Professor of Com*munication Engineering, Oregon State College. McGraw-Hill Book Company, New York. 550 pages. Price $3.50.*

IT WOULD BE DIFFICULT to define the scope and classify this volume more aptly than the author has done in its preface from which the following quotation is taken:

"The title of this book, 'The Electrical Fundamentals of Communication,' defines its scope. It presents the electrical fundamentals upon which communication, including the three divisions, telegraphy, telephony and radio with its allied branches, is based.

"The book is designed for the student of communication and the worker in the communication industry. It considers electrical phenomena, using explanations and illustrations taken from the communication industry itself. In this respect it differs from other books on electrical fundamentals which include explanations and illustrations largely drawn from the power industry."

The book may be classified as an elementary text in the sense that the

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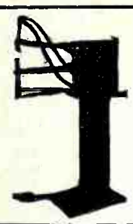

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fundamentals of electrical communication are largely descriptive. Indeed, every high-school graduate with an acquaintance of trigonometry and algebra should have no difficulty with the text. Thus, it would appear that this volume is admirably suited to the needs of many persons who are required to acquire an understanding of the principles of communication under the present training program. Nevertheless, the text is as rigorous as such a treatment permits. The directness with which each topic is attacked, the clarity with which electrical fundamentals are elucidated, and the pleasant reading of the text are attributable to the author's experience as a technical writer and teacher.

To this reviewer it appears that the complete elimination of hydraulic and mechanical analyses to represent electrical concepts is a distinct step forward. "The reader is presented the facts in electrical language and will learn them correctly the first time, instead of being obliged to study vague and inadequate analyses taken from other fields." Another commendable feature of this volume is the successful and straight-forward explanation of the difference between the direction of flow of an electric current in the conventional manner and that based on the electron theory.

The sixteen chapters provide a well-balanced outline of electrical theory and principle. Throughout, emphasis has been placed on an understanding of the essential concepts involved and the glitter and tinsel of that phase of "practicality" which so easily leads the student to believe that he has a greater understanding of electrical fundamentals than is actually the case, is conspicuous by its absence. There are no diagrams of complete telephone systems, or radio receivers, or public address systems which the reader can construct from parts purchased at the local radio supply house. But one who has conscientiously read and studied this volume cannot but help having a good insight into the electrical fundamentals of communication.

In physical make-up the volume is well done. The author has provided a summary of each chapter which outlines the highlights. This should prove useful to the student who desires to make a quick review of material he has studied. At the same time each chapter is provided with a number of review questions requiring written answers of the discussion type. In addition, a number of problems, without answers, are provided by which the student can check, through numerical computation, his understanding of the quantitative relationships covered in the various chapters.

In brief, Professor Albert's latest volume (and incidentally his first under the McGraw-Hill imprint) can be regarded as an excellent example of an understandable writing on a technical subject. The volume shows all the indications of being a satisfactory book for classroom use or for self instruction.—B.D.

Index to Advertisers

The Radio Amateur's Handbook

American Radio Relay League. 20th edition. 478 pages, plus 103-page catalog. Price $1.00, paper cover.

FOR A GOOD many years, the Radio Amateur's Handbook has represented an exceedingly good value as a text on elementary principles and the construction of communication equipment for amateurs and others engaged in high frequency radio communication. The 20th edition, weighing slightly more than 2 pounds, carries on the tradition of value.

The present edition continues the grouping of subjects which was put into effect last year, namely, the discussion of the elementary principles of radio communication in the first seven chapters of the book, with material on the construction and adjustment of receiving and transmitting equipment in the remaining chapters. With this arrangement, those who may desire to use the volume as elementary instruction in radio principles will find the first ten chapters exceedingly useful. At the same time those who may be required to construct, service, and operate the equipment will find the chapters in the section "Construction and Data" of value.

In general the type of treatment follows that of former editions. The section "Principles and Design" is intended to give the reader a good working knowledge of the fundamental principles of electricity and radio which may be required of operators and maintenance personnel. It does not provide an adequate foundation for a comprehensive understanding of radio theory, but it is not intended to do this. Instead, the Handbook has always aimed to present "an understandable non-mathematical treatment for busy, practical people of average education." As such it is eminently successful as is proven by the fact that the Handbook has found extensive use in the training of many men now in the armed services.

A new chapter in the 20th edition is No. XVI dealing with "The War Emergency Radio Service," under the Office of Civilian Defense, and utilizing the 112-116 megacycle band. This chapter deals with an outline of the emergency radio service system, the equipment which may be employed and describes a number of transmitters, receivers, and combined units for communication operation in high frequency bands. In addition, regulations governing all radio stations in the War Emergency Radio Service are included. In all approximately fifty pages are devoted to this new phase of radio communication.

Certainly anyone desirous of obtaining good practical information on the elements of radio communication, or the practical aspects of construction and design of equipment for use at high frequency, will be well rewarded in the ownership of one of the A.R.R.L. Handbooks.—B.D.

• • •

Bibliography on Educational Broadcasting

By ISABELLA M. COOPER. *University of Chicago Press. 1942. 576 pages. Price $5.00. Offset. Format, 8½x11 inches.*

MADE UP FROM A LARGE collection of material (books, pamphlets, periodicals) gathered during the nine years of the existence of the National Advisory Council on Radio in Education, plus some outside material, this volume is really a History of broadcasting from the earliest days. The aim of the compiler was to furnish a bibliography of practical utility giving access to reference and research material in the historical, technical and educational fields of broadcasting with particular application of this art to instruction.

Each item is listed by author, title of article or book, brief contents, where published and when, and then the compiler has added her own version of what the article or book contains. The 1800 selected items cover such matters as broadcasting of news, political implications, television, audience reaction, religion, program recordings, public health and many other general groupings.

A most useful bibliography of the non-technical phases of broadcasting. —K. H.