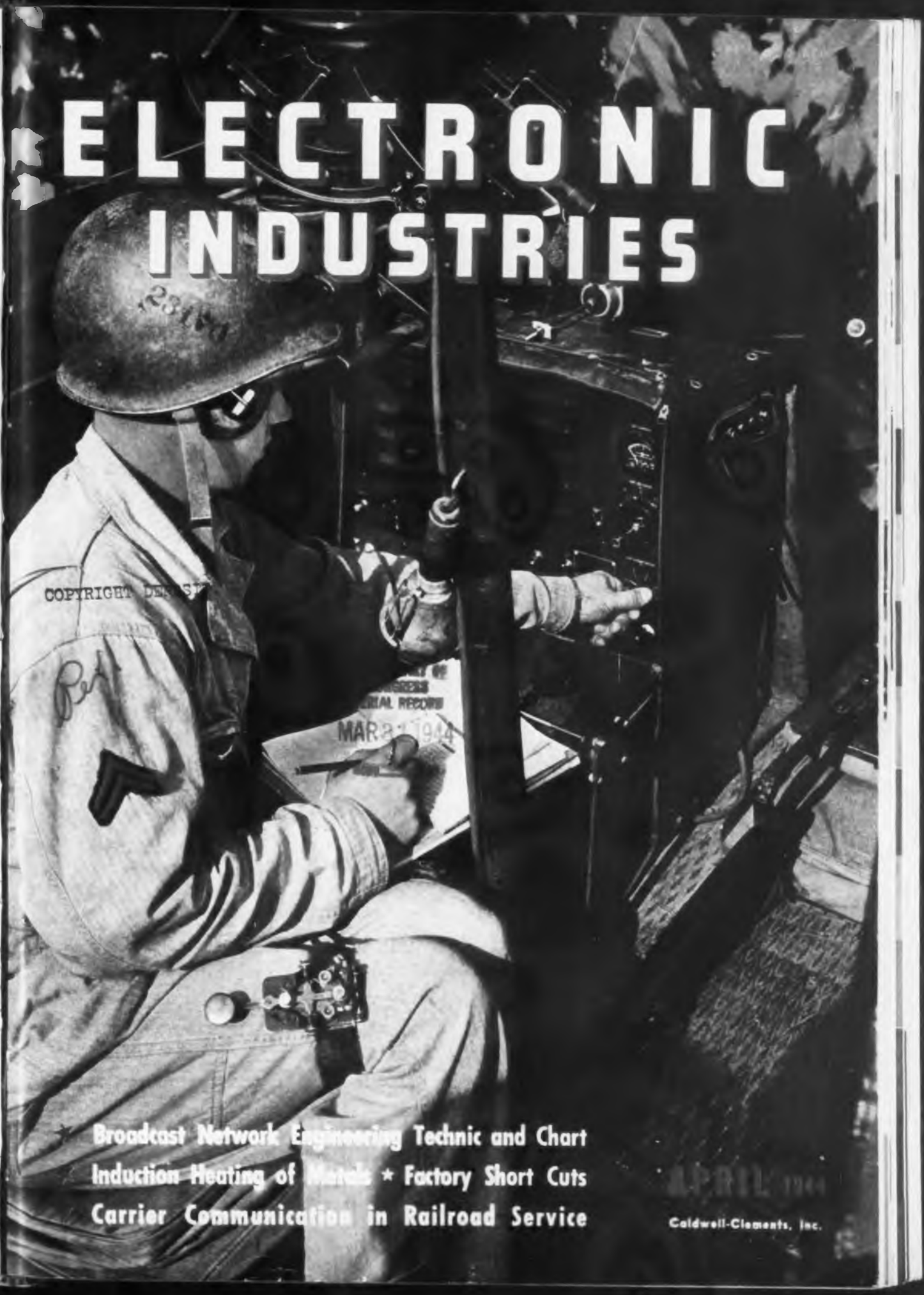
ELECTRONIC
INDUSTRIES
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MAR
1944
Broadcast Network Engineering Technic and Chart
Induction Heating of Metals ★ Factory Short Cuts
Carrier Communication in Railroad Service
APRIL
Caldwell-Clements, Inc.

MAY 31 1944

Trial by Jury . . .

P. R. MALLORY & CO. Inc.
MALLORY
FP* CAPACITOR

*Trademark Registered
Capacitor Design Patent No. 122,024

BEFORE an FP Capacitor leaves the Mallory plant, it goes through a series of inspection tests as gruelling as a jury trial. No capacitor is presumed to be innocent of defects until it is conclusively proved *not guilty*. By the time it reaches the end of the production line, it is either demonstrably perfect—or rejected.

Yet, even under this exacting system, few FP Capacitors fail to measure up. Thanks to a rigid control of raw materials, and thanks especially to standardization of parts, FP Capacitors are *right* in entirety because they're *right* in small details. This standardization is largely responsible for the small amount of rejects. It also makes for speedier production, resulting in improved performance and lower costs to the customer.

The FP Capacitor, of course, is only one of a number of condensers designed with typical Mallory skill, and checked with care, to perform outstandingly well. For specifications and complete data, send for the Mallory Catalog. Unusual application problems can be solved by writing direct. All Capacitors are available through Mallory distributors.

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

P.R. MALLORY & CO. Inc.
MALLORY
ELECTROLYTIC,
FILM AND PAPER
CAPACITORS

Keep Faith with the Men Who Fight — Buy War Bonds

ELECTRONIC INDUSTRIES

including INDUSTRIAL ELECTRONICS

★ IN THIS ISSUE APRIL, 1944 ★

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Electronic Industries, April, 1944. Vol. III, No. 4. Regular price per copy 35 cents. Published monthly by Caldwell-Clements, Inc., 480 Lexington Avenue, New York, N. Y. M. Clements, President; Orestes H. Caldwell, Treasurer. Subscriptions: United States and possessions, Mexico, Central and South American countries, $3.00 for one year; $5.00 for two years; $6.50 for three years. Canada $3.50 per year; $5.50 for two years; $7.15 for three years. All other countries $5.00 a year. Entered as Second Class Matter, September 20, 1943, at the Post Office at New York, N. Y., under the act of March 2, 1879.

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CALDWELL-CLEMENTS, INC.—TEL. PLAZA 3-1340 480 LEXINGTON AVENUE, NEW YORK 17, N. Y.

One of a series showing AMPEREX tubes in the making

Why AMPEREX

WATER AND AIR COOLED TRANSMITTING AND RECTIFYING TUBES

Photograph of sealing operation on vertical rotating first of exclusive Amperex design

ARMY E NAVY

A significant **"Amperextra"** in the manufacture of our tubes is the specially-created life testing procedure. In this phase of operation, samples of production are regularly being tested to provide a precise check on tube quality and tube endurance. Examinations must prove that each tube is built with more than normal life expectancy, otherwise we will reject it. Thus, you are assured a bonus of many hours of additional service . . . in all applications . . . broadcasting, industrial, electro-medical and military.

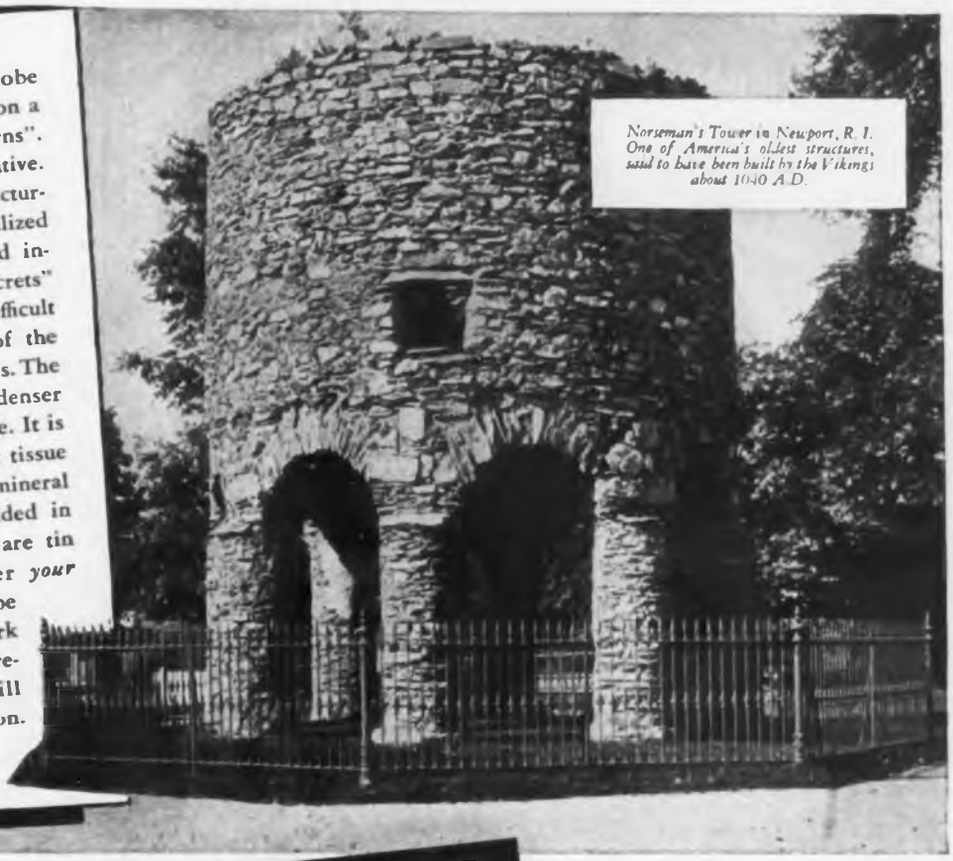
Good to the last drop on the battlefield . . . . . donate a pint of blood to the Red Cross

AMPEREX ELECTRONIC PRODUCTS

79 WASHINGTON STREET BROOKLYN 1, N. Y.

Stalwart *against* Time

THE REPUTATION of Tobe Capacitors for *long life* rests on a record of practically no "returns". Ratings are always conservative. Constant research . . . manufacturing skill born of long, specialized experience . . . frequent, rigid inspections—these are the "secrets" of Tobe's ability to master difficult specifications, like those of the new American War Standards. The "DP" Molded Paper Condenser shown below is an example. It is made of high grade Kraft tissue paper and aluminum foil—mineral oil impregnated and molded in low-loss Bakelite. Leads are tin copper wire. Whatever *your* condenser problems, Tobe engineers will gladly work with you. Inquiries and requests for samples will receive prompt attention.



Norseman's Tower in Newport, R. I. One of America's oldest structures, said to have been built by the Vikings about 1040 A.D.

LONG LIFE ASSURED

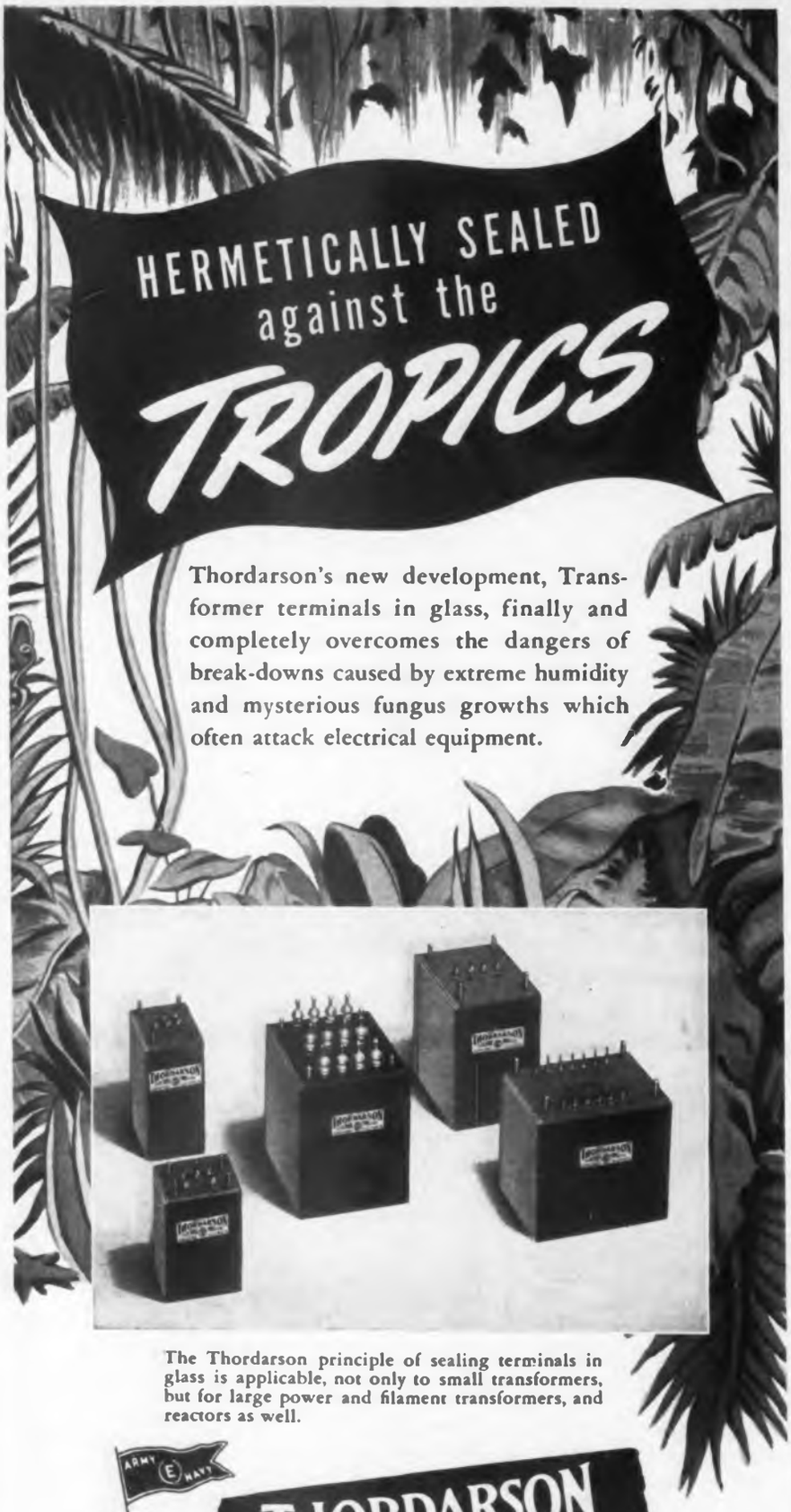
SPECIFICATIONS "DP" MOLDED PAPER CONDENSERS

CAPACITANCE.....001 to .04 MFD
WORKING VOLTAGE.....*See chart at right*
Flash test 3 times rated DC working voltage
SHUNT RESISTANCE At 185°F— 1000 megohms or greater
At 72°F—50000 megohms or greater
WORKING TEMPERATURE RANGE Minus 50° F to plus 185° F
OPERATING FREQUENCY RANGE..Upper limit 40 megacycles
Q at one megacycle—average 20
POWER FACTOR.....At 1000 cycles .004 to .006
DIMENSIONS.....13/16" x 13/16" x 19/64"

Capacity in MMFD.	DC Working Voltage Rating	TOBE & AMERICAN WAR STANDARDS DESIGNATIONS "A" Characteristic	"B"
1000	600—1500	CN35A102	CN35B102
1500	600—1500	CN35A152	CN35B152
2000	600—1500	CN35A202	CN35B202
2500	600—1250	CN35A252	CN35B252
3000	600—1000	CN35A302	CN35B302
4000	600—1000	CN35A402	CN35B402
5000	600— 800	CN35A502	CN35B502
6000	600— 800	CN35A602	CN35B602
7000	500— 700	CN35A702	CN35B702
8000	500— 700	CN35A802	CN35B802
10000	400— 600	CN35A103	CN35B103
20000	200— 300	CN35A203	CN35B203
30000	50— 150	CN35A303	CN35B303
40000	50— 100	CN35A403	CN35B403

TOBE DEUTSCHMANN CORP. TOBE CANTON · MASSACHUSETTS

A SMALL PART IN VICTORY TODAY **A BIG PART IN INDUSTRY TOMORROW**



LETTERS

New Manpower for Electronic Fields

Editor, Electronic Industries:

If you had asked me how many men I thought would be added to the normal radio population after the war I would have said about fifty thousand. When I read that you estimated the same figure in your editorial in March Electronic Industries I came to the conclusion that there must be some merit in the figure! I am willing to let my estimate stand at fifty thousand.

No doubt you know that we had about fifty-six thousand licensed amateurs before the war, of which about twenty-five thousand were probably active, and five to ten thousand occasionally used their transmitters, while the remainder just hung onto their licenses for future use.

To the best of our knowledge at least twenty-five thousand amateurs are now in the services. We are figuring on one hundred thousand amateurs after the war. It will be interesting to see how good a guess we are making.

George W. Bailey, President
American Radio Relay League
Office of Scientific Research & Development
1530 P Street, N.W., Washington 25, D. C.

Tube Protection

Editor, Electronic Industries:

Electronic engineers designing industrial controls seem to be using current-limit acceleration as a means for protecting the tubes. Industrial-control engineers used this method of acceleration during World War I. Since then, time-limit acceleration has been used for the more important controllers, with an overload relay or fuse to protect the equipment from abnormal loads in starting. This latter method insures starting the load under adverse conditions, if not too severe.

It is suggested that time-limit acceleration for industrial-motor control seems to have customer preference.

H. D. James
Consulting Engineer
Commonwealth Building Annex
Pittsburgh, Pa.

Radio and the Railroads

Editor, Electronic Industries:

Your suggestion to forestall railroad collisions by the use of two-way radio rather hit home in the orthopedic ward where I've been sojourning for the past two weeks. Nothing seriously wrong with me, but we do have a sailor boy across the aisle who was involved in that train wreck of the Atlantic Coast Line, near here, just before Christmas time. You may remember that some 80 or 90 servicemen going home on holiday pass were killed outright in this accident, which could easily have been prevented by such a cure of radio communication as you suggest.

Duncan Ross
U. S. Hospital
Fort Bragg, N. C.

No arc-overs or burning of contacts with these *compact* G-E VACUUM SWITCHES

another G-E electronic FIRST!

SINCE the contacts of these G-E switches are mounted in a vacuum, they are virtually free from the effects of corrosion and arcing. They are protected against dirt, oil and water, and require no maintenance.

Vacuum-type construction means: (1) Safety that makes these switches especially applicable for installations where gaseous or dust-laden atmospheres are a fire and explosion hazard. (2) High current rating for their size. (3) The switch produces clean, vibrationless circuit-breaks at any speed — whether twelve or twelve hundred a minute. *A hundred million or more contacts* during its lifetime are not unusual when operated within proper limits. . . . These features lead the procession of advantages in this new type of switch — which G.E. was first to develop and manufacture.

Simple, compact, and easily installed in any position, G-E vacuum switches are ideal where space is at a premium (as in airplanes). No self-contained coils; no auxiliary contacts or relays required! Movement can be obtained from the mechanism to be controlled (often through a cam or thermostat), or from any other apparatus to suit the user's application. They may be operated by air or liquid bellows, rod-linkage system, or other means. Movement is transmitted to the contacts through an operating arm fulcrumed in a flexible diaphragm and requiring only a minute operating force.

Typical applications: Limit switches. Thermostatic controls. Inertia-controlled devices. Radio antenna switching. Radio transmitter tank-coil assembly switching. Stratospheric applications.

SEND FOR BULLETIN ET-1—"G-E *Vacuum Switches.*" Contains additional information, and shows regularly available types and ratings. For special requirements, consult G-E electronic tube engineers. Address *Electronics Department, General Electric, Schenectady, New York.*

G-E TUBES ARE "FIRST" IN INDUSTRY, TOO! The sturdy steel-jacketed G-E sealed ignitron, for example, supplies the heavy current required for high-speed resistance welding. Ignitron rectifiers are widely used instead of rotating machinery. They are easier to maintain and lower in operating cost.

▪ *Tune in "The World Today" every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E "All Girl Orchestra" at 10 P. M. E.W.T. over NBC.*

G. E. HAS MADE MORE BASIC ELECTRONIC TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

161-C4

YOU CAN STILL GET PROMPT POST-WAR DELIVERY IF YOU RESERVE YOUR GENERAL ELECTRIC BROADCAST EQUIPMENT

NOW

STATION AND STUDIO EQUIPMENT • TRANSMITTERS

GENERAL ELECTRIC

160-C7

The General Electric

EQUIPMENT-RESERVATION PLAN

For post-war priorities on FM and AM broadcasting equipment

LARGE as is the amount of broadcast equipment already on reservation with General Electric, the tremendous war-geared G-E manufacturing facilities can produce *all* this reserved equipment for quick post-war delivery. Even twice this amount can be built within practically the same time if we know *now* what will be required and can plan for its production.

General Electric has the plant, the machines, and the skilled engineering and factory personnel, to swing into peacetime production virtually overnight. No extensive reorganization of production methods will be necessary at G.E. . . . since much of the equipment needed for commercial broadcasting is in the same basic pattern as that which today is proving its high standard under the acid tests of war.

Prompt post-war delivery is only one of the benefits you gain by reserving your G-E broadcast equipment NOW.

Your contact with us will enable you, your staff, and your consulting engineer to develop the details of your post-war station during the period before new construction is authorized. Then, you will be fully prepared to proceed with the building of your station.

General Electric can help you in any of the three broadcasting fields: FM—TELEVISION —or AM. You can benefit from exclusive G-E developments such as the FM circular antenna or the S-T relay system which permits you to establish your station for maximum coverage . . . your studio for maximum convenience. You can obtain from G-E *any* broadcast equipment, either station or studio, together with associated equipment for FM, AM, or television. No other manufacturer can offer such complete system experience and "know how."

Come to Schenectady and See for Yourself!

General Electric operates five proving-ground broadcasting stations at Schenectady — AM, International Shortwave, FM and Television. Broadcasters and prospective broadcasters are invited to inspect these facilities and discuss their problems with our station personnel.

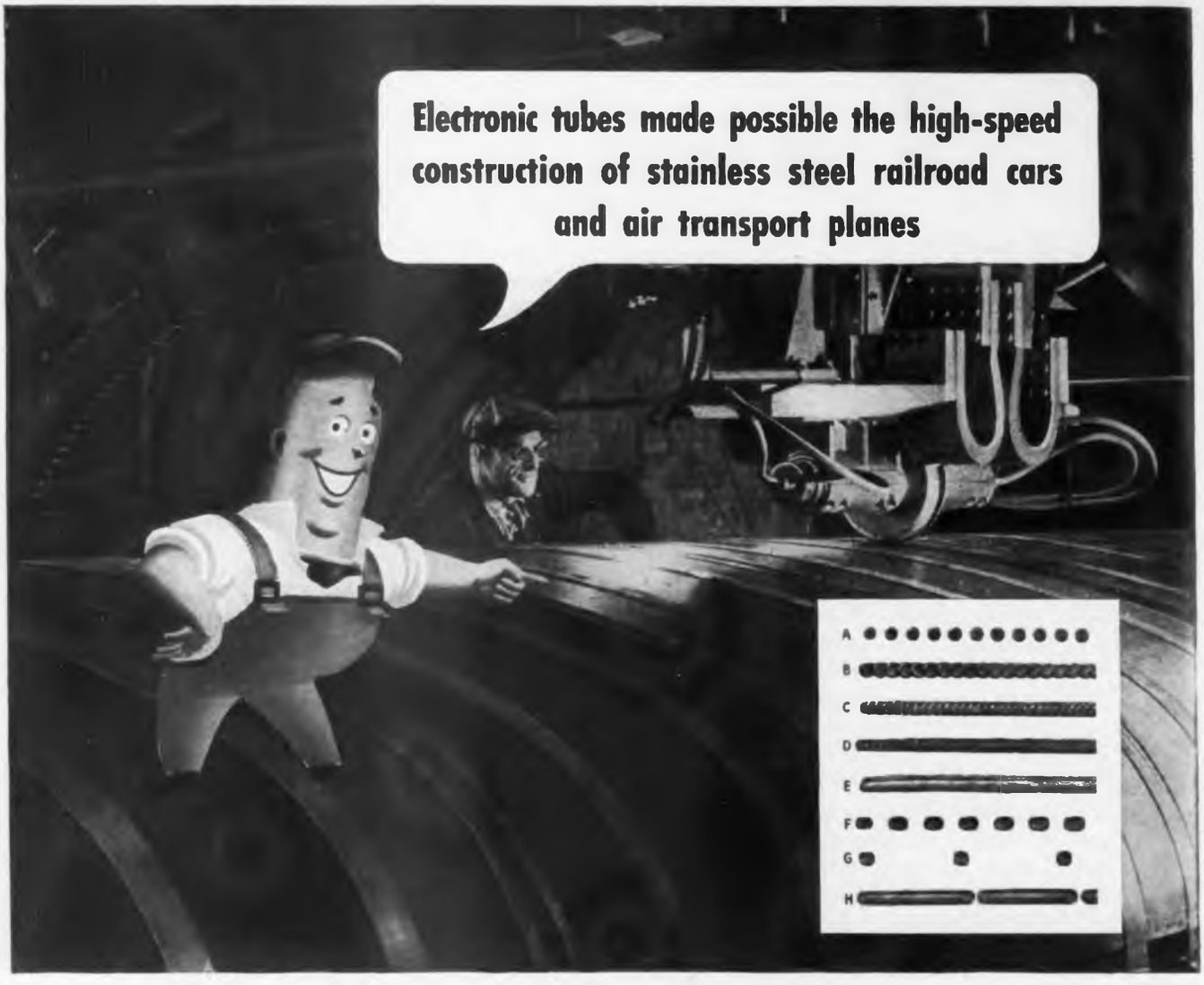
• **WRITE for your copy of the G-E Equipment-Reservation Plan,** and application forms. *Electronics Department, General Electric, Schenectady, New York.*

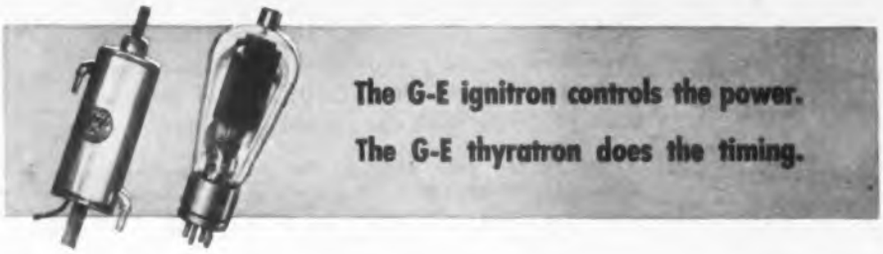
• *Tune in General Electric's* "The World Today" *and hear the news from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS network. On Sunday evening listen to the G-E* "All Girl Orchestra" *at 10 E.W.T. over NBC.*

ANTENNAS • ELECTRONIC TUBES • RECEIVERS

FM – Television – AM

Come to G-E for all three!





UNDER electronic control, as developed by General Electric electronic engineers, resistance welding has become a high-speed, precision operation that is making yesterday's impossible jobs a routine part of today's production.

With G-E ignitrons controlling the heavy surges of power required, and G-E thyratrons switching them on and off at lightning speed, seam welds can be spotted at any desired distances apart or brought together in an overlapping or solid line. Operations may be performed at any desired speed up to 1800 or more welds per minute — with exactly the right amount of heat applied at exactly the right spot.

Practically all metals can be electronically spot-welded together, or to other metals — in thicknesses ranging from tissue-thin nickel-copper alloy, 40 millionths of an inch thick, to laps of half-inch steel.

Main illustration shows stainless steel sheets being welded to railroad-car framework. Welder is double-wheel electrode type. Inset illustration shows typical seam welds made at approximately 7 feet a minute: (A to E) from 1⅔ to 21 spots to the inch; (F) essentially equal on-and-off periods; (G) long-off-short-on period; (H) short-off-long-on period.

There is a G-E electronic tube for every industrial purpose. Through its nation-wide distributing system, General Electric is prepared to supply users of electronic devices with replacement tubes.

"HOW ELECTRONIC TUBES WORK"

This booklet will be mailed to you *without charge*. Its 24 pages are interestingly illustrated and written in easily understood language. Shows typical electronic tubes and their applications. Address *Electronics Department, General Electric, Schenectady, New York.*

• *Tune in* "The World Today" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P.M. E.W.T. over NBC.*

G.E. HAS MADE MORE BASIC ELECTRONIC TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

165-C6

A Good Firm

to Connect With

BRITISH PLUGS

C.C. #50.343-1
British Ref. #10M-418
Signal Corps #PL-Q170

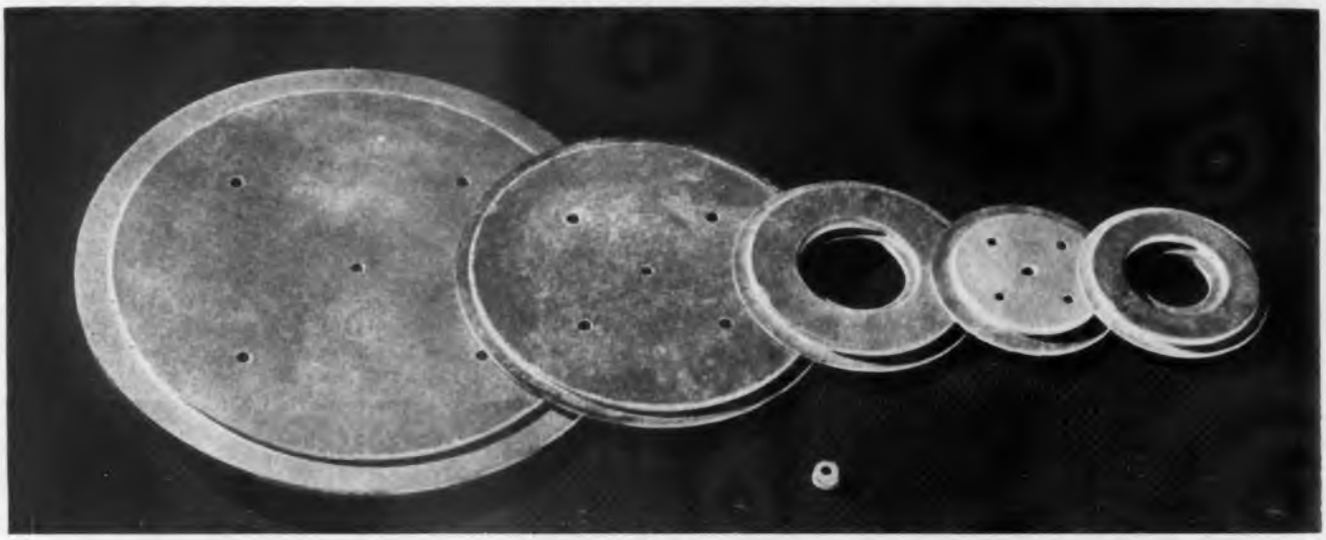
C.C. #50.397-1
British Ref. #110M-1191
Signal Corps #PL-170

C.C. #50.348-1
British Ref. #10-M-417
Signal Corps #PL-P170

Connector Corporation

401 NORTH BROAD ST., PHILADELPHIA, PA.

MACHINED TO A SIZE TO FIT ANY REQUIREMENT



PYRO-PLASTICS

PYRO-PLASTICS Gives You!

- High Dielectric Strength
- Low Power Factor
- High Resistance to Electric Arcs
- Dimensional Stability
- Practically impervious to moisture absorption
- No Deterioration with age
- Resistance to Heat
- Impervious to oil and gas
- Low Coefficient of thermal expansion
- Resistant to Fungi Growth

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TRADEMARK REG.

A NEW NAME in the field of insulation! A glass bonded mica, but better because of its components—the result of years of exacting research.

PYRO-PLASTICS is moulded under extremely high temperatures and high pressure. It is dense, moisture resistant and will give almost unlimited years of low-loss high frequency service.

PYRO-PLASTICS is available in three stock sizes from 10x12" to 6½x18½." It can be fabricated to the .005 of an inch in any desirable shape. For those who cannot do their own fabricating we're equipped to meet the most exacting specifications—in any quantity regardless of shape.

CHARACTERISTICS

ELECTRICAL

Power Factor (1000 KC)	.002-.004
Dielectric Constant	7.3

MECHANICAL

Tensile Strength— lbs. per sq. in.	6,000
Comprehensive Strength— lbs. per sq. in.	25,000-33,000
Flexure	20,000
Hardness—Sclerescope	40-50
Moh Scale	3-4

PHYSICAL

Water Absorption (48 hrs.) per cent	.009
Coefficient of Linear Expansion per degree C	10x10-6
Density—lbs. per cu. inch	100
Specific Gravity	2.83
Color	Gray
Surface	(Hard Smooth)
Tolerance for thickness	5%

More exact thickness may be obtained at additional cost.

QUOTATIONS CHEERFULLY SUBMITTED ON REQUEST

INTERNATIONAL PRODUCTS CORPORATION

2554 GREENMOUNT AVENUE

BALTIMORE 18, MARYLAND

THESE 4 RCA MINIATURES

MADE HISTORY

AND THEY HAVEN'T STOPPED YET!

BUY MORE WAR BONDS

Remember them — the RCA 1R5, 1S4, 1S5, and 1T4 — the "granddaddies" of them all, the miniatures that made the popular Personal Radio possible back in 1940?

Only 2⅛" tall, with a ¾" diameter — but they were born wearing 7-league boots! Right now miniatures are doing battle service — and plenty of it — in many types of compact, light-weight, vital war equipment.

Tomorrow? No need for us to tell you radio designers to watch the post-war trend to miniatures! But here's how we can help you, right now:

You know about RCA's Preferred-type Tube program that, two years before Pearl Harbor, made possible larger manufacturing runs on fewer types of tubes, resulting in better tubes of greater uniformity at lower cost. And you know about today's "Army/Navy Preferred List of Tube Types" that insures ready replacement of standard types on the fighting fronts.

Miniatures, due to their post-war importance, will almost certainly earn their peace-time RCA "Preferred" rating, just as so many of them today are on the Army/Navy list. Our engineers will gladly advise you right now which RCA tube types — and which miniatures — are likely to be included in our post-war Preferred Tube program. Write today to RCA, Commercial Engineering Section, 699 South 5th Street, Harrison, New Jersey.

RCA

RADIO CORPORATION OF AMERICA

• The Magic Brain of all electronic equipment is a Tube . . . and the fountain-head of modern Tube development is RCA

Endorsed in the laboratory

The use of DeJur precision meters in laboratory test equipment is an endorsement of their accuracy. In many fine laboratories, these meters are subjected to severe day-by-day service. Efficiency remains constant because 25 years of electrical knowledge go into their design and engineering. Application of DeJur components to your needs, in or out of the laboratory, will provide proof of DeJur quality. Our engineers will gladly work with you on any problem of measurement and control . . . for present or peacetime assignments.

Bring the Peace Closer . . . Buy More War Bonds

AWARDED FOR EXCELLENCE IN PRODUCTION AND QUALITY OF MATERIEL
ARMY E NAVY

DeJur-Amsco Corporation

MANUFACTURERS OF DeJUR METERS, RHEOSTATS, POTENTIOMETERS AND OTHER PRECISION ELECTRONIC COMPONENTS

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NEW YORK PLANT: 99 Hudson Street, New York 13, N.Y. • **CANADIAN SALES OFFICE:** 560 King Street West, Toronto

The M9 GUN POINTER directs ack-ack fire with deadly accuracy, operating on built-in CONSTANT VOLTAGE

With amazing success on our far-flung battle fronts the Army's new M9 gun pointer, operating on electrical voltage controlled to minute limits of fluctuation, directs shells to their targets swiftly and surely, spelling almost certain death to enemy aircraft.

This uncanny accuracy in our implements of war is a tribute to the skill of America's design engineers. Their ingenious application of scientific instruments and devices from every known source has achieved an exactness in modern warfare that has left consternation and fear in the hearts of our enemies.

Without SOLA Constant Voltage Transformers many of these achievements would not have been possible. These automatic, self-protecting transformers have been on the job day and night. On the production line, in research laboratories, even at the battle fronts their important role has been to iron out the peaks and valleys of power fluctuations to the very narrow voltage limits so essential to precision.

On countless drafting boards this war-gained knowledge is already being projected into new things for the future. And here, as in the implements of war, built-in SOLA Constant Voltage Transformers will continue to provide safe, stable operating voltages.

SOLA Constant Voltage Transformers are available in standard units from 10VA to 15KVA for use with any existing equipment where voltage regulation is required. They are fully automatic, with no moving parts to get out of order. They require no manual supervision. Voltage fluctuations as great as 30% are instantaneously reduced to the safe operating voltages specified on the label.

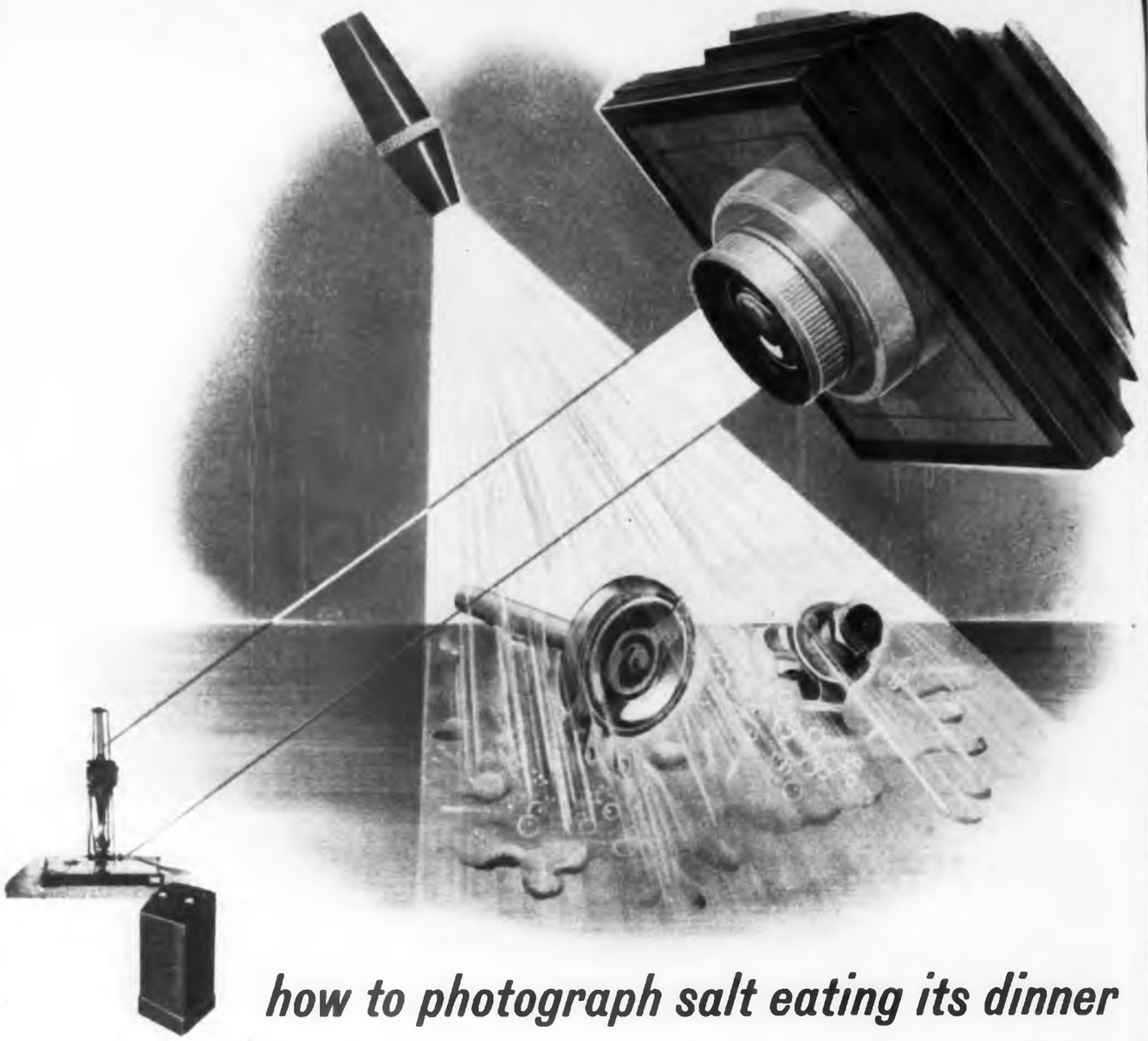
Custom built units of convenient size and capacity can be designed as a built-in part of any electronic device or electrically operated equipment where narrow voltage limitations are required. Sola engineers are available for study of your voltage problems.

SOLA
Constant Voltage Transformers

To Manufacturers:
Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.

Ask for Bulletin 10CV-74

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 14, Ill.**



how to photograph salt eating its dinner

Salt, from the sea and air, has a tremendous appetite for many metals—eating them away unless they're protected. The exact effect of its gluttony and the success of the means used in preventing this costly damage are measured accurately by Utah's salt-spray test. One of the stages in Utah's *complete* circuit of radio and electronic tests.

Immediately after the parts have been subjected to the salt spray, microphotographs are taken and developed in the especially equipped Utah dark room. Thus, it is possible to make a microscopic inspection of the actual condition of the metal *before* other atmospheric changes take effect. Since metal surfaces exposed to salt-spray tests change rapidly *after tests are completed*, it is necessary and possible, by this photographic method, to determine and *accurately* record corrosion in metals.

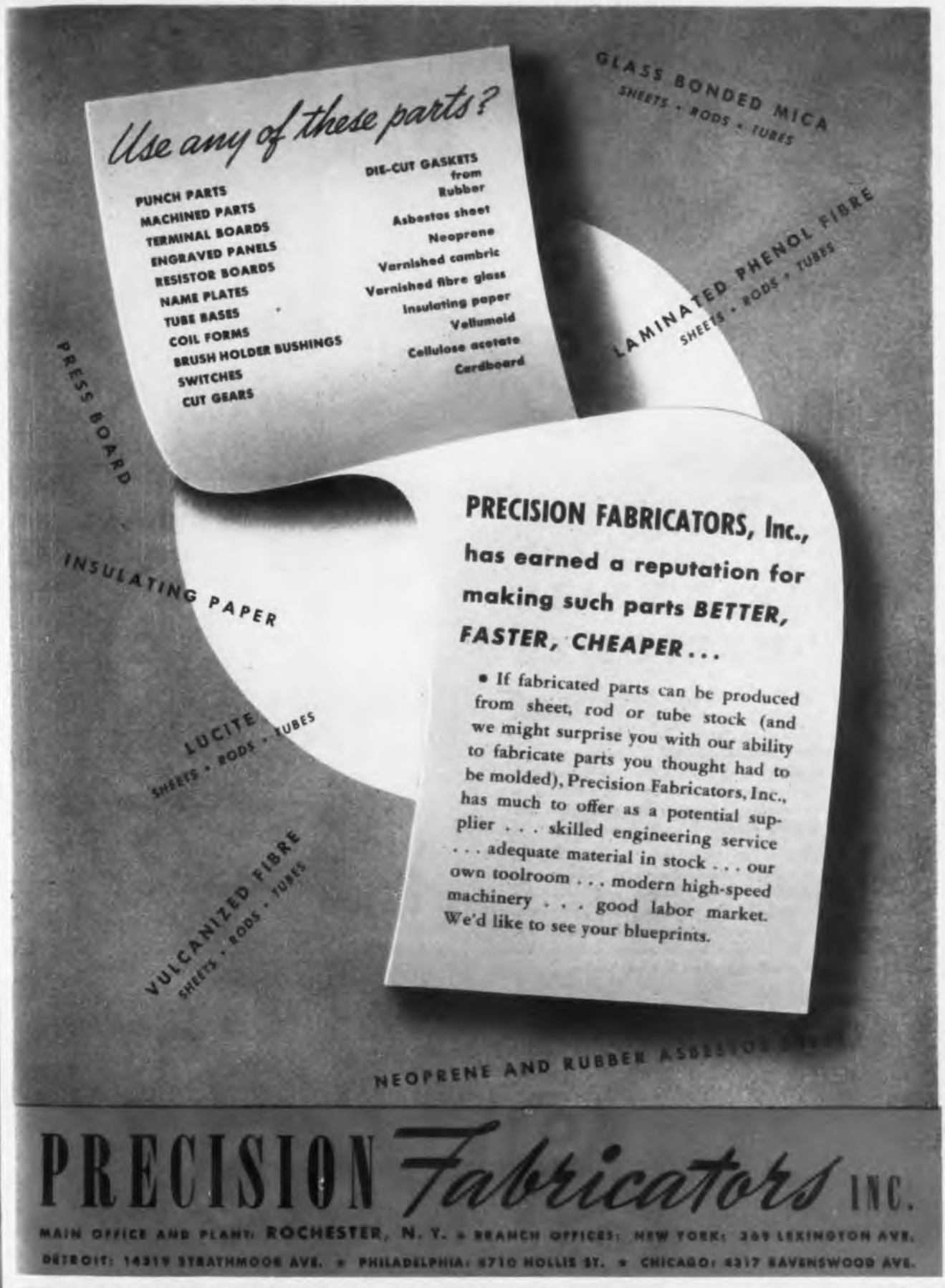
As a result of this and other Utah tests, efficient performance of Utah parts is assured under any and all conditions normally encountered—the failures due to inadequate, inaccurate testing are avoided.

* * *

Every Product Made for the Trade, by Utah, Is Thoroughly Tested and Approved

utah **Radio Products Company,**

850 Orleans Street, Chicago 10, Illinois


Use any of these parts?
PUNCH PARTS
MACHINED PARTS
TERMINAL BOARDS
ENGRAVED PANELS
RESISTOR BOARDS
NAME PLATES
TUBE BASES
COIL FORMS
BRUSH HOLDER BUSHINGS
SWITCHES
CUT GEARS
DIE-CUT GASKETS from
Rubber
Asbestos sheet
Neoprene
Varnished cambric
Varnished fibre glass
Insulating paper
Vellumoid
Cellulose acetate
Cardboard
GLASS BONDED MICA
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SHEETS • RODS • TUBES
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SHEETS • RODS • TUBES
VULCANIZED FIBRE
SHEETS • RODS • TUBES
PRECISION FABRICATORS, Inc., has earned a reputation for making such parts BETTER, FASTER, CHEAPER...
• If fabricated parts can be produced from sheet, rod or tube stock (and we might surprise you with our ability to fabricate parts you thought had to be molded), Precision Fabricators, Inc., has much to offer as a potential supplier . . . skilled engineering service . . . adequate material in stock . . . our own toolroom . . . modern high-speed machinery . . . good labor market. We'd like to see your blueprints.
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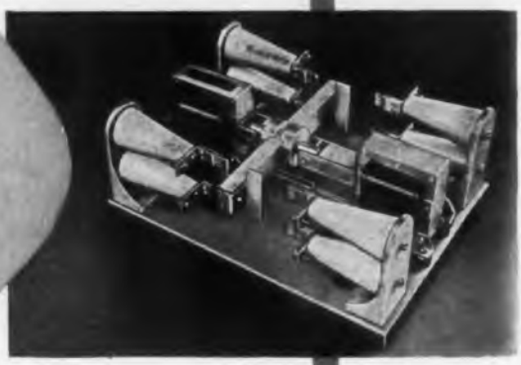
SPECIFICATION FABRICATORS OF MYCALEX ★ PHENOL FIBRE ★
VULCANIZED FIBRE ★ RUBBER ★ ASBESTOS AND OTHER MATERIALS



INDIVIDUALLY DESIGNED

For years Johnson has specialized in individually designed components for radio transmitting equipment. Pictured on this page is a gas filled pressure variable condenser with Mycalex insulated flexible coupling, a coupling inductor, a broadcast station phasing unit for a directional antenna system, a broadcast station tower coupling unit, and a switching relay capable of carrying heavy currents, and requiring no holding current to maintain contact.

These are typical of the thousands of Johnson-designed units that are in service all over the world. Some of them are adaptations of a standard design and others are engineered from the beginning for a particular application. Johnson Engineers like performance specifications. If you have a radio problem, write for the Johnson solution. We believe you will like it, and there is no obligation.

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6EC400	4	600	4½	1½
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10EC200	2	1000	4½	1½
15EC50	.5	1500	2¾	1½
15EC100	1	1500	4½	1½

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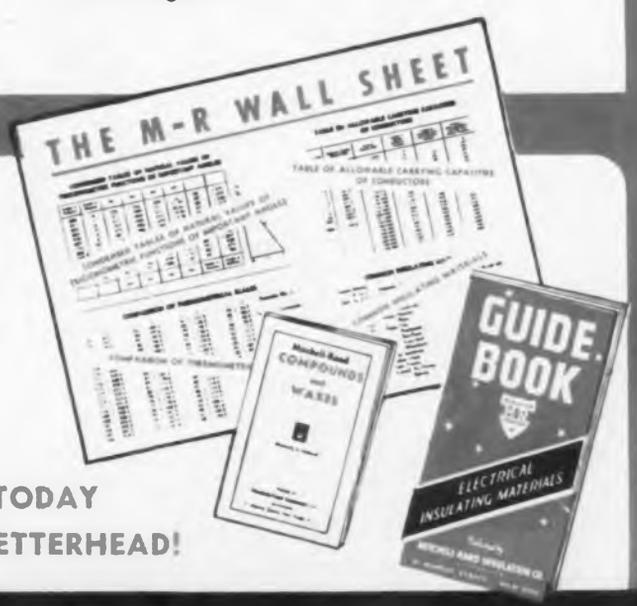

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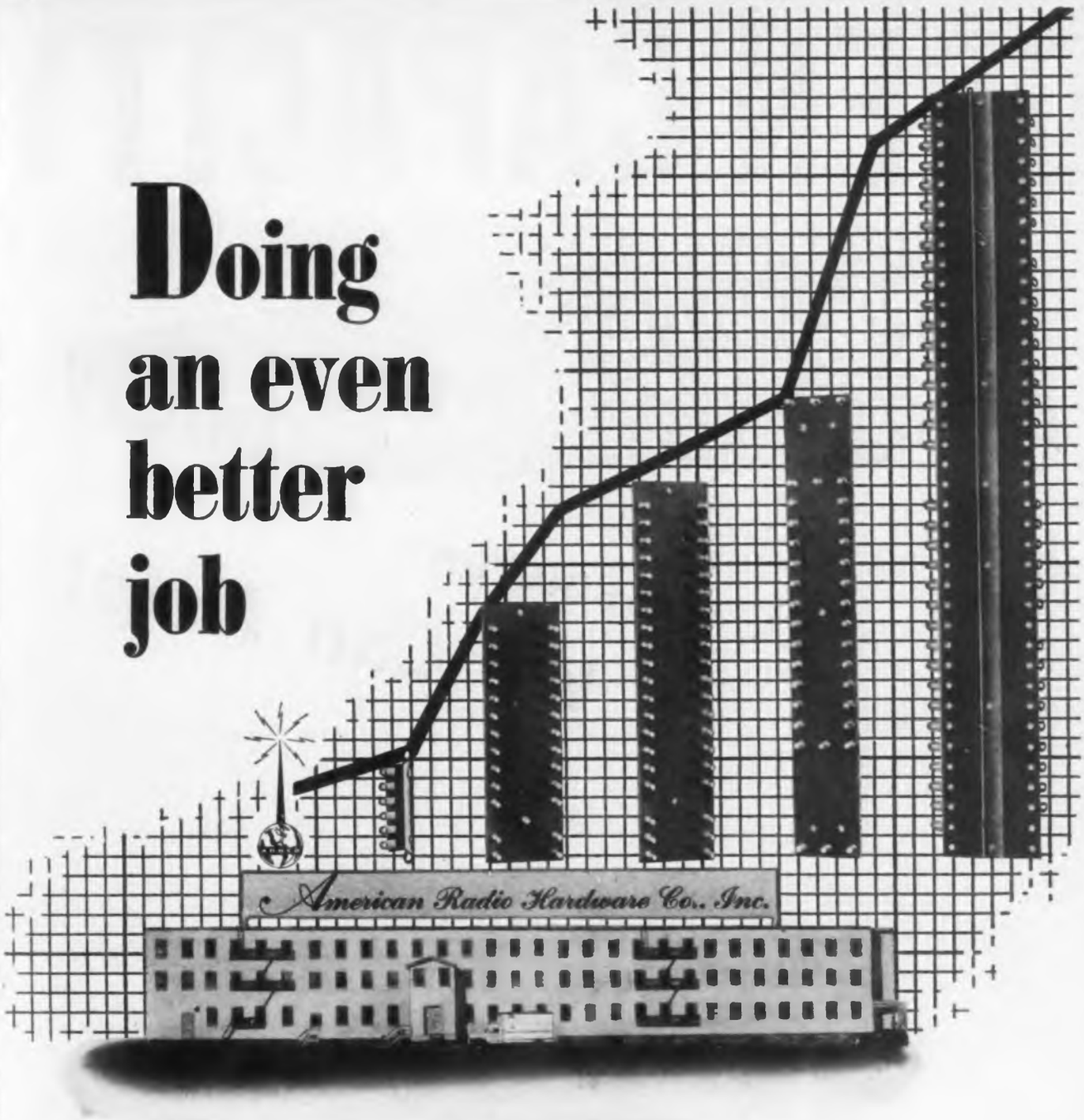

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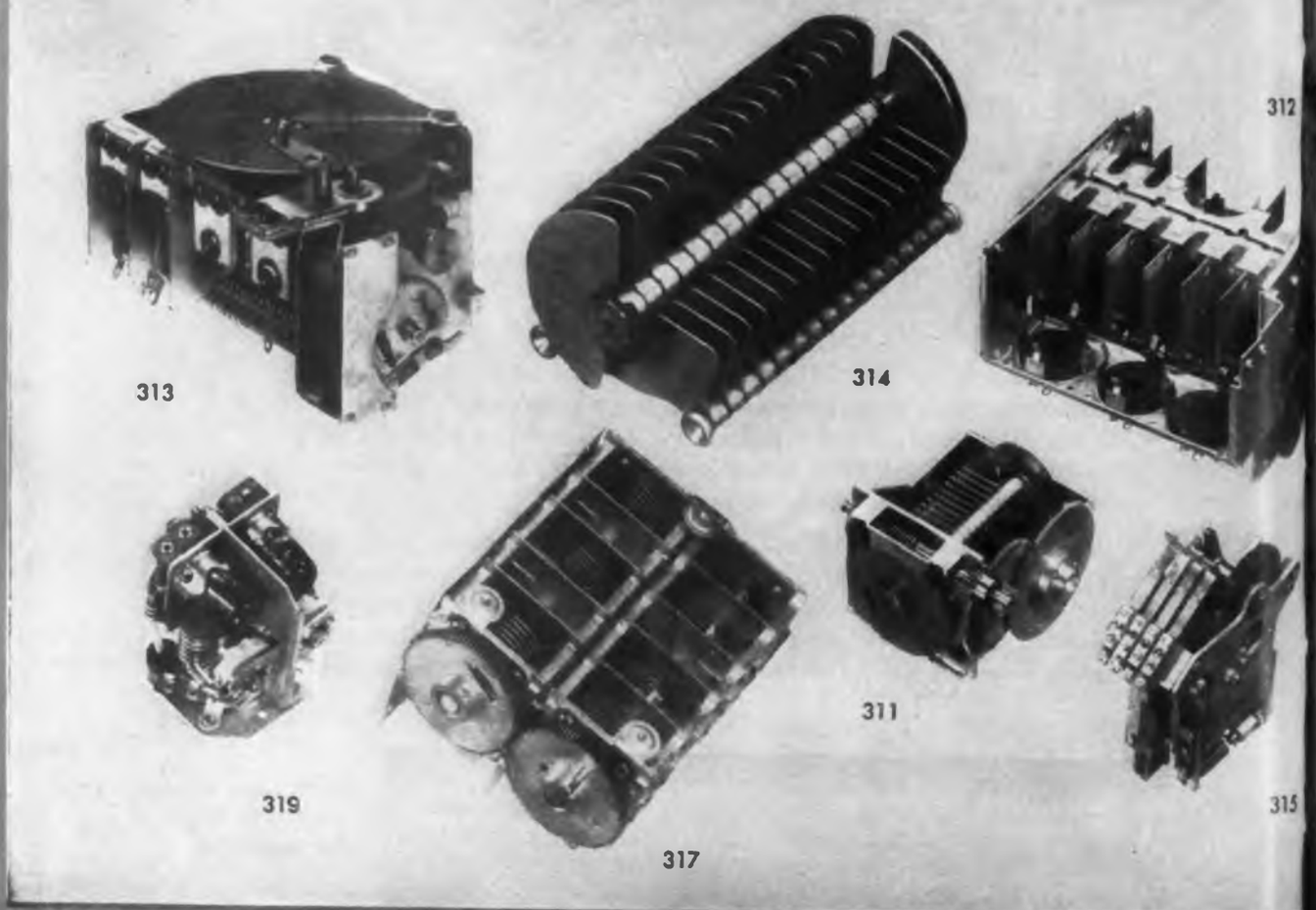

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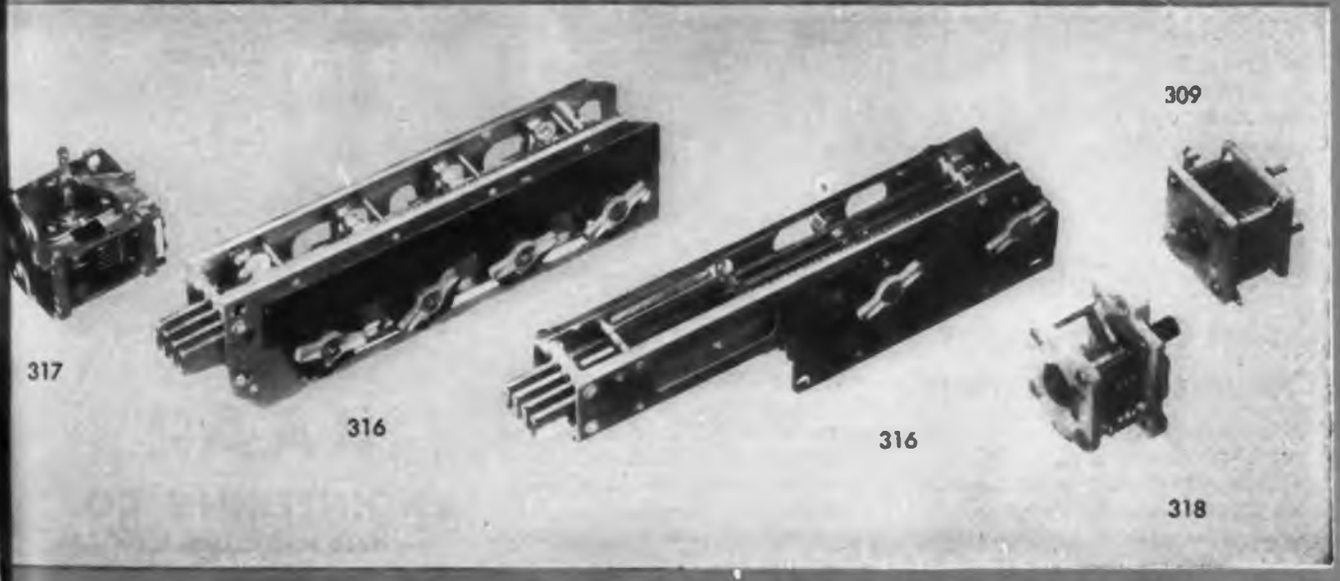

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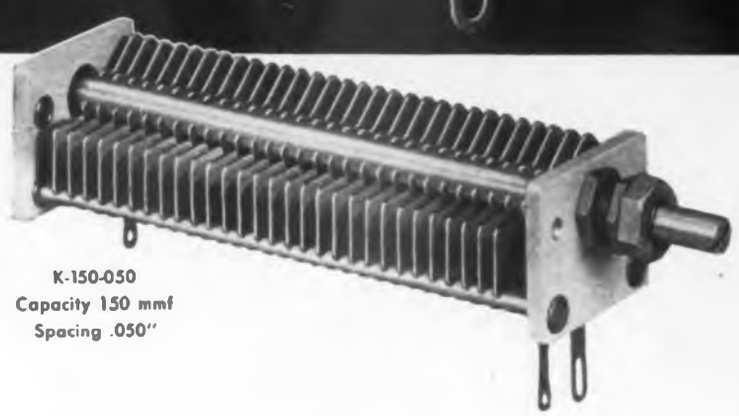

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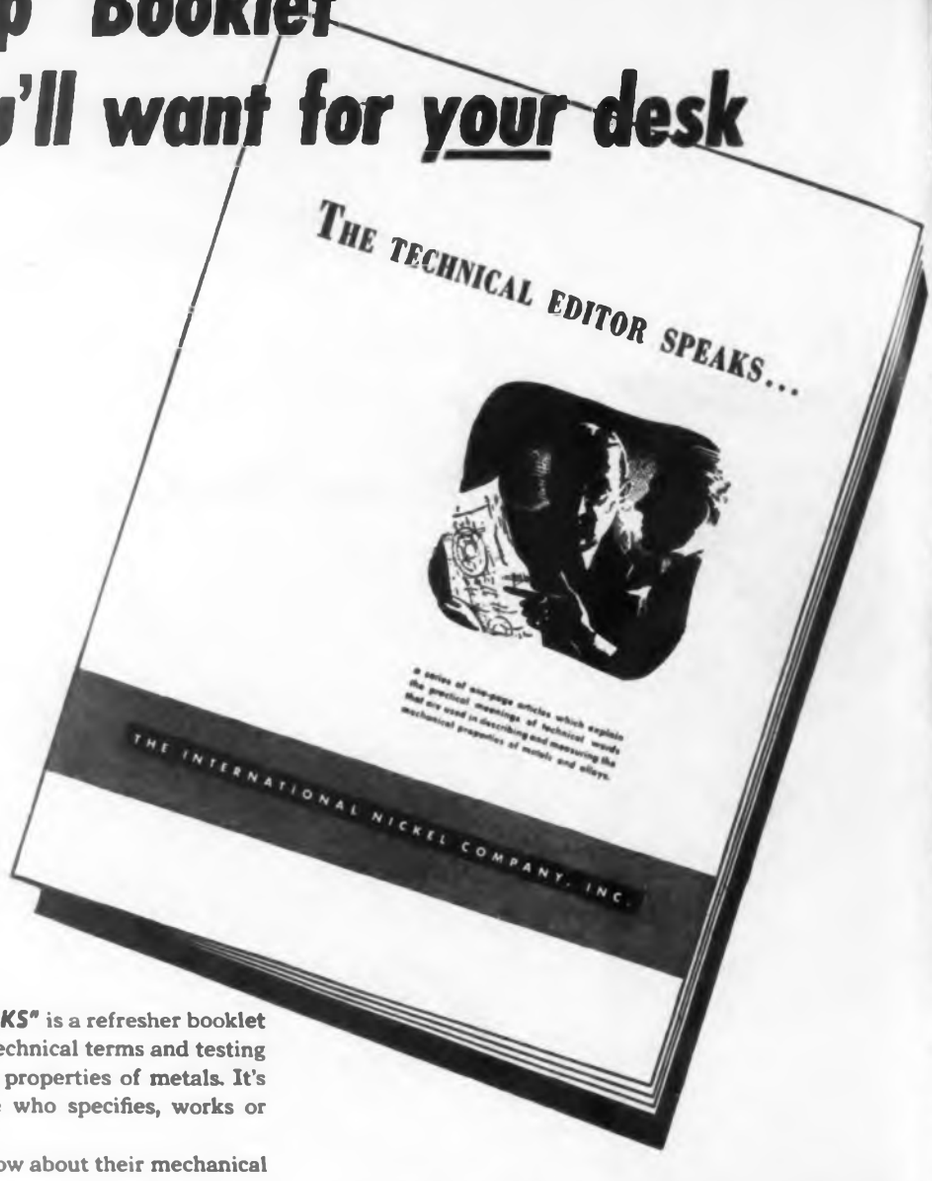

"THE TECHNICAL EDITOR SPEAKS" is a refresher booklet that brings you up-to-date on the technical terms and testing procedures used in measuring the properties of metals. It's a handy, useful guide for anyone who specifies, works or uses metals.

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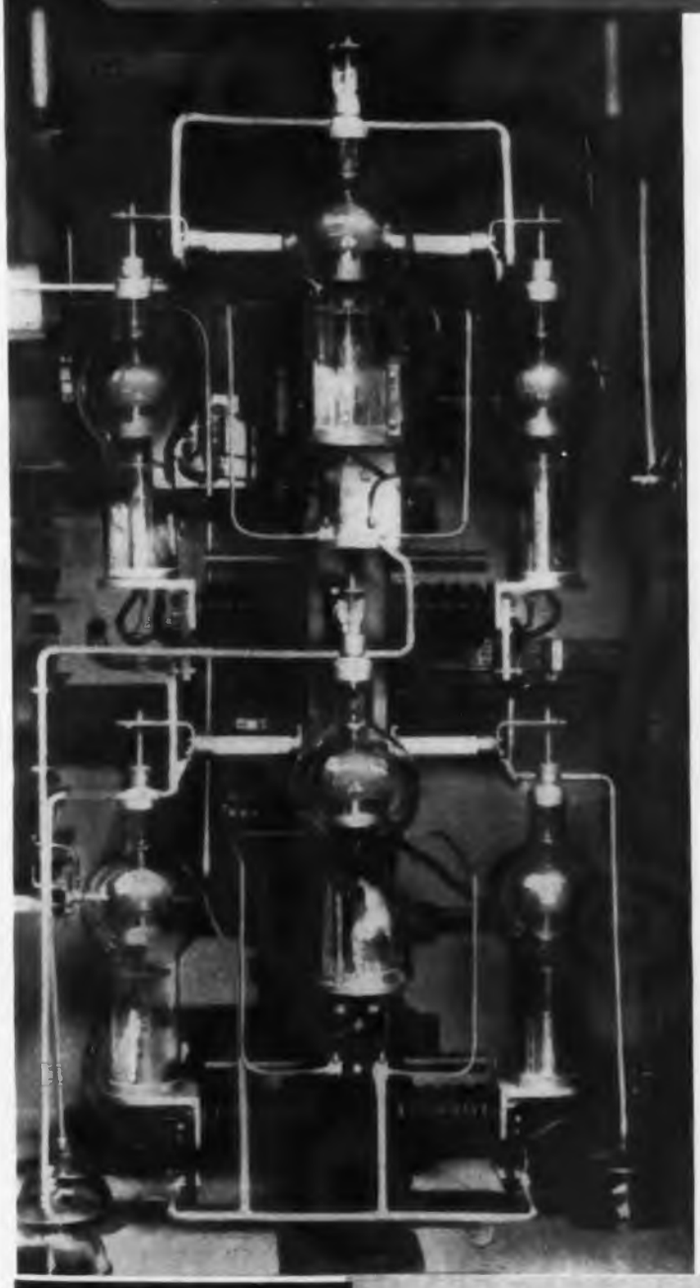
HOW TO MAKE SCARCE TIN GO THREE TIMES AS FAR!



WE'RE a "have not" nation when it comes to tin. That's why a new plating method—developed by Westinghouse—makes big news! High frequency induction heating is the answer, and it not only fuses a uniform, corrosion-resisting tin coat on sheet steel five times faster than previous methods—it also uses only one-third as much tin!

Unexpectedly, glass made by Corning plays an important part in this job. The picture at the left shows the key units creating the high-frequency, tin-smoothing waves. They are glass vacuum tubes about like you'd find in a radio station. Note, too, the glass bowl insulators handling the "juice." As an example of the type of service these glasses must give, one plant is installing tin-plating oscillator units with 72 times the power of the largest radio broadcasting station now on the air in the United States!

High electrical insulating qualities are just one of the interesting characteristics you can get in glass made under the Army-Navy "E" flag at Corning. There are glasses with an expansion coefficient practically equal to that of fused quartz; glasses that are extremely resistant to mechanical shock; glasses that can be made into intricate shapes formerly considered impossible. If you even suspect that glass may help solve one of your problems, we want you to know that Corning's "know-how" is at your service. A study called "There Will Be More Glass Parts In Post-War Electrical Parts" will help bring you up-to-the-minute. Won't you write for a copy? Address the Electronic Sales Department I-4, Bulb and Tubing Division, Corning Glass Works, Corning, N. Y.

Photo Courtesy of Westinghouse

CORNING *means* Research in Glass

Electronic Glassware

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HE DOESN'T KNOW A THING ABOUT CATHODE COATING

BUT HE DOES KNOW THAT EVERY TIME A SET OF TUNG-SOL ELECTRONIC TUBES ARE ISSUED TO HIM, THEY GIVE EXACTLY THE SAME FINE PERFORMANCE AS THE PREVIOUS SET

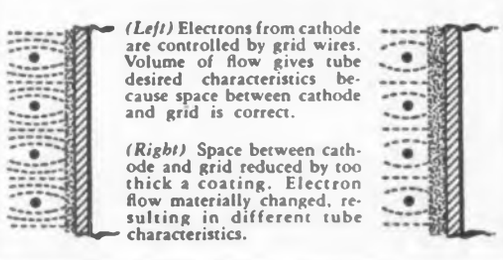
Even if you did mention cathode coating to the average G. I., or man on the street, his answer probably would be:

"What in thunder is Cathode Coating?"

It is a substance sprayed on the cathode of an electronic tube to induce the electrons to flow. On small cathodes the amount of this coating must not vary more than one-tenth of a milligram — a weight of about one-five-hundredth of a postage stamp.

Tung-Sol coats its cathodes about twenty-five at a time. One out of each batch is weighed, then wiped clean of its coating and weighed again. If there was too much coating the whole lot is scrapped, or re-coated if there was too little. The amount of loss on this operation is more than compensated for by the high degree of uniformity in the performance of Tung-Sol tubes. This is one of the many reasons why builders of electronic devices have such high praise for Tung-Sol tubes and why, after the war, you should always remember to use Tung-Sol tubes for replacements.

THICKNESS OF CATHODE COATING GOVERNS TUBE CHARACTERISTICS



(Left) Electrons from cathode are controlled by grid wires. Volume of flow gives tube desired characteristics because space between cathode and grid is correct.

(Right) Space between cathode and grid reduced by too thick a coating. Electron flow materially changed, resulting in different tube characteristics.

TUNG-SOL

vibration-tested

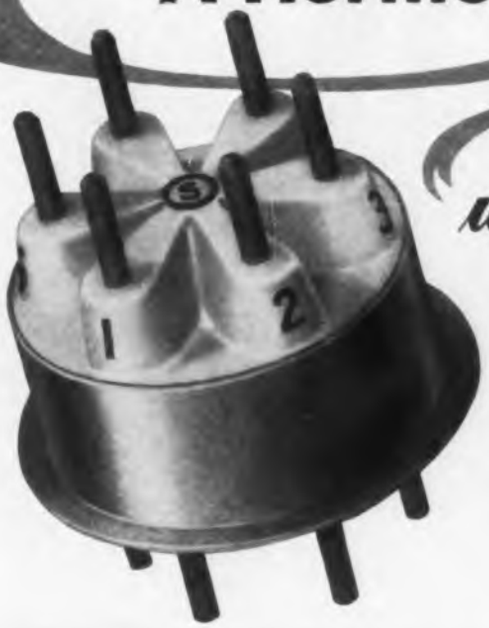
ELECTRONIC TUBES

ARMY E NAVY

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

A Hermetic Seal



with KOVAR

TRADE MARK 337963, REGISTERED IN U. S. PATENT OFFICE

HERMETIC seals of Kovar and glass are made in a wide size range and with single or multiple electrodes. Electrodes may be solid or tubular.

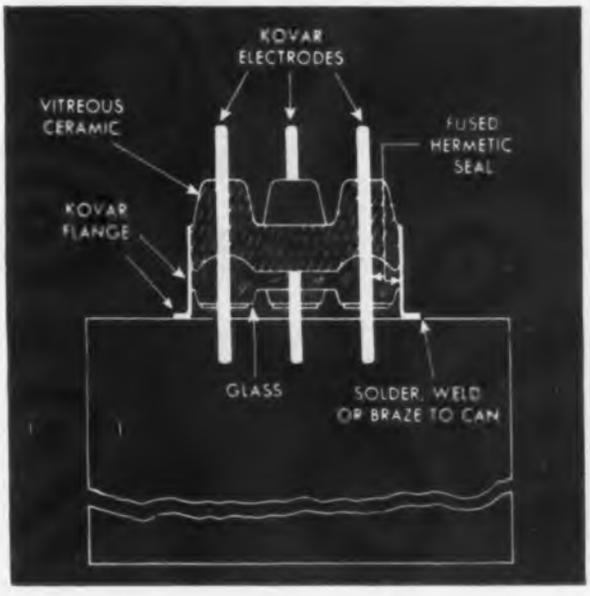
The design illustrated uses a vitreous glazed ceramic top, clean in appearance and numbered to identify each electrode. The Kovar electrodes are located in the ceramic and hard glass preform. This assembly is then sealed to the Kovar parts by fusing the hard glass.

The seal between Kovar and glass is a chemical bond in which the oxide of Kovar is dissolved into the glass during a heating process. The result, a hermetic seal—permanently vacuum and pressure tight, effective under the most extreme climatic conditions—tropical to stratosphere.

Kovar IS the answer to permanent vacuum or pressure tight sealing. Let Stupakoff help engineer YOUR hermetic sealing problems with Kovar.

. . . its elements

and its application



Use KOVAR for sealing

ELECTRONIC TUBES	SWITCHES
TRANSFORMERS	RELAYS, ETC.
RESISTORS	INSTRUMENTS
CAPACITORS	GAUGES
CONDENSERS	METERS
VIBRATORS	RECEIVERS

TRANSMITTERS

ARMY (E) NAVY
"FOR GREAT ACHIEVEMENT"

Let's All Back The Attack — BUY WAR BONDS

SINCE 1897

STUPAKOFF

Products for the World of Electronics

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

COAXIAL CABLES

ANDREW Coaxial Cables for the famous HALLICRAFTERS SCR-299

ANDREW Coaxial Cables are standard equipment on the Hallicrafters-built SCR-299: the mobile communications unit that is doing such an outstanding job on the fighting fronts. It is highly significant that ANDREW Coaxial Cables were chosen as a component of this superb communications unit.

The Andrew Company is a pioneer manufacturer of coaxial cables and accessories. The facilities of the Engineering Department are available to users of radio transmission equipment.

DRY AIR PUMP

ANDREW CO.

COAXIAL CABLES. The Andrew Company is now able to supply standard 70 ohm 7/8" soft temper coaxial cable in lengths up to 4,000 feet! The cable is electrically identical to rigid cables of equal size, but has these extra advantages: the cable may be uncoiled and bent by hand, thus greatly simplifying installation; no connectors, junction boxes or expansion fittings need be installed in the field; thus a big saving is made in installation time and labor.

DRY AIR PUMP. This hand-operated pump quickly, efficiently and economically dehydrates the air inside coaxial cables, in addition to having a multitude of other applications. It dries about 170 cubic ft. of free air, reducing humidity from 60% to 10%.

GAS-TIGHT TERMINAL. The new Andrew glass insulated terminal is an outstanding development that provides a 100% air-tight, gas-tight system for gas filled coaxial cables. A special design that minimizes shunt capacity makes this terminal ideally suited to high frequency operation.

COAXIAL ANTENNA. Suitable for fixed station use and pretuned at the factory to the desired operating frequency, the Andrew type 899 vertical coaxial antenna provides an efficient, easy-to-install, and inexpensive half-wave radiator in the frequency range from 30 to 200 MC. Careful engineering has utilized to the utmost the well known advantages of the coaxial antenna over other types of vertical half-wave antennas.

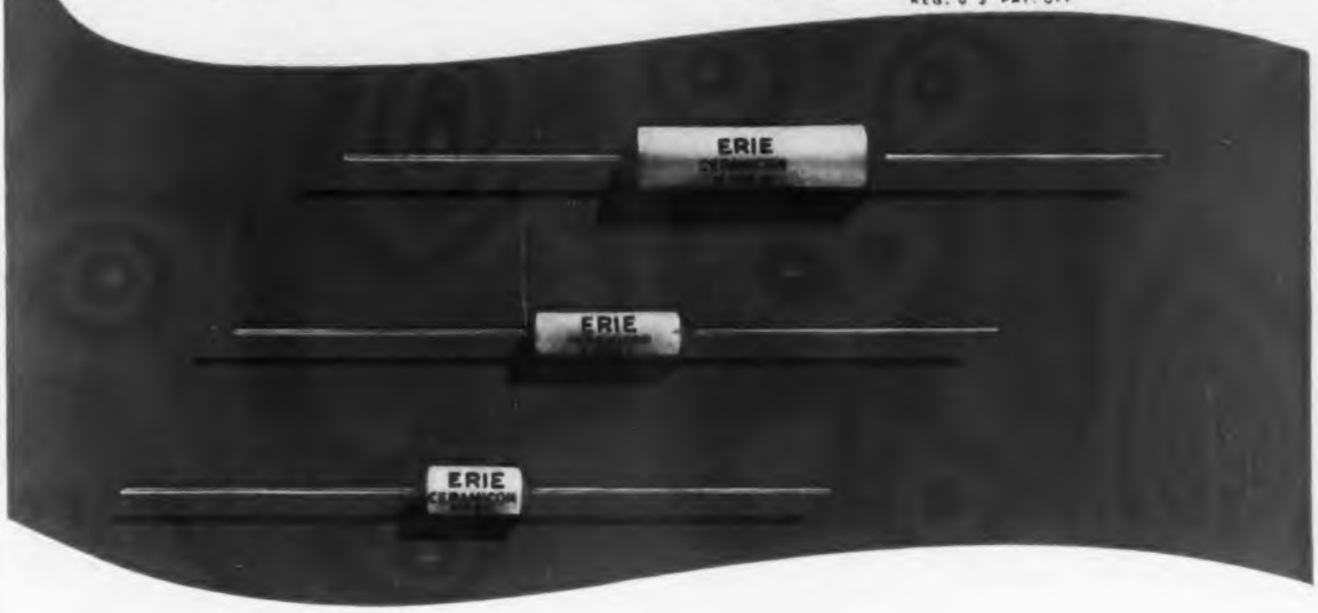
GAS-TIGHT TERMINAL

CATALOG DESCRIBING COAXIAL CABLES AND ACCESSORIES FREE ON REQUEST.
WRITE FOR INFORMATION ON ANTENNAS AND TUNING AND PHASING EQUIPMENT.

THE ANDREW COMPANY • 363 EAST 75TH STREET • CHICAGO 19, ILLINOIS

Erie INSULATED Ceramicons

REG. U. S. PAT. OFF.



Have 5 Inherent Advantages

1. COMPLETELY ENCLOSED
2. GREATER MECHANICAL STRENGTH
3. MORE DIRECT AND UNIFORM ELECTRICAL PATH
4. CAN BE LOCATED ANYWHERE IN CHASSIS
5. BETTER PROTECTION AGAINST HUMIDITY

WHAT do the five advantages of Insulated Ceramicons listed here mean to you? From the standpoint of design, they mean a more compact, efficient lay-out. Insulated Ceramicons can be located *anywhere* in the chassis without regard to the proximity of other components. They make possible shorter leads which are *musts* in higher frequency circuits. They mean greater protection against humidity . . . so important in today's military equipment. They provide extra insurance against breakage in handling on the assembly lines or damage from shock and vibration in actual service. The method of attaching wire leads to the silver electrodes provides a more uniform and direct electrical path.

Erie Insulated Ceramicons, for temperature compensating applications, are made in three sizes and in capacities up to 375 mmf.

Where your specifications call for capacities within the above ranges, specify Erie Insulated Ceramicons.

For complete information covering operating characteristics of Erie Insulated Ceramicons, write for data sheet.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • • TORONTO, CANADA

★ ★ ★ ★ ★ ★

A SMALL RHEOSTAT with BIG FEATURES

The fact that a Rheostat is small, in no way diminishes the importance of its functioning.

Ward Leonard recognizes this and has produced their 4" Plate Type Rheostat with all the desirable features of their largest equipment. It dissipates heat from both sides. The contacts are solid metal blocks for durability. Action is smoothness itself. There are forty-three steps of control.

WL Rheostat Bulletins

Bulletins are available describing the various Ward Leonard Rheostats. The line is complete including from the small ring types up to the heaviest duty, multiple mounted, power driven units. Write for data bulletins describing the type of Rheostats of interest to you.

ARMY E NAVY ARMY E NAVY

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control (WL) devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 61 SOUTH STREET, MOUNT VERNON, N. Y.

★GUNG HO!

Each man, each machine acts as a unit . . . And every part—small and large—in every piece of equipment, performs *as one* . . . That's vital; that's what all the effort's about . . .

The very command: "cast off!" "contact!". . . must get through instantaneously, perfectly. And they do—because in every line of communication each CINCH part "works *GUNG* in perfect harmony *HO*."

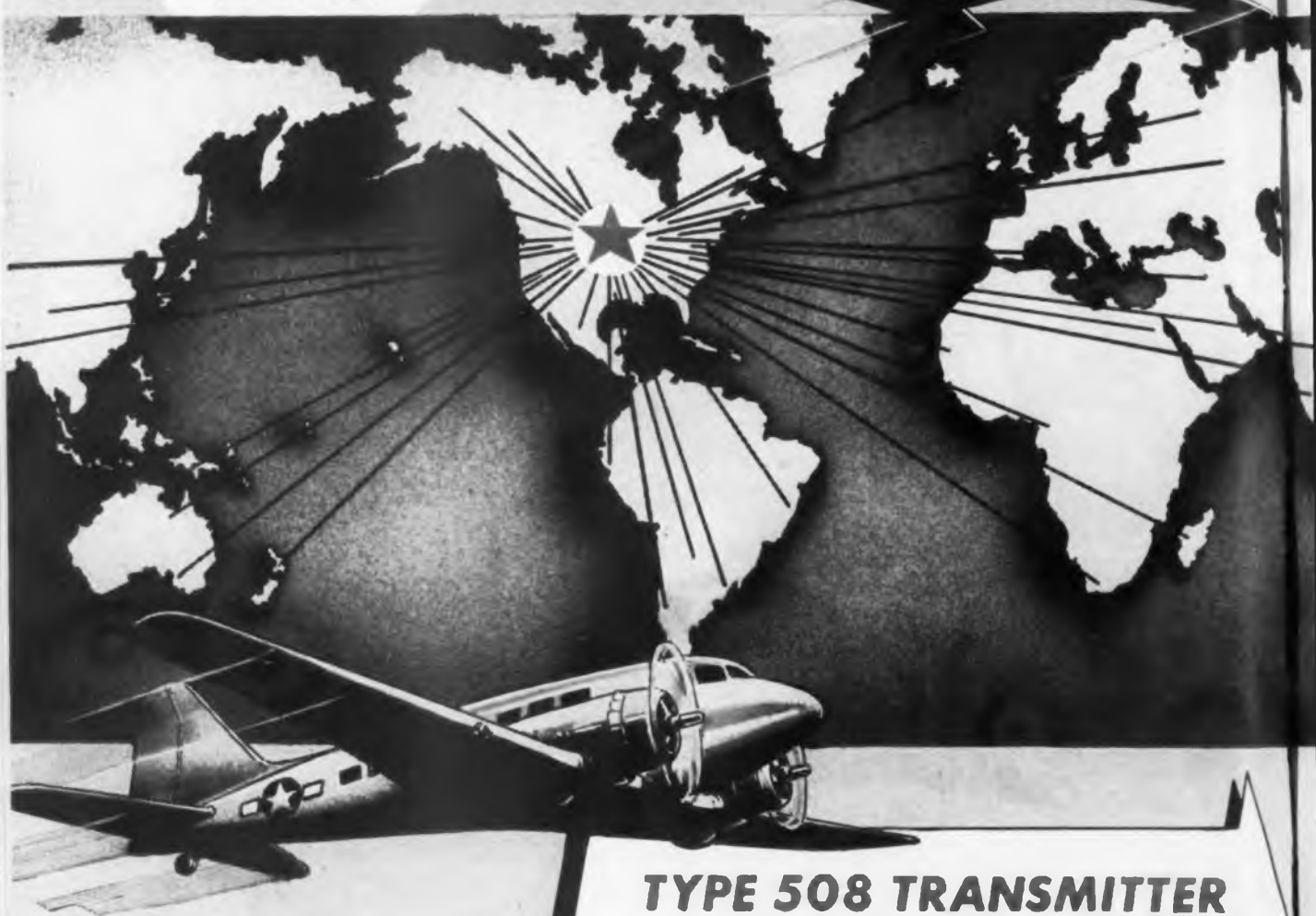
★ *From the Universal Picture, "Gung Ho"—GUNG: Work; HO: Harmony.*

Actual Size No. 9834

CINCH Miniature Socket with "integral" or one piece shield and saddle. The high base virtually acts as a shoe horn . . . as tubes must travel a straight path when inserted or removed, thus preventing tube breakage. Full floating contacts . . . a shield base that acts as a support neutralizing vibration shock and distortion.

CINCH MANUFACTURING CORPORATION
2335 West Van Buren Street, Chicago, Illinois
SUBSIDIARY: UNITED-CARR FASTENER CORPORATION, CAMBRIDGE, MASS.

AAC TRANSMITTERS



TYPE 508 TRANSMITTER

(Illustrated at right). Type 508 Transmitter as designed by AAC for Army Airways Communications Service. Power output 450 watts each channel. Types of emission A1, A2, A3 and FM teletype. Five channels can be operated simultaneously. Single or dual modulator can be supplied.

E-34

AAC Products

AIRCRAFT PRECISION RADIO

Burbank, Calif. Kansas

Serving the AIR TRANSPORT COMMAND Along Vital World-Wide Routes

THE Air Transport Command has become the greatest air transportation system in the world . . . delivering planes, materials and personnel to the Allied forces everywhere!

As ATC pilots fly the seven seas and girdle the earth they are served by communications systems of which Aircraft Accessories Transmitters are an important part. These "508 units" are an outstanding example of the engineering skill and production tempo of Aircraft Accessories. Designed specifically to performance requirements of Army Airways Communications Service (AACS), which sets up and operates radio facilities for the ATC, this equipment is now in operation at many of the widespread world outposts maintained by AACS.

This type of AAC equipment can be readily adapted to immediate use by other airlines. Deliveries can be made in remarkably short time, if adequate priority ratings are available.

ELECTRONICS DIVISION KANSAS CITY, KANSAS

ACCESSORIES CORPORATION

and ELECTRONICS • ENGINEERED POWER CONTROLS

City, Kans. New York, N. Y. Cable Address: AACPRO

MOTHER'S ON THE PLASTIC FRONT

Remler worker removing threaded ear pieces for telephone hand set from plastic molding press.

A VARIETY OF TASKS in all departments of the Remler Company are performed by women. Their dexterity and painstaking attention to detail contribute to the precision accuracy of Remler components and communication equipment. • Like their sister workers in factories all over the country, many of these Remler women also have the responsibility of managing a household. To this double task they bring a devotion worthy of their menfolks in the fighting fronts. Hats off to the women of America!

REMLER COMPANY, LTD. • 2101 Bryant St. • San Francisco, 10, Calif.

REMLER

SINCE 1918

Announcing & Communication Equipment

PLUGS & CONNECTORS

Signal Corps • Navy Specifications

Types:		PL			NAF
50-A	61	74	114	150	
54	62	76	119	159	
55	63	77	120	160	1136-1
56	64	104	124	291-A	
58	65	108	125	354	No.
59	67	109	127		212938-1
60	68	112	149		

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

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has a plate dissipation of
300 WATTS
EIMAC 152TH
has a plate dissipation of
150 WATTS
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has a dissipation of
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of these 5 EIMAC tubes
Eimac has never stopped development of new vacuum tubes. While many types must still be kept secret for military reasons the five here presented can be announced. Full technical data is available now on these five as well as new information about the entire Eimac line. Write today for your copies.
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A sixty-four page booklet that will assist engineers in explaining the fundamentals of electronics to the layman. Copies will be mailed to you without obligation ... additional copies for your associates upon request. Don't delay! The edition is limited.
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EIMAC 25T
has a plate dissipation of
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PHILCO, THE LEADER ... AND TELEVISION!

Much is being said today in the public and trade press about Television, the "billion dollar industry" of the future. Where will Philco, the industry leader, stand when Television is here for you to sell?

Since 1928, for sixteen years, Philco engineers have devoted millions of dollars to research in the field of television. More than any other research group, they have been responsible for constant improvement in the clarity, sharpness and detail of the television picture. Their pioneer contributions have helped to bring television to maturity, ready for rapid expansion after the war.

In this and many other directions, Philco has been in the forefront of the developments that make television a bright hope for the future to appliance dealers. And when it is ready to sell in your community, you can depend on Philco to fulfill the obligations of leadership.

PHILCO TELEVISION STATION WPTZ

Since 1933, Philco has owned and operated its own television station in Philadelphia, sending out studio programs and sports events direct from the scene. It has also rebroadcast programs from New York, establishing the technique upon which future television chains can be built. All this has been a rich laboratory of experience through which Philco engineers will help to make television, some day, a nationwide service.

PHILCO CORPORATION

Detective work to Foil Corrosion

In Automatic Electric's chemical laboratory, before any materials are accepted for use in relays, they are carefully tested for the presence of sulphur, bromine, chlorine, or other elements that might cause corrosion, affect insulation or give rise to other troubles

IN THE selection of materials and finishes for use in Automatic Electric relays, performance and durability are given first consideration. The aim of the designers is to produce an apparatus that will resist all corrosive influences throughout long years of tough service—even when this means foregoing the bright, shiny appearance which is so attractive at first. Every factor in the design of Automatic Electric relays is given similar attention—resulting in a unique fund of design data and experience. This background is the reason why Automatic Electric relays serve so dependably under tough conditions.

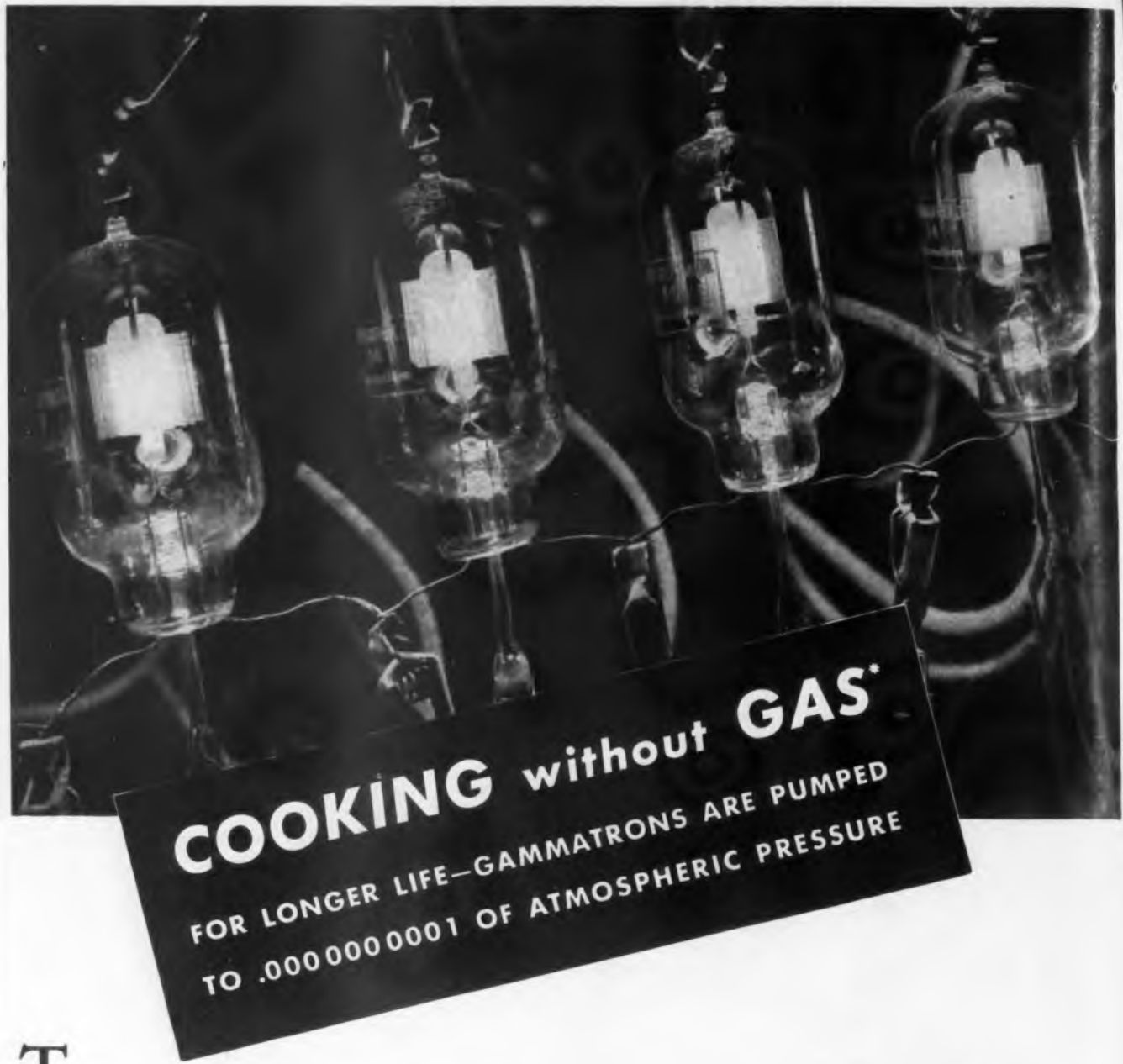
You can make this experience work for you—by calling in the Automatic Electric field engineer. His job is to help you select the apparatus that will best meet your need. Call him in next time you are faced with an electrical control problem. Write for Catalog 4071.

AUTOMATIC ELECTRIC SALES CORPORATION
1033 West Van Buren Street • Chicago 7, Ill.

In Canada: Automatic Electric (Canada) Limited, Toronto

Relays AND OTHER CONTROL DEVICES *by* AUTOMATIC ELECTRIC

PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED



These Gammatron tubes are being submitted to an exhaust process so severe that only tubes made with tantalum elements can withstand it. They are "cooking" at 3,000° F, running at this temperature from 30 to 40 minutes. At the same time they are being pumped to create a vacuum equal to one ten-billionth of atmospheric pressure . . . the best commercial vacuum obtainable.

Heintz and Kaufman Ltd. has perfected such a rigorous pumping process to protect Gammatron tubes from filament bombardment. If many gas molecules remain in an evacuated tube, electrons traveling from the filament to the plate strike these molecules and ionize them. These ions, being positive, dart toward the filament, hitting with such force they strip the filament of its coating. This action, termed filament bombardment, materially shortens the life of a tube.

The severity of the Heintz and Kaufman exhausting process assures superior protection against filament bombardment, and thus adds to the operating life of all Gammatrons.

*(*Practically, but not precisely true. Even at .000 000 000 1 of atmospheric pressure, there are two billion gas molecules to the cubic centimeter of evacuated space.)*

HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA, U. S. A.

Gammatron Tubes

FOR VICTORY AND SECURITY BUY WAR BONDS

Sound Ideas . . .

Sound ideas! On the drafting board . . . in practical engineering . . . in production "know-how". These form a strong union out of which come many Electro-Voice developments. And the latest of these is the Model T-45 "Lip Mike" . . . a noise-cancelling Differential Microphone.

The soundness of Electro-Voice design refinements will be even more effectively demonstrated in peacetime. We have grown up with the field. We know its needs and its possibilities. You may be sure that products born of Electro-Voice ideas will perform a sound function.

Electro-Voice distributors are giving greater understanding to your requirements than ever before. If your limited quantity needs can be filled by any of our Standard Model Microphones, with or without minor modifications, we suggest that you contact your nearest radio parts distributor.

Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC.
1239 South Bend Ave. • South Bend 24, Indiana
EXPORT DIVISION: 13 EAST 40th ST., NEW YORK 16, N. Y. — U. S. A. CABLES: ARLAB

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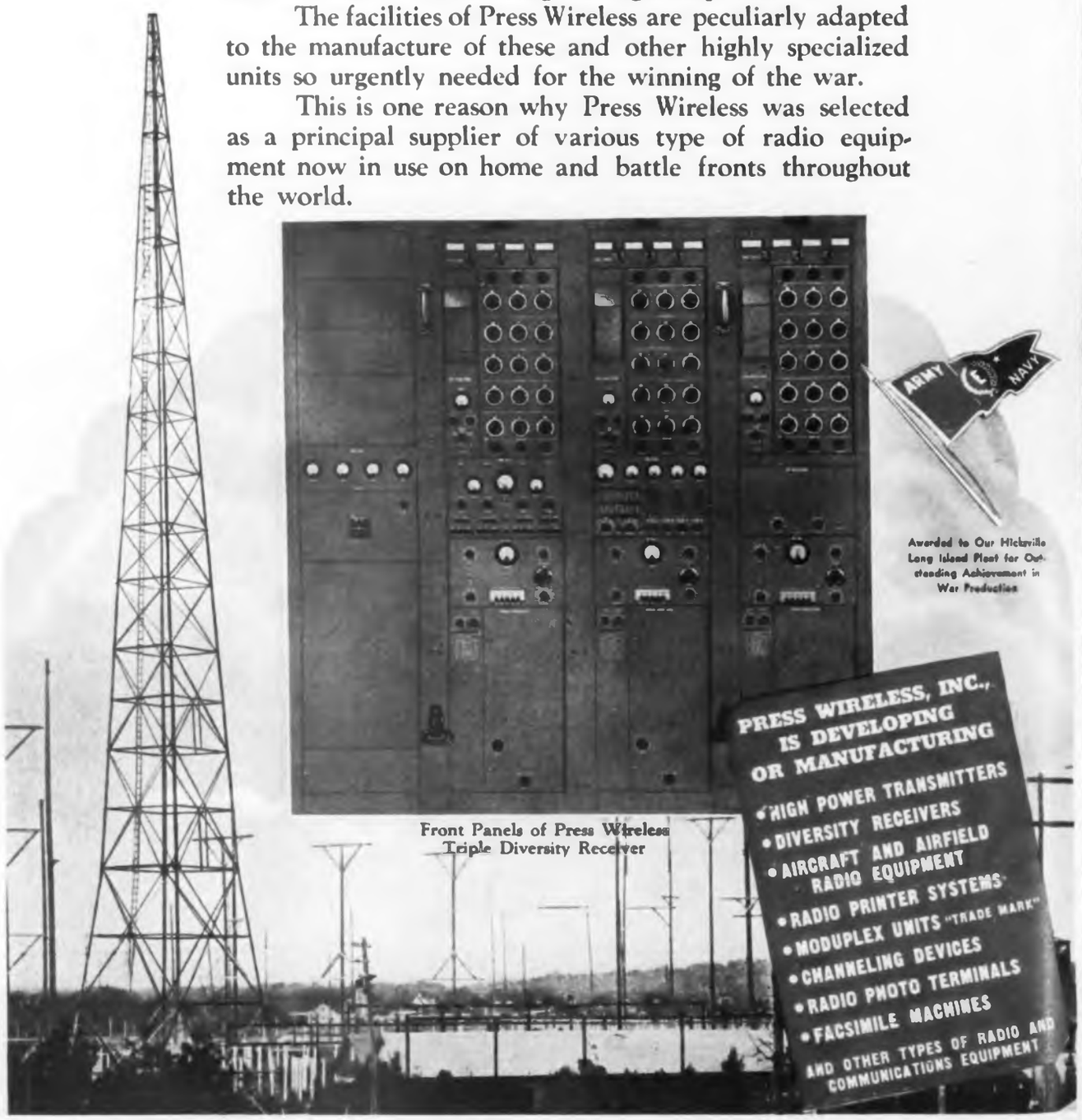
PRESS WIRELESS PROVIDES RADIO CENTRALS FOR THE WORLD...

Triple diversity receivers made by Press Wireless Inc. for our allied governments will soon be in service as radio centrals for national and international communication networks of increasing strategic importance.

The facilities of Press Wireless are peculiarly adapted to the manufacture of these and other highly specialized units so urgently needed for the winning of the war.

This is one reason why Press Wireless was selected as a principal supplier of various type of radio equipment now in use on home and battle fronts throughout the world.



Front Panels of Press Wireless Triple Diversity Receiver

PRESS WIRELESS, INC. *Executive Offices* 435 N. MICHIGAN AVENUE, CHICAGO *Sales Office, Manufacturing Division* 1475 BROADWAY, NEW YORK CITY

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THIS BIG 28 PAGE BROCHURE IS "MUST" READING FOR ENGINEERS

Don't fail to get your hands on a copy of this book of data. It's the "last word" on the subject of glass-bonded mica, from the history of the product to its almost-endless applications. It shows that MYKROY differs in formula from the earlier glass-bonded mica materials, and states the case for MYKROY as the perfect dielectric for the more exacting needs of all high frequency circuits.

Here is a wealth of information about advanced insulation, including many useful charts and graphs. Here are results of tests, and the official ratings.

This book will show you why we can solve your insulating problems and help to improve the efficiency of your product. It will show why our plant and facilities have been increased more than 4000%, and that there is NO SHORTAGE of MYKROY.

Use the coupon to order your copy. But please fill in firm name and title clearly.

SEND FOR YOUR FREE COPY TODAY

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Gentlemen: Yes! I want the book of facts about the advanced electrical and mechanical properties of MYKROY insulating material.

Name..... Title.....

Company.....

Address.....

CHICAGO 47: 1917 NORTH SPRINGFIELD AVENUE
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Masterpiece OF SKILLED HANDS

One of the world's masterpieces in marble — "The Kiss", by the celebrated French sculptor, Auguste Rodin (1840-1917), creator of the famed and familiar "The Thinker".

Machines can do **almost** anything. . . . But it takes *more* than machines to create an electronic tube. . . . A tube may be brilliantly engineered for electronic and mechanical advancements. It may contain the highest quality components. Yet it will be no better in performance than the skill and care of the hands that assembled it. . . . Each tube that leaves the UNITED testing line is an industrial masterpiece. Into its manufacture has been wrought the perfect hand workmanship which is the counterpart of its perfect design.

UNITED

ELECTRONICS COMPANY

NEWARK, 2 New Jersey

Transmitting Tubes EXCLUSIVELY Since 1934

ARMY E

COIL FORMS OF

Steatite BODY (302)

and *Centradite BODY (400)

An almost endless variety of coil forms (up to 5 inches in diameter) are available processed to your specifications within reasonable tolerances. We are also able to furnish pressed pieces to approximately 6 inches square. • The facilities of Centralab's engineering and laboratory experience are at your disposal.

Write for Bulletin 720

Centralab

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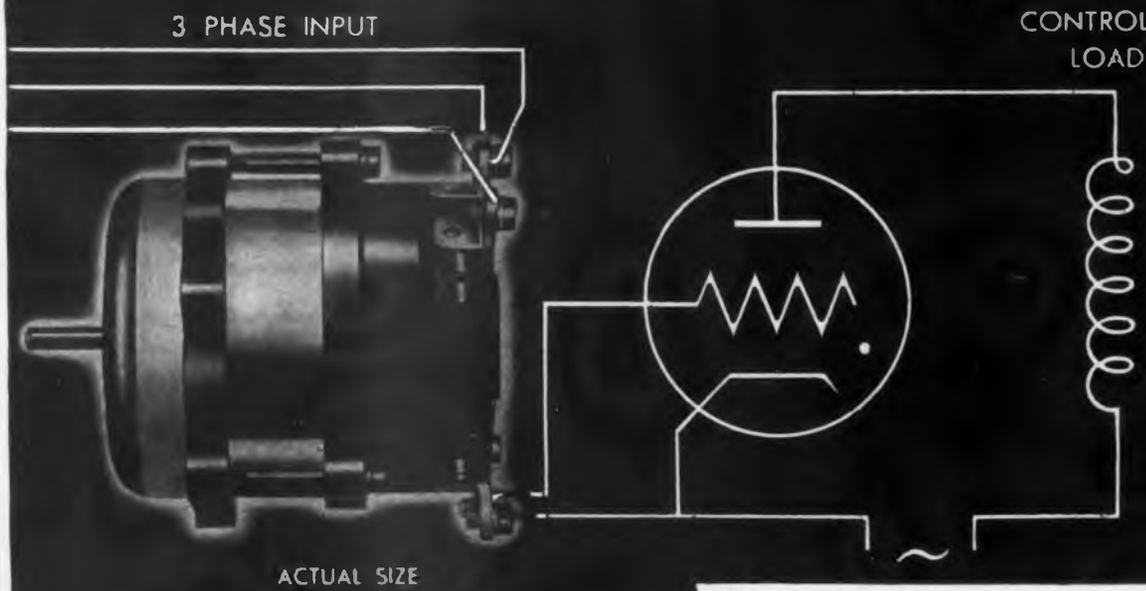
Division of GLOBE-UNION INC., Milwaukee

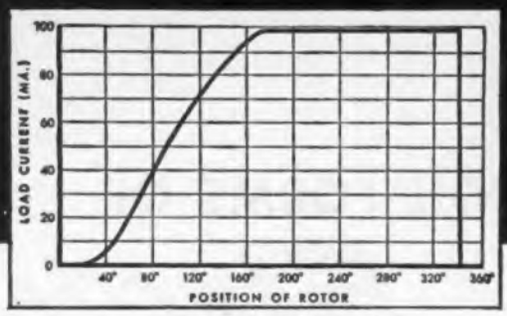
* Centradite is especially indicated where Low Thermal Expansion, High Resistance to Heat Shock, Low Porosity and Low Loss Factor are requisites.

Design Engineers!

Here's a versatile unit with many electronic control applications...THE KOLLSMAN CIRCUTROL

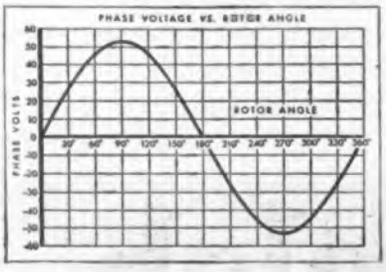


CIRCUTROL UNIT
used as
Thyratron Phase Control



Typical of the many special applications for which design engineers have found the Kollsman Circutrol particularly suited, is phase control of Thyratron type units. In this application the unit offers accurate linear control, as shown by the above graph.

When used as a rotatable transformer, the Circutrol Unit produces a phase voltage which varies sinusoidally with the angular position of the rotor as shown in the graph at right.



Another advantage of the unit as a rotatable transformer is that it is designed to withstand continuous rotation at speeds up to 1800 R.P.M., although many applications require nothing more than positioning of the rotor.

Electrically, the Circutrols are motor-like precision units having high impedance two- or three-phase stator windings and single-phase rotors. Units are available which operate from 32, 115 and 220 volts, 60 cycles, and 110 volts, 400 cycles.

These units may also be used as single or polyphase induction regulators, controllable voltage modulators, single or polyphase alternators or phase shifters.

For complete information about the Kollsman Circutrol write to Kollsman Instrument Division of Square D Co., 80-12 45th Ave., Elmhurst, N. Y.

ELECTRICAL EQUIPMENT • KOLLSMAN AIRCRAFT INSTRUMENTS

SQUARE D COMPANY

ELMHURST, NEW YORK • GLENDALE, CALIFORNIA

CENSORED CENSORED CENSORED

The sad case of a Case History

Many an achievement in the war effort is "born to blush unseen". . . at least for the present. The case history, complete with photographs and diagrams, cannot now be revealed.

In many ways General Electronics Industries has been helping to establish the great war record of electronics, through cooperative research with industrial organizations and Army and Navy research agencies. Present conditions do not permit a full recounting of these achievements.

General Electronics Industries is one of the largest organizations specializing in electronics. And this organization, which has met the exacting tests of war, has the research engineering skill and production facilities that will best answer your electronics needs when the war is over.

Engineering Department, General Electronics Industries, 342 West Putnam Avenue, Greenwich, Connecticut.

GENERAL *Electronics* INDUSTRIES

TRADE-MARK REG. U.S. PAT. OFF.

GREENWICH • STAMFORD • BRIDGEPORT • NEW MILFORD • NEW YORK

History of Communications Number Four of a Series

SMOKE SIGNAL COMMUNICATIONS

MODEL T-45
LIP MICROPHONE

While the puffs of our early American smoke Signals were not as complicated as the Morse Code, this type of communication was a speedy and effective means of communication at that time and could be seen for scores of miles on a clear day. Used for transmitting their battle messages, smoke signals in the days of the early American meant a progressive means of communication.

Restricted by climatic conditions this type of communication was limited in its use. Universal microphones in the part they play in modern electronic voice communication must withstand the climates of the Arctic and the Tropics all in a day's work. Built to accomplish a specific job, Universal Microphones are "getting the message through" on every Allied front.

Model T-45, illustrated at left, is the new Lip Microphone being manufactured by Universal for the U. S. Army Signal Corps. Shortly, these microphones will be available to priority users through local Radio Jobbers.

UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA

FOREIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA ·· CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA

CELLULOSE ACETATE is big in the electrical news today. Designers and engineers have new appreciation of its corrosion-resistance properties—its high dielectric strength.

Lumarith, in foil and film form, is the safe lining and covering for coils, tubes and bobbins. It has no corrosive effect on current-carrying copper wire even in the presence of moisture. It has good resistivity and high dielectric strength. Electrical equipment, subject to extreme conditions of moisture and humidity, will benefit from this extra protection Lumarith can supply.

Investigate the electrical possibilities of Lumarith plastics. Write for Celanese electrical booklet. The facts you'll need are available in its pages. Celanese Celluloid Corporation, *The First Name In Plastics*, a division of Celanese Corporation of America, 180 Madison Avenue, New York City 16. *Representatives:* Dayton, Philadelphia, Cleveland, Chicago, St. Louis, Detroit, Los Angeles, Washington, D. C., Leominster, Montreal, Toronto.

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KEN-RAD

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TRANSMITTING TUBES RECEIVING TUBES
CATHODE RAY TUBES INCANDESCENT LAMPS
SPECIAL PURPOSE TUBES FLUORESCENT LAMPS

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We build cabinets, chassis, panels and racks for diversified electronic equipment . . . quickly, precisely, economically. The hundreds of different dies available will reduce the cost of the dies needed on your job and may, in many instances, eliminate die-cost entirely. Because of these unique facilities, we manufacture to required specifications at the lowest possible cost. Moreover, we'll go over your plans with you . . . make recommendations if they can be helpful . . . suggest means of expediting deliveries. Briefly, ***ours is an extra pair of hands*** . . . offered willingly as part of a firmly-established policy of unselfish service to our clients.

The services of a Karp engineer are available for a discussion of your problems.

ANY QUANTITIES — ANY METAL — ANY SIZE — ANY FINISH

ARTISANS IN SHEET METAL

KARP METAL PRODUCTS CO., INC.

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CABINETS
CHASSIS
RACKS
PANELS

KEEP BACKING THE ATTACK . . . BUY MORE WAR BONDS

All Resistors OBEY OHM'S LAW

● ***Because it is a resistor, Thyrite* obeys Ohm's law—but its resistance varies with change in applied voltage*** ***(I varies as E^4).***

Perhaps you will find Thyrite useful in solving some of your special circuit problems. Or perhaps you'll find the answer in our wide line of standard enameled units.

Widely used throughout the electrical and electronics industries, G-E resistors are typical of the great variety of standard and special G-E components that are available to manufacturers of electronic equipment.

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

Each type of G-E electronic component is designed by specialists in that particular field. Help in selecting those best suited to your requirements is readily available from qualified G-E representatives. Located in principal cities throughout the United States, these men can help you co-ordinate purchasing, and expedite procurement.

Before ordering or specifying electronic components, find out what G.E. has to offer—by calling in the nearest G-E representative. ***General Electric Company, Schenectady 5, N. Y.***

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...can Thyrite GET AROUND IT?

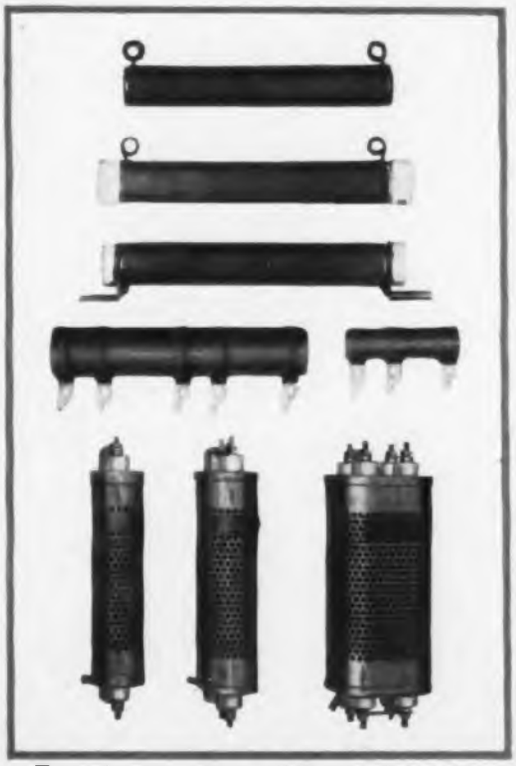
THYRITE—*the G-E nonlinear resistance material*

Typical forms of G-E Thyrite resistors

Thyrite is a silicon-carbide ceramic material, dense and mechanically strong. Its nonlinear resistance characteristic is stable, and substantially independent of polarity or frequency. Thyrite has been used for 14 years in many important applications, including electronic. Thyrite can be produced in various shapes and sizes (those which can be successfully molded). Among its countless applications are:

1. Circuit protection (by limiting voltage surges)
2. As a stabilizing influence on circuits supplied by rectifiers
3. As a potentiometer (making division of voltage substantially independent of load current)
4. For controlling voltage-selective circuits

G-E VITREOUS-ENAMEL RESISTORS



Typical construction of G-E enameled resistors

These resistors employ a strong, high-heat-resisting body developed to withstand sudden and extreme changes in temperature. Their resistance remains nearly constant through temperature changes, because of the low temperature coefficient of the resistance wire. The enamel, in which the wire is embedded, is fused at high temperature to a uniform glassy structure. It is moistureproof, durable, and forms a mechanically air-tight casing.

Made in a wide range of resistance and current values, from 10- to 180-watt units, G-E enameled resistors are available in a wide variety of constructions, which include the addition of stranded copper leads, circular-band terminals, copper leads and porcelain bushings, Edison screw bases, etc.

They also are available in virtually every required style—open or enclosed, for any style of mounting.

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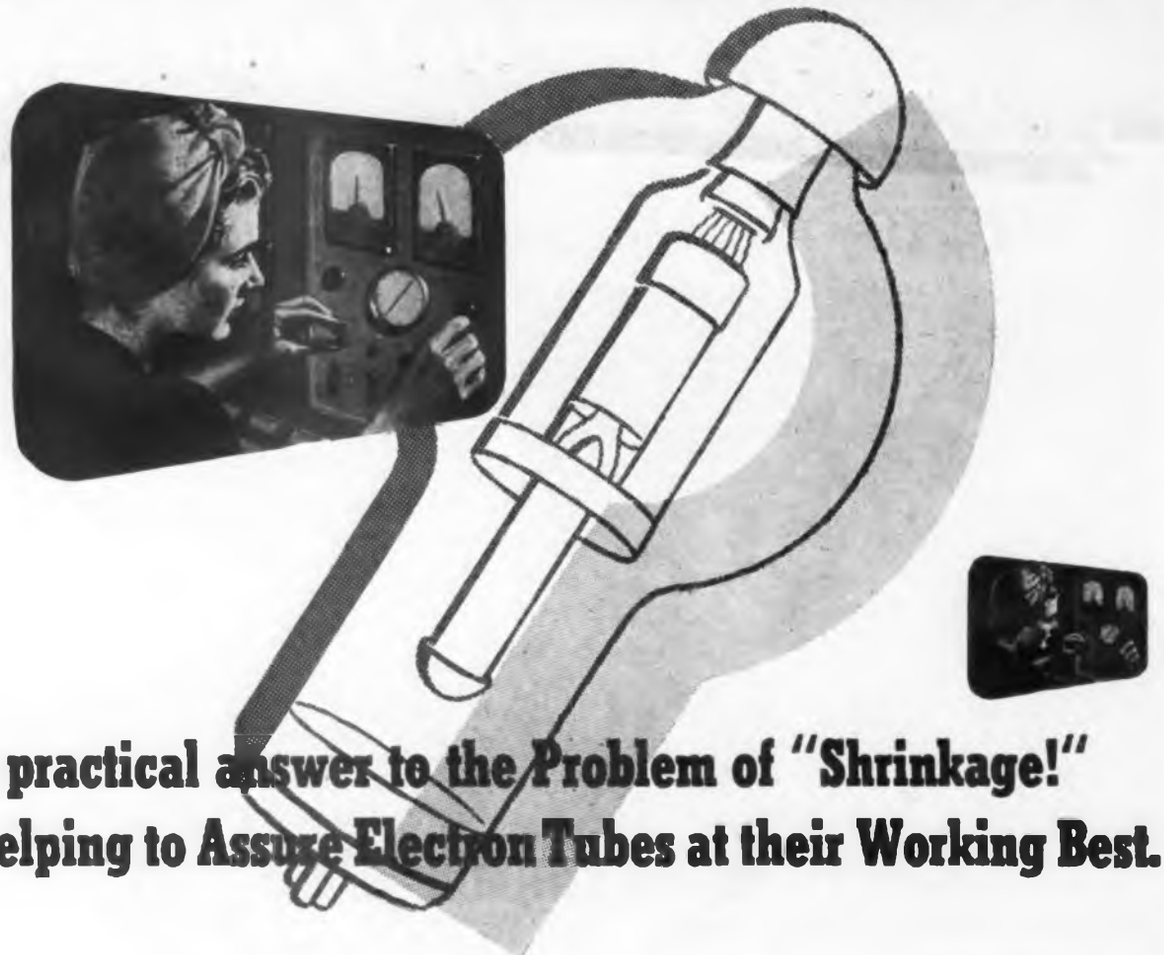
SHERRON TUBE TEST UNITS



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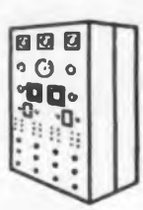
...helping to Assure Electron Tubes at their Working Best.

Miracles are expected from electronics, and miracles are being performed—where the electron tube is at its working best. In short, the ideal must be the standard. Toward this end, Sherron test units are honored as indispensable equipment by many of the nation's most important makers of tubes . . . In its diversified electronic applications, Sherron test equipment is safeguarding production standards and maintaining positive quality controls. All equipment designed to meet specific manufacturing problems.



Sherron Tube Test Units Measure:
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Manufacturing Processes:
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he should be twins

The electronic engineer is one of the hardest-working men contributing to the war effort today. His highly specialized training and knowledge is not easily or quickly acquired. His skill calls for many years of constant application. Because the demand for experienced engineers and designers jumped so greatly after Pearl Harbor, each one virtually has been doing the work of two men.

Raytheon is proud of its engineers and their great contribution to the war effort . . . and Raytheon is proud of its part in furnishing electronic tubes and equipment that meet all requirements of stamina, "Plus-Extra" quality, and complete dependability under the most severe wartime demands.

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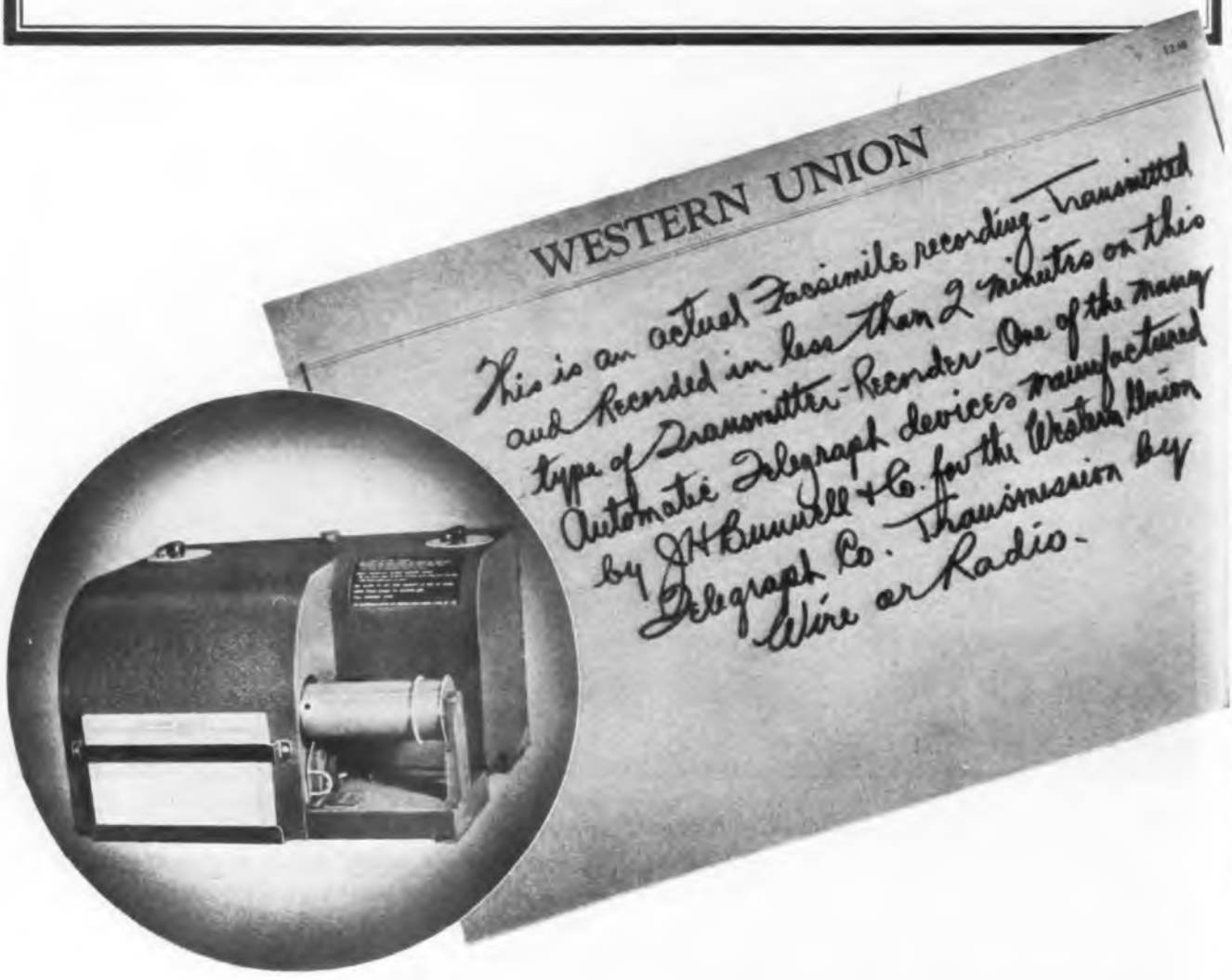

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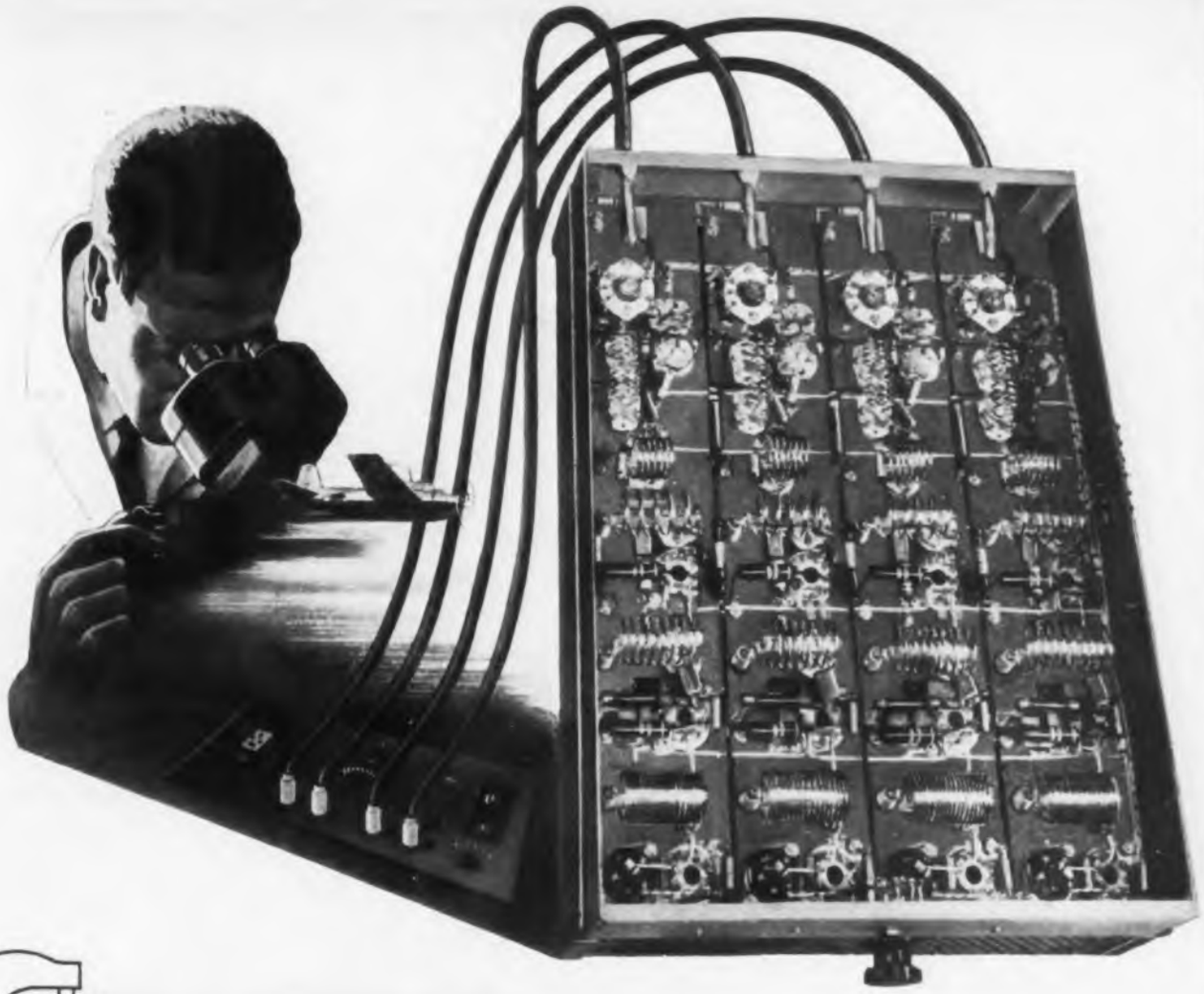

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The reason for our successful interpretation of specialized production problems is an open secret. ECA has an invaluable supplement to sound experience and versatile facilities. This is the competitive spirit in our ranks fostered by both management and labor. Such a challenge to individual effort results in greater efficiency, greater economy, and a deeper insight into the assignment at hand.

The ECA Laboratory Frequency Standard is an excellent example of our work. This unit is used in our production department for testing and calibrating equipment. It is a frequency standard providing checking of ultra-high frequencies with an accuracy of one hundredth of one percent. It is composed of crystals and a series of frequency multipliers which multiply each crystal frequency 64 times. This unit was built in the ECA laboratory since there is no commercial equipment available that will guarantee the required accuracy at certain ultra-high frequencies. It has made possible the delivery of specially needed equipment for the war agencies.

100% IN WAR WORK . . OCCASIONALLY, HOWEVER, PRODUCTION SCHEDULES PERMIT US TO ACCEPT ADDITIONAL ASSIGNMENTS

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You can sell Sylvania Radio Tubes with complete confidence.

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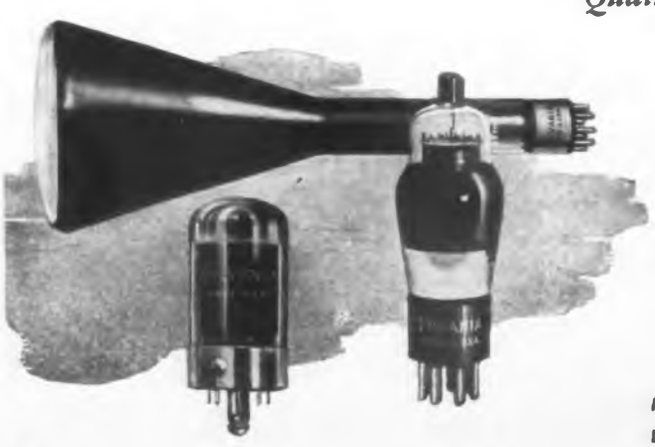

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SYLVANIA

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RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, INCANDESCENT LAMPS, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES

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"Mr. Dag"

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In the typical applications below, trace the record of some of these properties. You can do this simply by matching the ribbon colors against the property chart.

1 3 14 13 15

1, 3, 14, 13, 15
CITATION: "Die and punch life is increased and forgings having better finish are produced to closer tolerances with Dag colloidal graphite treated lubricants."

2 6 14 13

2, 6, 14, 13
CITATION: "Excellent electrical contact is obtained between copper oxide discs and adjacent metal electrodes in rectifiers when dry coatings of Dag colloidal graphite are used on the crystalline oxide surfaces."

1 2 3 14 8

1, 2, 3, 14, 8
CITATION: "Dag colloidal graphite is extensively used to impregnate asbestos packings for pumps handling chemicals and explosive fluids. It protects the packing against chemical action and provides safe, dry lubrication."

Check this list

and pick out those properties which you can use. Then state your problem to us and let our engineers give you the benefit of their experience. It is quite possible that they have already studied a parallel application. You'll pin a medal on yourself for calling in Mr. Dag.

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7 Particles Bear Like Electric Charges
8 Insoluble in Acids and Alkalies
9 Black and Opaque
10 Gas Adsorbent
11 Little Photoelectric Effect
12 Miscible with Most Fluids
13 Films Adhere Tenaciously and Dry with Sharp Edges
14 Microscopically Fine Particles. Penetrates Fine Pores
15 An Excellent Suspension

A TRIBUTE to the members of the Signal Corps, United States Army, for their great achievements in the field of military communications. On every front, from the development laboratory to the most remote outpost, they are doing their job superbly well.

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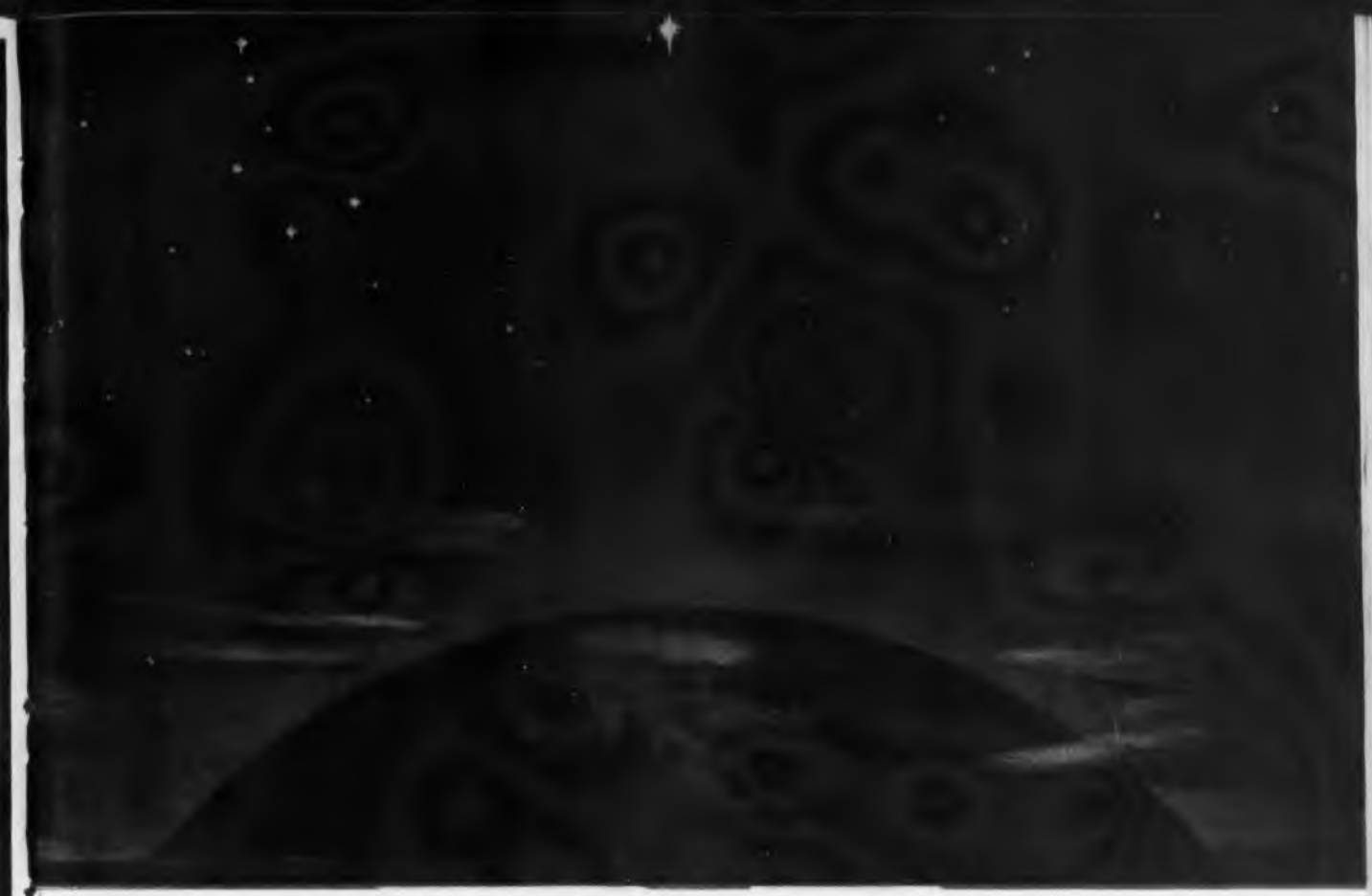

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First Awarded July 27 1942
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● Aerovox Types 1860 and 1865 capacitors are designed for ultra-high-frequency applications particularly in television and FM transmitting equipment, and also for critical electronic functions, operating at high frequencies. Readily adaptable for use as fixed-tuning, by-pass, blocking, coupling, neutralizing and antenna-series capacitors.

Losses are extremely low due to highly refined sulphur dielectric used. Corona losses are avoided by the unique design and construction, grounded case, and insulated terminal.

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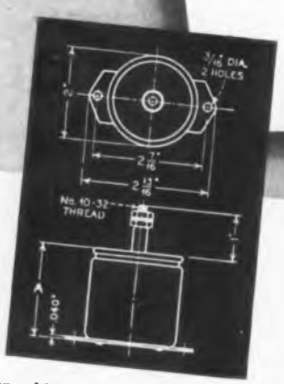
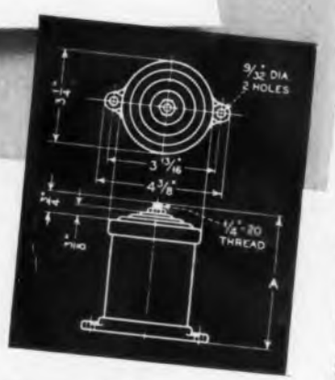


Type 1860 (see photo and above drawing) has suitably plated brass terminal mounted in mica insulating plate. Dimension A is from 2 to 3½".

10,000 test volts eff. .00001, .000025 and .00005 mfd.; 5000 v., .00005 mfd.

Catalog lists maximum current in amperes at operating frequencies from 1000 KC. to 75 MC. max., for both types.



Type 1865 (no photo, but see drawing above) differs in the use of cast-aluminum case and steatite insulator to support terminal and withstand higher voltages. Dimension A is from 2-11/16 to 6-11/16".

• • •

Tolerance for both types, plus/minus 10% standard. Available in closer tolerances. Minimum tolerance, plus/minus 2 mmf.

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- Precise measurements of frequencies

U H F

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NOW AVAILABLE HERMETICALLY SEALED

The UTC Ouncer type transformer is one of the most popular units in military equipment at the present time.

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Postwar Plans, Money and Manpower

Engineering management is faced with a puzzling dilemma when it turns to the problem of postwar design. Today management has enormous funds at its disposal. But spare engineering talent that can be deflected into peacetime design and thinking is scarce indeed. Later on, when peacetime rolls around, there will be plenty of engineers and designers available, but large operating funds will not be available.

The answer therefore, is that postwar designing has got to be started now, even on a limited scale. Each organization's peacetime operations can be outlined and planned at present, taking advantage of existing favorable conditions—without interfering with war work which, of course, must come first!

Re "Two Wavelengths in Every Garage"

Recent developments in transmission using frequencies in the centimeter range, have extended our facilities for communication. Contemplation of the 3,000,000 standard 10-kc bands that, mathematically, are available, in the range above 1-centimeter wavelength, has caused the "planners" to revel in new-found kilocycles, and in what these will do for John Doakes. "Two wavelengths in every garage" may be a future political slogan.

However, applying the cold facts of engineering analysis, and using as a yardstick, the best practices of the present, with a receiver stability of possibly ± 0.1 per cent, we can actually get only about 2800 bands. Moreover in the upper end of the range, it would seem that a wide swath may still belong to the experimenters for some time yet, and cut down the availability of even this number of bands.

It seems that for a while there will still not be enough frequencies available, and that people will still be given names at birth—instead of just assigning them a frequency!

Means for attaining greater precision and lower drift in receivers is the most important problem for the radio engineer to solve, for this one factor is the limit for the number of services that radio channels can handle.

Prewar Producers to Get First Chance Postwar

Charles E. Wilson, executive vice-chairman of the War Production Board, already has outlined one important principle of reconversion of prime interest to radio men. This principle would give first chance at civilian-goods manufacture to those factories which made such civilian goods prewar.

Significant, therefore, is the new WPB form that has been put in the hands of the electric-iron manufacturers who are now scheduled for limited civilian production. Known as Form WPB 3550.1, this application will prevent producers who have completed their war contracts from entering into the manufacture of a civilian product they did not make in 1940. This will be accomplished by setting production quotas for the 2,076,000 irons on the basis of 1940 output.

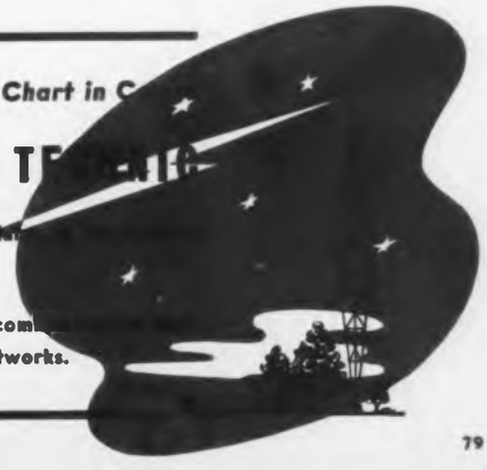
Particular significance is also attached to the terms of the application which safeguard maintenance of war production through required detail information on the amount of controlled materials which will be needed to fulfill quotas and the manner in which labor requirements will be met. The five questions on labor can be taken as an official declaration that it is no longer a question of materials that is holding back reconversion, but labor.

Supplement to This Issue *Large Chart in C*

BROADCAST NETWORK ENGINEERING T

Covering many phases of trans-continental hookup problems and pro
a network. How energy levels are built up to give nationwide coverage.

Compiled by the editors of Electronic Industries in collaboration with com
neers involved with the facilities of the principal nationwide broadcasting networks.



COUPLING METHODS FOR

by **WESLEY M. ROBERDS**

Engineering Dept., RCA-Victor Division, Camden, N. J.

Design principles of output transformers and various types of energy applicators for special jobs

● The applications of induction heating are legion and the special requirements of each given case must be considered before one can state just what are the proper values of frequency, power, and time to be used. However, the various heating jobs fall generally into two classes: the type of work that is to be heated more or less uniformly throughout, and the type where only a small part of the whole is to be heated.

The voltage (and hence the power) generated in the work by a given current in the inductor coil depends on the mutual reactance between the work and the inductor coil. This mutual reactance increases with the frequency. But after a certain frequency is reached other factors may become more important than mutual reactance. Among these are over-all efficiency, depth of layer to be heated, etc.

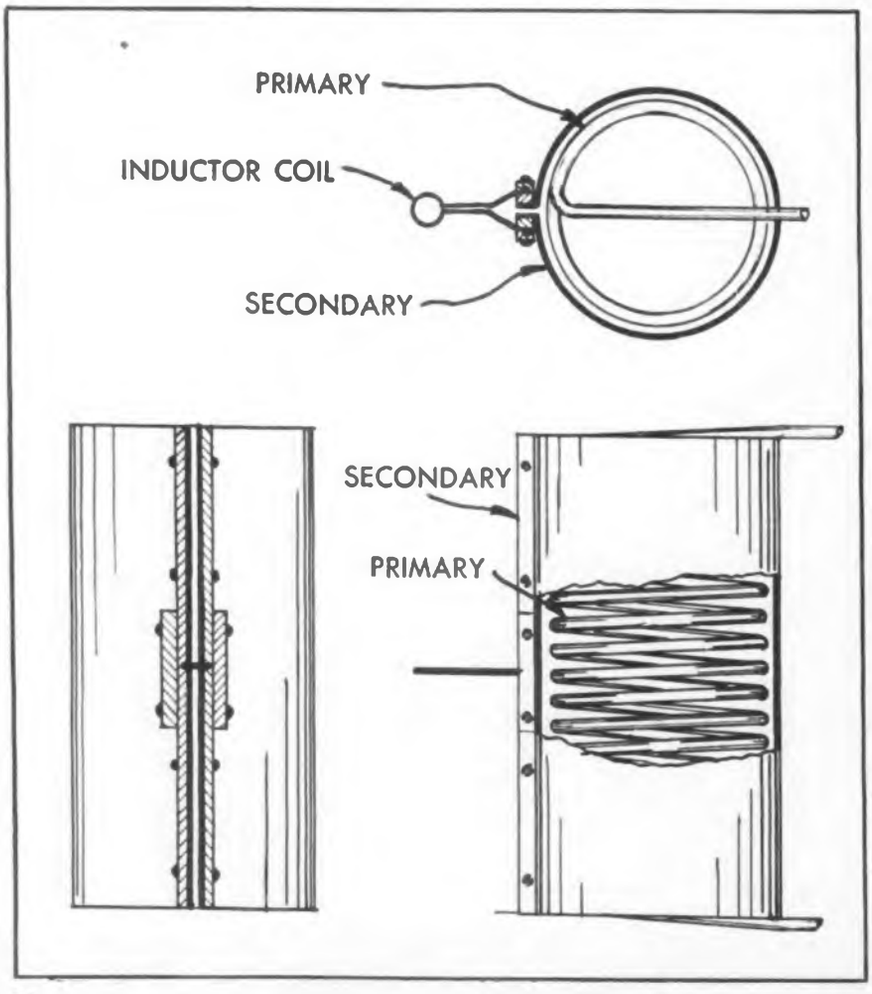
If a piece of work is to be heated clear through then the lowest frequency which is consistent with good coupling and efficiency is to be preferred. The lower the frequency the greater is the current penetration and therefore the more nearly uniform is the heating. To further increase the uniformity of heat distribution, low power concentrations and long heating times are also used.

On the other hand, in processes such as case-hardening of steel, the highest practicable frequency makes possible the most precise control of depth of heated layer. Because of the rapidity with which heat flows in a metal, such differential heating must be done with high power and short heating times. In fact, the power demands may be so great with certain technics that in order to use generators of reasonable size every available means must be used to concentrate the power.

Moreover, while it is not very difficult to design a generator which is capable of delivering 75 kw of power at frequencies up to 25 mc, the problem of concentrating that power in an area of one square inch is quite a different matter. The problem involves such factors as the actual shape of the area to be heated, frequency, type of coupling system, and the thermal and electrical properties of the work material.

For the "heat-through", low power concentration, class of work, the coupling may be accomplished by wrapping several turns of inductor coil about the work. Such a coil will have a considerable inductance and hence in some cases can be connected directly to the terminals of a rotating type generator, although a parallel tuning capacitor is usually also included. Or in case the generator is a spark gap or electron tube oscillator, the

Fig. 1—General purpose output transformer. Secondary is a split cylinder



INDUCTION HEATING

inductor coil can be made a large part of the tank circuit inductance.

On the other hand, in those classes of work where high power concentrations are necessary, it is best of course, to limit the applicator to a single loop around the work. But even one turn around the circumference of a 3-in. rod entails the simultaneous heating of so much area that the most powerful oscillators have difficulty in heating it rapidly enough for the self-quenching technics.

Self-quenching is used in case-hardening problems where very high powers are applied for times of the order of one tenth of second. In such short times, the heating is confined quite closely to the volume occupied by the induced currents. Thus, at the end of the heating cycle only a small fraction of the total mass of the work is heated. Heat is then conducted away to the cold parts so fast that the temperature of the surface drops even more rapidly than in a deeply heated piece which is immersed in a quenching medium.

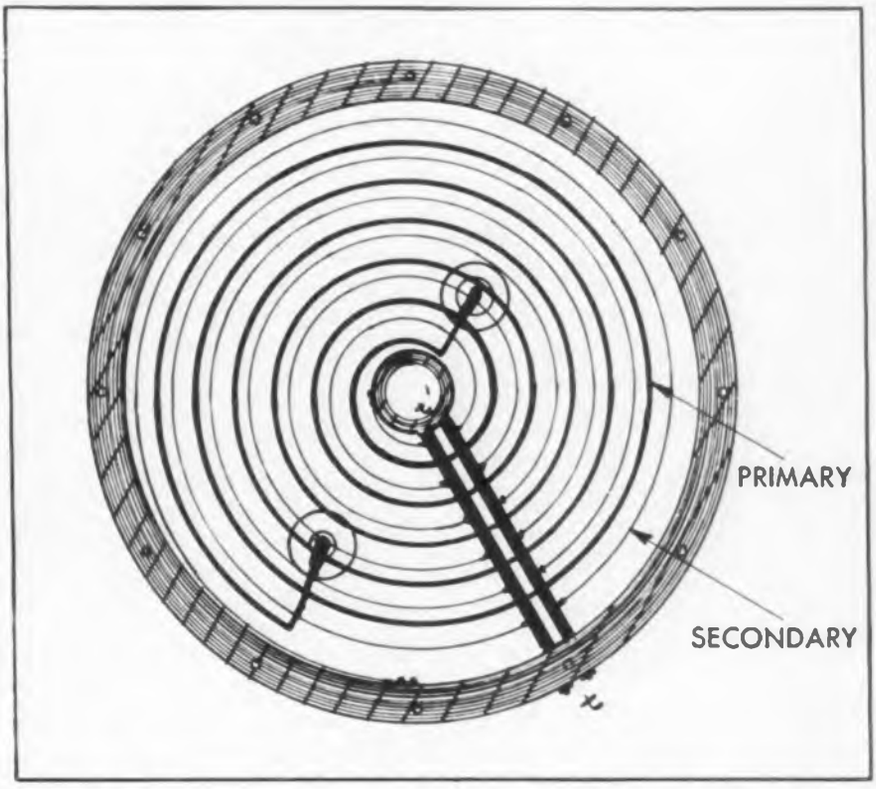


Fig. 2—Spiral type. Paralleled secondary loops interleave primary

Alternate methods

Although this technic requires power concentrations of 60 to 80 kw per square inch, the accuracy with which the hardened layer is controlled and the ease with which the operation is performed justifies its use.

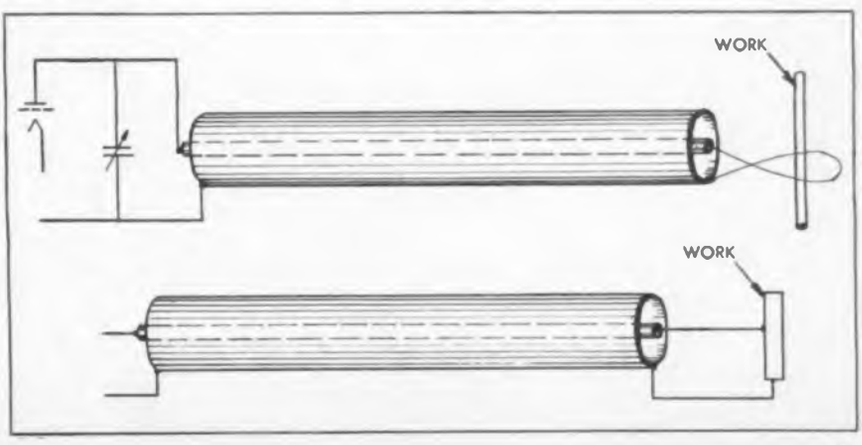
Suppose, for example that a 3-in. steel rod is to be heated by a single turn, loop inductor. The loaded inductance of the applicator coil is equivalent to approximately one tenth microhenry. At a frequency of 1 mc its impedance is only about .6 ohm. Therefore, in order to couple energy from the plate circuit of a power oscillator tube to this load requires either (1) that a tuning capacitor be used in parallel with the inductor, (2) that the frequency be several hundred megacycles, or (3) that some sort of impedance matching transformer be used.

A tuning capacitor would have to have a capacity of .1 mf and be capable of carrying 1000 amperes. Moreover it ought to be variable over a wide range. Such a device is far too bulky and expensive to be practical.

Very high frequencies cannot be used, even if it were possible to generate them at high powers, because at the necessary power levels the voltage drop around the loop would be so great that arcing would occur between the coil and the work. In fact, at powers in the order of 100 kw the frequency must be 1 mc or less in order to heat the 3-in. rod mentioned before.

In some instances the autotransformer principle is used. That is, the applicator coil is connected across one or two turns of the tank inductance. However, in such cases the coupling coefficient between tank circuit and load is low and unless a high frequency is used the efficiency is low. Moreover, there is likely to be considerable radiation loss.

Fig. 3—Coaxial "transformer" is useful for high frequency, low power jobs



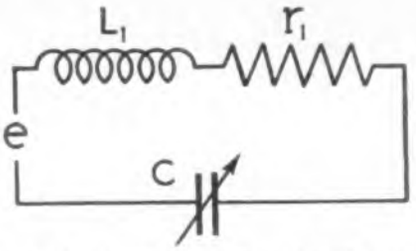


Fig. 4—Circuit for calculating efficiency

On the other hand, it has been found that a properly designed transformer of the isolated secondary type has very low radiation losses, can be made compact in size, and is highly efficient over wide frequency ranges.

In order to achieve the maximum amount of coupling between the oscillator and the work the entire magnetic flux of the tank circuit should link the transformer secondary. This can be approximated by connecting the primary directly across the tank capacitor and then making the secondary a single loop around the primary.

For proper impedance matching, the transformer's physical dimensions should be such that the secondary's impedance is of the same order of magnitude as that of the loaded applicator coil to be connected to it.

Split cylinder secondary

Probably the best general type of current transformer is the design in which the secondary is a split cylinder surrounding and forming an envelope for the primary, (Fig. 1). At power ratings of 1 kw or more, the primary should be made of copper tubing through which water can be passed for cooling purposes. Usually ten to twenty turns are desirable. The split cylinder construction of the secondary makes it essentially a one turn coil. It should be mounted rigidly with respect to the primary and with as small an annular spacing between primary and secondary as will withstand the voltage applied across the primary. The leads to the inductor coil are preferably taken out at the center of the secondary as shown in the figure.

By closing the ends and sealing the split in the secondary with some electrical insulating material the transformer may be filled with oil or compressed gas, to provide greater insulation between primary and secondary. Such a design is likely to be unsatisfactory mechanically, however, because it is almost impossible to make it oil or gas tight. Moreover, oil adds greatly to the weight, offers a fire hazard and is always messy.

A better plan for providing high voltage insulation is to enclose the whole transformer in a ceramic or steel envelope and then to fill it with oil or compressed gas. Leads can be brought out through insulating bushings.

In designing these transformers, it is generally customary to make the length about 50 per cent greater than the diameter, although there is no need to maintain this exact ratio. But when such relative dimensions are used the inductance of the secondary is roughly .02r μh where r is the radius in inches. Therefore, the secondary inductance alone of a transformer 10 in. in diameter and 15 in. long, is in the order of .1 μh which approximately equals that of a 3 in. inductor coil, loaded with a steel cylinder.

Spiral type transformer

Another type of coupling transformer which is highly efficient (up to 85 per cent) is a design in which the primary is a flat spiral and the secondary is a group of one turn loops interleaving the turns of the primary. Some idea of the design can be obtained from Fig. 2. In one model built to have a rating of about 100 kw the primary is made of slightly flattened, ⅜ in. copper tubing. The secondary leaves are about 3 in. wide and are connected in parallel. The device is enclosed by the outer secondary turn and by thick bakelite plates at top and bottom. The case is filled with oil for insulation.

Difficulties with this type of transformer are due chiefly to the inter-winding capacities which, while being useful as tank capacitor, nevertheless make it difficult to ground the secondary when used in a Colpitts circuit. Moreover, this type is mechanically more difficult to build than is the secondary envelope type.

A third type of "transformer" which is especially useful at frequencies above 10 mc is simply a coaxial line approximately one quarter wavelength long. A capacitor at the oscillator end allows a wide range in tuning if desirable. The applicator coil is connected between the inner and outer conductors as shown in Fig. 3. Such a "transformer" is useful for heating small objects where very high frequencies are needed and power requirements are not great. Efficiencies of 65 to 75 per cent are common, and the work can be at some distance from the oscillator.

Before proceeding with quantitative results, it may be well to define terms and to state briefly how the data were taken. By the term "coupling efficiency" of an applicator coil is meant the ratio of the power appearing in the load to the power input to the coil. Similarly, the "efficiency" of a transformer-applicator combination means the ratio of the power appearing in the load to the power applied to the input terminals of the transformer.

Most of these efficiencies were measured with a Q-meter. However, a few direct measurements of efficiencies on steel loads were made by measuring input powers electrically and the output powers calorimetrically. The two methods checked closely. The circuit whose efficiency is desired is connected across the "inductance terminals" of the Q-meter; the capacity is varied to tune to a given frequency; and the value of Q is read. This is designated as Q. The load is then inserted in the applicator and the circuit again tuned and the value of Q noted. This second value is de-

Fig. 5—Efficiency comparison of various transformer types.

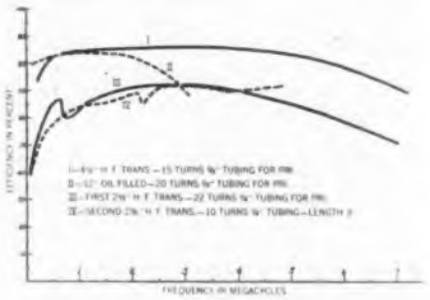


Fig. 6—Efficiency with typical metal loads.

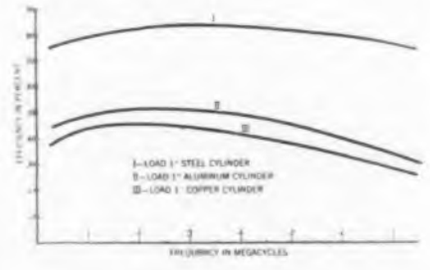
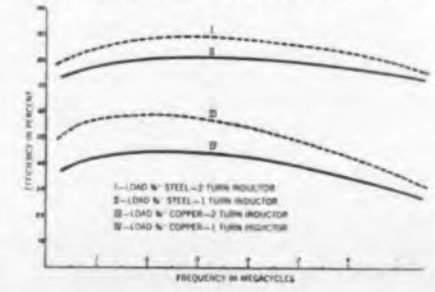


Fig. 7—Efficiency v. turns in applicator



signated as Q_2. The capacities necessary to tune the circuit in the two cases are called C_1 and C_2 respectively.

The "efficiency of coupling" is then found from the relation:

$$E = 1 - \frac{C_2}{C_1}\frac{Q_2}{Q_1}$$

This expression can be obtained in several ways. A simple but not very rigorous derivation is as follows (see Fig. 4):

Let the circuit under test be represented by an inductance L_1, a resistance r_1 which are connected in series with a tuning capacitor C. An emf e of frequency f_1 is applied and the circuit is tuned by adjusting the capacitor to a value C_1. The resulting current is i.

Now assume that the load is added to the circuit. The equivalent inductance is reduced to L_2 and the resistance is increased to r_2. In order to retune the circuit to the frequency f_1 the capacity is increased to C_2. The voltage is then increased until the current is again equal to its original value. This is necessary to make the losses in the coupling circuit equal to what they were in the unloaded condition. The efficiency is then

$$E = \frac{i^2 r_2 - i^2 r_1}{i^2 r_2} = 1 - \frac{r_1}{r_2}$$

In the unloaded condition the Q of the circuit was

$$Q_1 = \frac{L_1\omega_1}{r_1}$$

In the loaded condition

$$Q_2 = \frac{L_2\omega_2}{r_2}$$

Therefore in the above expression for E the values of r can be replaced by equivalent values of Q:

$$E = 1 - \frac{\frac{L_1\omega_1}{Q_1}}{\frac{L_2\omega_2}{Q_2}} = 1 - \frac{L_1\omega_1 Q_2}{L_2\omega_2 Q_1}$$

Replacing the ratio

$$\frac{L_1\omega_1}{L_2\omega_2} \text{ by } \frac{1/C_1\omega_2}{1/C\omega_2}$$

and noting that $\omega_1 = \omega_2$

$$E = 1 - \frac{C_2}{C_1}\frac{Q_2}{Q_1}$$

Since it is not easy to measure the coupling efficiency of an applicator coil alone, at the frequency at which it is used, and since it is generally used in conjunction with some sort of transformer, the applicator and transformer will be treated as a unit and their effects distinguished only when it is convenient to do so.

FACTORS IN COUPLING HF ENERGY TO WORK:

1. Speed, depth, and degree of heating required
2. Power, frequency, and stability limitations of oscillator
3. Thermal and electrical properties of work material
4. Type, size, and shape of area to be heated
5. Losses and interference due to work coil heating and radiation
6. Problem of matching impedance of oscillator to that of work

Outside loop inductors

The simplest type of applicator or inductor is one or more turns of tubing (usually copper) looped around the work to be heated. The efficiency of such a loop varies with a number of factors, among which are: the spacing between inductor and work, the frequency, the material of the work, number of turns in the inductor, size of the work, the radial width of the inductor, etc.

The efficiency of coupling between applicator and work varies with the spacing between these parts. It can be shown that for a single inductor with a radius (a) spaced so that its center is a distance (h) above an infinite conducting plane, the efficiency of coupling between the inductor and the plane varies as the ratio $\frac{a}{h}$. In the case of a finite curved surface the law still holds so long as the radius of curvature is at least eight times the depth of current penetration. For any given set-up of inductor coil and load, at frequencies high enough that the depth of current penetration is small compared to any radius of curvature, theoretical considerations show that efficiency should not change with frequency.

When the current transformer is included with the inductor coil however, the overall efficiency may vary markedly with frequency even though the radius of the work is several hundred times the depth of current penetration. Note for example, the curves shown in Fig. 5. Each represents the characteristics of a transformer of the secondary envelope type of different dimensions. Each transformer was used with the same inductor coil and work. The coil was a single loop of 3/16 in. copper tubing, having an inside diameter of 2-3/16 in., and the work was a steel cylinder 2⅛ in. in diameter. The efficiencies are measured from transformer primary to the work. In Curve II are plotted the efficiencies of a large oil filled transformer about 12 in. by 22 in. and having a power rating of over 100 kw. The primary was 20 turns of ½-in. copper tubing. It is seen that the efficiency is fairly high and constant from about 100 kc to over 2 mc. It becomes self resonant at about 3 mc.

Curve III is a similar plot for a small, air insulated, unit about 2½ in. in diameter and 7 in. long. The primary was 20 turns of ¼-in. tubing. It is seen that this transformer shows a "resonant point" at about 600 kc, although its fundamental frequency is at 9 mc.

Curve IV is the frequency-efficiency curve for another 2½ in. transformer whose length was 3 in. and whose primary was only 10 turns of ¼-in. tubing. The efficiency approximates that of the other 2½-in. unit. However, in this case the irregularity in the curve occured at about 2.4 mc rather than at 600 kc.

Experience with the two 2½-in. transformers indicated that perhaps one slightly larger and having a larger tube for the primary

(*Continued on page 174*)

BEHIND THE

Glimpsing some of the modern research facilities

1. Development tests being run on a new type of welding timer unit involve the use of a large mercury vapor rectifier tube

2. In addition to the Research laboratory, each Square D plant has its own product development laboratory. General view of the Detroit laboratory

3. A special room is provided for the spectrograph, which has a dark room adjoining

4. Automatic flux graph recording device developed by the laboratory. The piece on which the flux is to be measured is clamped into position at left. Machine automatically records its flux field contour on the circular chart

DEVELOPMENT SCENES

afforded by laboratories at Kollsman Instrument Division of Square D Company

5. Set-up in the Kollsman electrical laboratory to test small drag cup motors. Operator measures inductance and the "Q" of the unit with a bridge

6. Spectrographic densitometer in use. Automatic developing machine provides the film for analysis of spectrograph results shortly after the pictures are taken

7. A combustion furnace in use in test for free iron in oxide

FILTER NETWORKS FOR

by **GROTE REBER**
Stewart Warner Corp., Chicago

Characteristics of transmission line sections for band pass filters at 160 megacycles

● Wave filters in the ideal case are composed of pure reactive linear elements. Within the pass band the filter exhibits a pure resistance at its input terminals and accepts energy from the input device. Since no dissipation is possible within the filter, all accepted energy must appear at the output terminals and be transferred to the output device. For this reason the termination must be resistive to absorb the energy. Outside the pass band an infinite filter exhibits pure reactance at its input terminals and since a reactance cannot accept energy the filter appears as a perfect reflector to energy arriving from the input device.

The mathematical analysis predicts an instantaneous change from resistance to reactance as the frequency goes from the inside of the pass band to the outside. In the actual case this transition is more or less gradual. The quality of the actual finite filter can be estimated by the abruptness with which this change occurs. Available non-dissipative linear elements are capacitances, inductances, open and short circuited lines shown respectively in Fig. 1 as 1A, B, C, D. The current and voltage relations of these elements are given in the figure. Crystals are not included because such mechanical devices may be represented as composed of electrical equivalents in the form of inductance, capacitance and resistance.

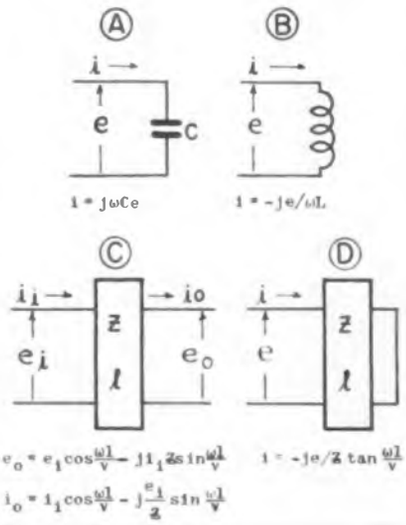


Fig. 1—Basic filter components with lumped C and L in (A) and (B). (C) is open line section, and (D) shorted line

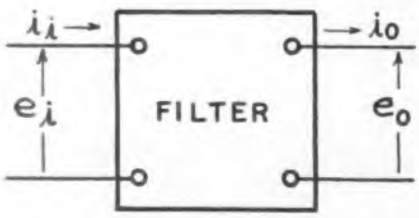


Fig. 2—General representation of a filter which may combine any or all elements of Fig. 1

Any filter may be represented in the general case as a box with four terminals as shown in Fig. 2. Inside the box there may be any combination of the elements shown in Fig. 1. Using the elementary voltage and current relations set out in conjunction with Kirchhoff's laws allows the entire system to be analyzed. Thus the voltage and current relations[1, 2] of any four-terminal symmetrical network can be stated in the following general form where subscripts i denote input side at left and subscripts o denote output side at right in all figures.

$$e_o = e_i A - i_i B \qquad i_o = i_i C - e_i D \qquad (1)$$

The nature of parameters A, B, C, and D will depend upon what is inside the box. A and C are dimensionless while B has the dimension of ohms and D is in terms of reciprocal ohms. The characteristic impedance of the network is

$$K = \sqrt{\frac{B}{D}} \qquad (2)$$

and the voltage transformation ratio is

$$\phi = \sqrt{\frac{C}{A}} = \frac{e_i}{e_o} \qquad (3)$$

Therefore the input and output impedances become respectively

$$K_i = K\phi \qquad K_o = K/\phi \qquad (4)$$

The pass band of any filter will be that range of frequencies where the network exhibits only a resistive component at its terminals. For this to be realized the value of

$$\cosh \theta = \sqrt{AC} = \phi A = C/\phi$$

must stay between plus and minus unity.

$$\begin{array}{lll} \text{At lower cutoff, } \omega_e & \phi A = -1 & \\ \text{At midband, } \omega_m & \phi A = 0 & (5) \\ \text{At upper cutoff, } \omega_\mu & \phi A = +1 & \end{array}$$

Beyond these limits K will be reactive. A useful check on the accuracy of the analysis may be had from the relation

$$AC - BD = 1 \qquad (6)$$

For most purposes the filter must have a constant transformation ratio over the pass band. Consequently ϕ must be independent of the frequency. Usually it is desirable to have K independent of the frequency also. However this seems to be impossible of complete reali-

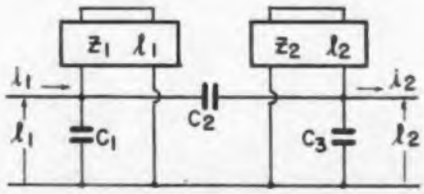


Fig. 3—Pi filter using shorted line sections in shunt branches and C_2 for coupling

UHF AMPLIFIERS

zation and the best that can be done is to hold K reasonably constant over a major portion of the band.

Practically all filters are used in conjunction with vacuum tubes. Therefore the input and output capacitances of the tubes must be considered. These are worked into the filter structure as elements and remove one very objectionable feature of the system; namely, the multiple pass bands characteristic of distributed constant networks.

π Networks with capacitances

One simple design consists of a pair of lines connected by three capacitances in a π configuration. This is shown in Fig. 3. In order that ϕ may be constant and independent of frequency let

$$l_1 = l_2 = l \quad \text{and} \quad (C_2+C_1)/Z_2 = (C_2+C_3)/Z_1$$

We then find

$$\phi^2 = Z_1/Z_2 = (C_2+C_3)/(C_2+C_1) \qquad (7)$$

and

$$K = \left[\frac{1}{\frac{2\omega(C_2+C_3)}{Z_1\tan\frac{\omega l}{v}} - \frac{1}{Z_1Z_2\tan^2\frac{\omega l}{v}} - \omega^2(C_1C_2+C_1C_3+C_2C_3)}\right]^{\frac{1}{2}} \qquad (8)$$

In the usual case, C_1, C_2, l, w_e and w_μ are known which leaves Z_1, Z_2, C_3 and ϕ as unknowns. By the use of equations (5) and (7) we obtain

$$C_2^2\left[\left(\frac{\omega_e\tan\frac{\omega_e l}{v}+\omega_\mu\tan\frac{\omega_\mu l}{v}}{\omega_e\tan\frac{\omega_e l}{v}-\omega_\mu\tan\frac{\omega_\mu l}{v}}\right)^2-1\right]-C_3(C_2+C_3)-C_1C_2=0 \qquad (9)$$

$$Z_1 = \frac{1}{\omega_e C_2(1+1/\phi+C_1/C_2)\tan\frac{\omega_e l}{v}} \qquad (9a)$$

Z_2 and ϕ may be had directly from (7). If C_3, l, ϕ w_e, w_μ are known, leaving C_1, C_2, Z_1, Z_2 as unknown, we have

$$C_1 = \frac{C_3[\omega_e(1+\phi)\tan\frac{\omega_e l}{v}+\omega_\mu(1-\phi)\tan\frac{\omega_\mu l}{v}]}{\phi\,[\omega_e(1+\phi)\tan\frac{\omega_e l}{v}-\omega_\mu(1-\phi)\tan\frac{\omega_\mu l}{v}]} \qquad (10)$$

$$C_2 = (C_1\phi^2-C_3)/(1-\phi^2)$$

Z_1 and Z_2 may be found from (9a) and (7).

Another configuration of considerable importance is shown in Fig. 4. Here the input and output lines are coupled by a small line at the base which acts as a type of mutual inductance. To make ϕ independent of frequency, two possibilities

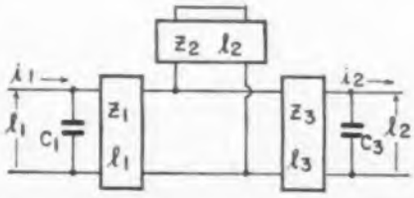


Fig. 4—Filter circuit using open lines at input and output coupled by section of shorted line

are available. The first requires that

$$l_1 = l_2 = l_3 = l \quad \text{and} \quad \frac{Z_1^2}{Z_3} = \frac{Z_1+Z_2}{Z_2+Z_3} = \frac{C_3}{C_1}$$

We then find

$$\phi^2 = \frac{C_3}{C_1} = \frac{Z_1+Z_2}{Z_2+Z_3}$$

However solving for Z_3 gives

$$Z_2 = -Z_1Z_3/(Z_1+Z_3)$$

which is a negative number and this solution is only a mathematical curiosity since lines of negative characteristic impedance are not available. The second solution requires that

$$l_1 = l_2 = l \quad \text{and} \quad C_1 = C_3 = C \quad \text{and} \quad Z_1 = Z_3 = Z$$

We then find

$$\phi^2 = \frac{Z_1}{Z_3} = \frac{C_3}{C_1} = 1$$

so, theoretically, it is only possible to build filters of unity transformation with this structure. Also

$$K = Z\sqrt{\frac{\frac{1}{Z}\sin\frac{2\omega l}{v}+\frac{\sin^2\frac{\omega l}{v}}{Z_2\tan\frac{\omega l_2}{v}}}{2\omega C\cos\frac{2\omega l}{v}-\frac{1}{Z_2\tan\frac{\omega l_2}{v}}\left(\cos\frac{\omega l}{v}-\omega CZ\sin\frac{\omega l}{v}\right)^2+\left(\frac{1}{Z}-\omega^2C^2Z\right)\sin\frac{2\omega l}{v}}} \qquad (12)$$

In the usual case w_e, w_μ, l, l_2, C are known leaving Z, Z_2 as unknowns. These may be computed from (5) and (11) to be

$$\begin{aligned}&Z^2\omega_e\omega_\mu C^2\left(\tan\frac{\omega_e l_2}{v}\sin\frac{2\omega_e l}{v}\sin^2\frac{\omega_\mu l}{v}-\tan\frac{\omega_\mu l_2}{v}\sin\frac{2\omega_\mu l}{v}\sin^2\frac{\omega_e l}{v}\right)\\&+2\omega_e C\left(\tan\frac{\omega_\mu l_2}{v}\sin^2\frac{\omega_e l}{v}\left(\cos\frac{2\omega_\mu l}{v}+1\right)-\frac{1}{2}\tan\frac{\omega_e l_2}{v}\sin\frac{2\omega_e l}{v}\sin\frac{2\omega_\mu l}{v}\right)\\&-2\omega_\mu C\left(\tan\frac{\omega_e l_2}{v}\sin^2\frac{\omega_\mu l}{v}\left(\cos\frac{2\omega_e l}{v}-1\right)-\frac{1}{2}\tan\frac{\omega_\mu l_2}{v}\sin\frac{2\omega_\mu l}{v}\sin\frac{2\omega_e l}{v}\right)\\&+\frac{1}{2}\tan\frac{\omega_e l_2}{v}\sin\frac{2\omega_\mu l}{v}\left(\cos\frac{2\omega_e l}{v}-1\right)-\frac{1}{2}\tan\frac{\omega_\mu l_2}{v}\sin\frac{2\omega_e l}{v}\left(\cos\frac{2\omega_\mu l}{v}+1\right)\\&=0\end{aligned} \qquad (13)$$

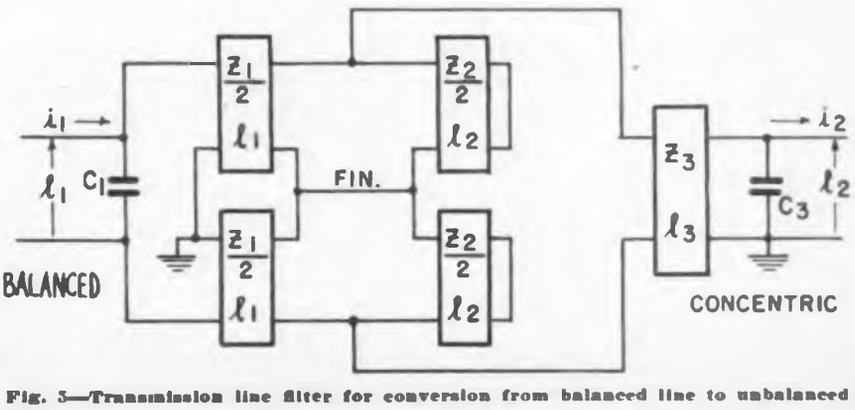


Fig. 5—Transmission line filter for conversion from balanced line to unbalanced concentric

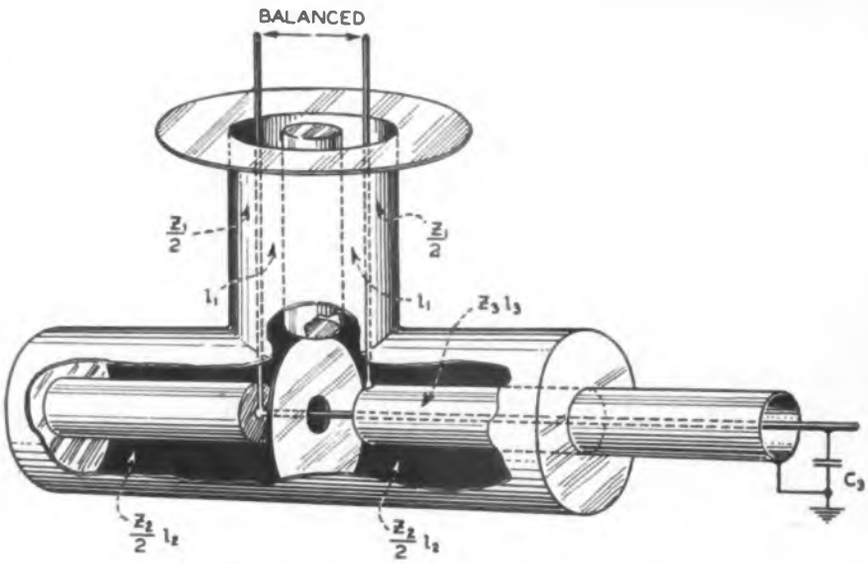


Fig. 6—Physical picture of coaxial line sections for filter in Fig. 5. Central spacing in illustration not in scale

$$z_s = \frac{z\left(\sin\frac{\omega_0 l}{v}\cos\frac{\omega_0 l}{v} - \omega_0 C z \sin^2\frac{\omega_0 l}{v}\right)}{\tan\frac{\omega_0 l}{v}\left(\omega_0 C z \sin\frac{2\omega_0 l}{v} - \cos\frac{2\omega_0 l}{v} + 1\right)} \quad (14)$$

l_s must be only a few percent of a wavelength to give a reasonable Z_s for most practical assemblies. Actually it is possible to build filters with large transformation ratios using this structure, by choosing l less than an eighth of a wavelength and invoking the approximations

$$c = \sqrt{c_1 c_3} \qquad z = \sqrt{z_1 z_3} \quad (15)$$

The values of Z and Z_s are computed on basis of unity transformation from (13) and (14). Z_1 and Z_3 are obtained from (15) and (11) as

$$z_1 = z\phi \qquad z_2 = z/\phi \quad (16)$$

Fig. 5 shows how the input and coupling lines may be split up into two series lines. Fig. 6 shows a suitable mechanical layout involving this configuration as a transfer device between parallel wire and concentric conductor transmission lines.

The scheme of mechanical layout shown in Fig. 6 can be adapted to any structure which has a shunt short circuited element at the base of an open series element. For instance the entire transformation from concentric low impedance to parallel wire high impedance can be performed in one structure as developed in Figs. 7A, B, C. Unfortunately since this structure is unsymmetrical the mathematics will not show any pass band but only two additional resonant frequencies where the edges of the band should be. Furthermore since only four, instead of five, elements are available the band width and transformation ratio are interrelated. The two edge frequencies are given by

$$\omega_e, \omega_\mu = \omega_m\left[\left(2+\phi \pm (4\phi+\phi^2)^{\frac{1}{2}}\right)/2\right]^{\frac{1}{2}} \quad (17)$$

The rest of the design formulas are:

$$\phi = C_1/C_2$$

$$1/\omega_m C_1 = z_1 \tan\frac{\omega_m l_1}{v} \quad (18)$$

$$1/\omega_m C_2 = z_2 \tan\frac{\omega_m l_2}{v}$$

Even with these limitations this structure is quite useful between low and high impedance systems.

A generalized impedance-frequency curve over the pass band is shown in Fig. 8. This is characteristic of all filters using two shunt terminated elements per section independent of the type of coupling. Adding more elements per section or cascading sections will make the rise at the edges steeper, producing a relatively flatter response over the pass band when worked into the proper load resistor.

By going to a really fancy configuration such as Fig. 9 it will be possible to obtain a very flat center portion and equally steep sides. The transition of the filter impedance from a resistance to a reactance as the frequency goes from within to without the pass band will be abrupt. If an impedance-frequency curve is computed it probably will be found to have three minima instead of one as in Fig. 8. The impedance-frequency curve of any chain of sections will depend almost entirely on the nature of the section which terminates the chain into the load resistor. The better this match, the flatter will be the response curve.

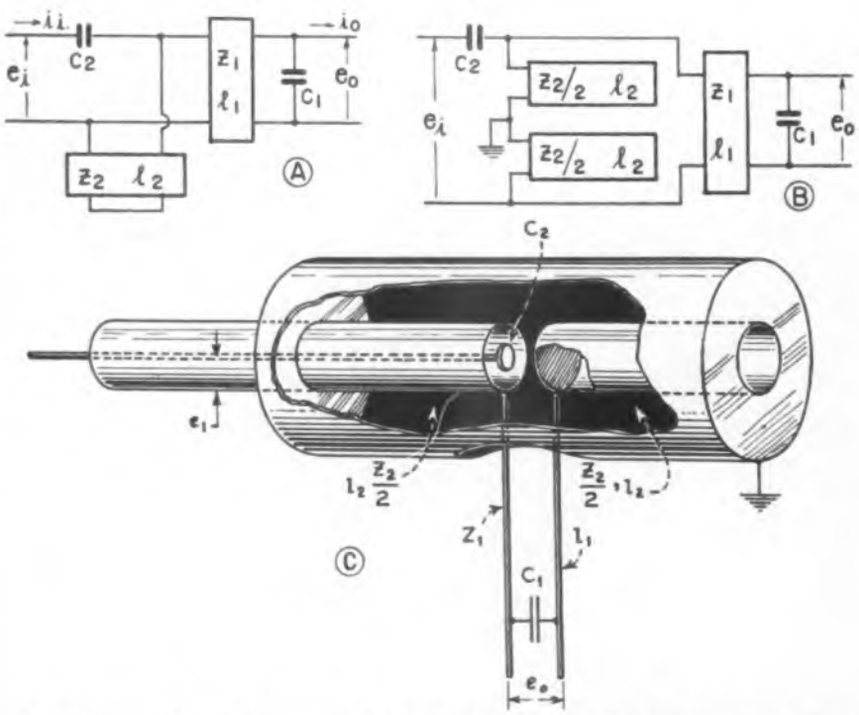


Fig. 7—Coaxial filter in block and physical forms for transition from low Z coaxial to high Z parallel lines. Spacing at center at C_2 actually is smaller than shown

Wheeler[3] has shown that the maximum resistive impedance which can be built up across any capacity is

$$K = 1/\pi f_w \sqrt{C_1 C_o} \qquad (19)$$

where f_w is bandwidth in cycles per second and C_i and C_o are respectively the input and output capacities of the network in farads; or conversely the output and input capacities of successive stages. Since the effective capacitance of the line (one-half the true capacitance between inner and outer conductors) is included in C_i and C_o it is apparent the lines should be short and of high characteristic impedance, so that the line capacity will be a small part of the total capacity. To reach the above limiting impedance it will be necessary to work from the simple to the complex as shown in Fig. 10.

10A and B are simple dead end filters where all the circuit capacity, input and output voltages and load resistor are effectively in parallel. There is little choice between these two. Splitting up the capacity by putting the input voltage at one end and taking the output voltage off the other end of the filter produces 10C. The midband impedance of this combination is K/2 compared to K/4 for the first two examples. 10D is not as good a choice as 10C because an extra section is required for the same result.

By adding another section to the output side and splitting up the output capacity into two parts, each of $C_o/2$, then applying one-half to the output of first section and the other half to input of second section we arrive at 10E. This filter has a first section which transforms from K/2 to K and a second section of impedance K. The net effective impedance of the combination is $\sqrt{2}K/2$. An alternate to 10E may be obtained by adding a second full section to front of 10C.

Thus in 10F the first section has an impedance of K and the second section transforms from K to K/2 which produces the same result as 10E. There must not be any resistor at open end of first section or half the power will be dissipated in it and the net result will be no better than 10C. Actually the energy arriving from the source splits into two equal halves on the input side of filter which is the connection between sections in this case. One-half travels to the right and is dissipated in load resistor R/2. The other half travels to the left and encountering an open circuit is completely reflected. Then it travels to the right and is dissipated in the load R/2 so that all the energy of the input circuit finally appears in the load resistor which is as it should be.

Fig. 10G shows a three section filter where both the input and output capacities are split up. The operation is the same as 10F. Here all three sections have an impedance K giving a total effective impedance of K which is the theoretical maximum attainable.

All these filters have been considered with the flow of energy from left to right. However they may be turned around by interchanging e_i and e_o with equal re-

(*Continued on page* 192)

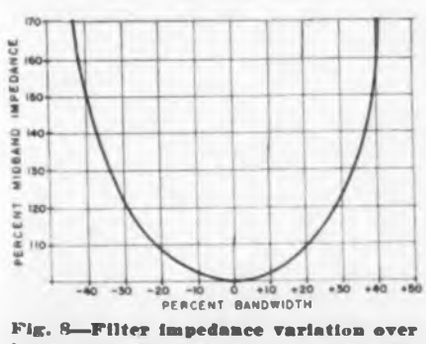


Fig. 8—Filter impedance variation over band pass for two shunt terminating elements

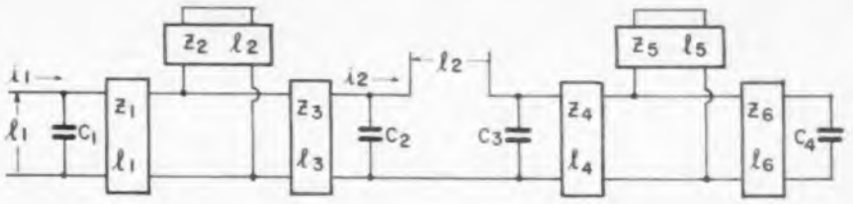


Fig. 9—Complex pass-band filter with good response characteristics for resitive load at output terminals 1.

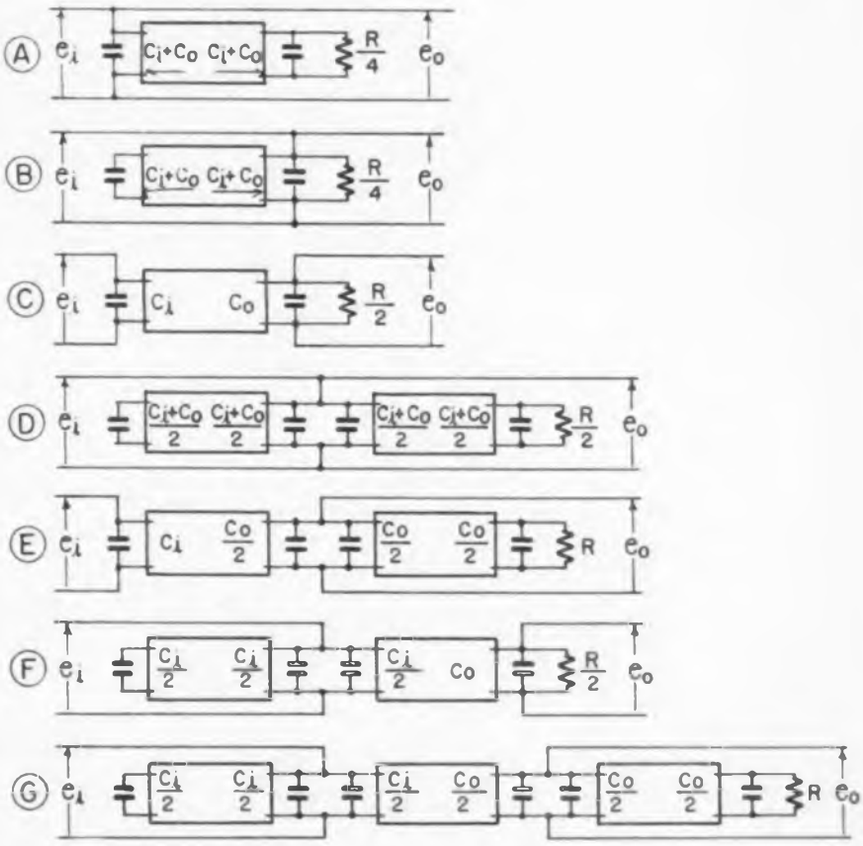


Fig. 10—Progressive filter arrangements, from simple at A to complex at G, for variety of circuit and load conditions

THE COVER

This Kodachrome, made by the US Signal Corps, and showing an Armored Division corporal operating from a half-track reveals the manner in which combat forces have been trained to take every advantage of natural camouflage.

BROADCASTING NETWORK

(See Chart Supplement With This Issue)

Problems involved in producing a program and maintaining a high order of fidelity over 70,000 miles of lines and hundreds of terminals linking broadcast stations

● The chart in colors, included in this issue, calls attention to some of the current practices and facilities of that parent organization of all electronic fields of activity—the radio industry and its associated branches. It shows graphically how program transmission is effected over a typical broadcasting system network, with a program originating in a Hollywood studio, and being broadcast by a New York station, one link only in a nationwide network. The network outlined on this chart is that of CBS, one of the four major systems operating on the regular broadcast frequencies. Much of the information dealing with terminal facilities on this chart was obtained through the courtesy of the engineering group of this network.

Few of the radio audience listening in New York to a West Coast network program realize the path of transmission and the tremendous number of electronic devices linked together forming this path before the program is heard from a loudspeaker. Undoubtedly few radio engineers except those who are associated with such a network, have kept abreast of all the procedures that have been built up to take care of the fidelity of tone and smoothness of operation that the broadcast listening public demands.

It is manifestly impossible to show in one place all of the facilities that must be handled by the operating staff, when the program must be transferred to the hundreds of remote stations that are to be connected and disconnected according to the network's needs.

Many repeater points

The chart shows the program originating in the CBS Hollywood studio of KNX where it is handled by the West Coast Master Control, and then sent over circuits of the Long Lines Department of the American Telephone & Telegraph Co. to the CBS Chicago Master Control. From Chicago, Long Lines bring the program to the Master Control board in New York and other facilities shown at the right-hand part of the chart, and then through a standby studio before it is sent out over special lines to the 50,000 watt key transmitter WABC, located on an island in Long Island Sound near New York City.

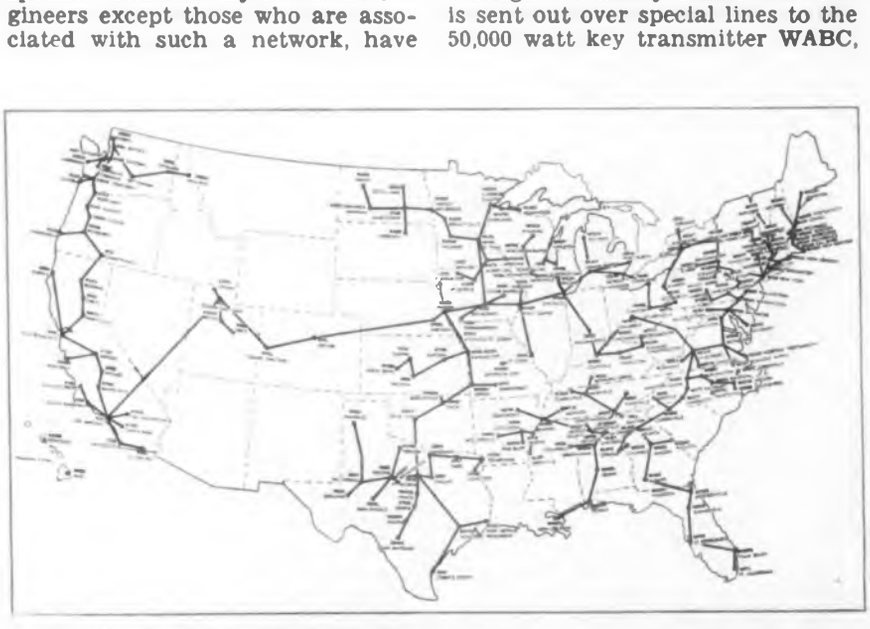
A single program originating on the West Coast passes through several hundred vacuum tubes before it reaches the loud speaker of a home receiver. These tubes range in size from the small type, such as is used in a receiver, to the 100 kw water-cooled type used in the broadcast transmitter.

In any broadcast network there are many amplifying equipments installed at all the key stations on its chain, with duplications of all important items at all of the other associated stations as well. The key stations are capable of handling several different program transmissions simultaneously. Also at the finger tips of the control engineers, spare equipment of each item can be substituted in a matter of seconds in case of failure. Possibly 20 program amplifier channels are available at all times in any of the larger network stations.

In the lower left-hand corner are pictured some of the facilities associated with a single program—the large studio with its numerous microphones connected in and out at will to give the greatest fidelity of reproduction. Each is handled through its own preamplifier, mixers, attenuation controls, and booster and channel amplifiers, reaching one of the transcontinental program lines, which ties the network together as a unit. The RCA pre-amplifier and program amplifiers illustrate typical applications of the use of vacuum tube amplifiers in program control.

Special facilities

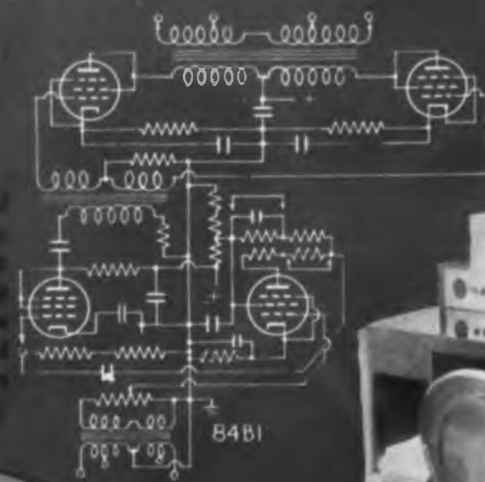
Other amplifier arrangements with special characteristics are also a part of the control engineer's stock of trade, together with reverberation chambers and cueing and sound effects facilities. His work is varied and all important. Branched lines transfer the program about the studio and to local transmitters. From the studio the program goes to the telephone lines.



MUTUAL BROADCASTING SYSTEM—Location of basic and affiliated stations and wireline tie-ins of Mutual (WOR New York) with 220 outlets

Broadcast technicians monitor continuously at junction points on networks, where other side branches join. Besides the four major networks, many regional networks are handled over the Long Lines system.

At the New York master control the signal has a level comparable with programs from local studios and can be handled through regular program amplifiers, such as that shown here, and is switched directly at the master control desk, to the local transmitter and other parts of the network.



...y repeater stations, each ...nuation equalizer to flat... ...gh frequencies (item HF) ...). It also has delay equal... ...an attenuation equalizer.

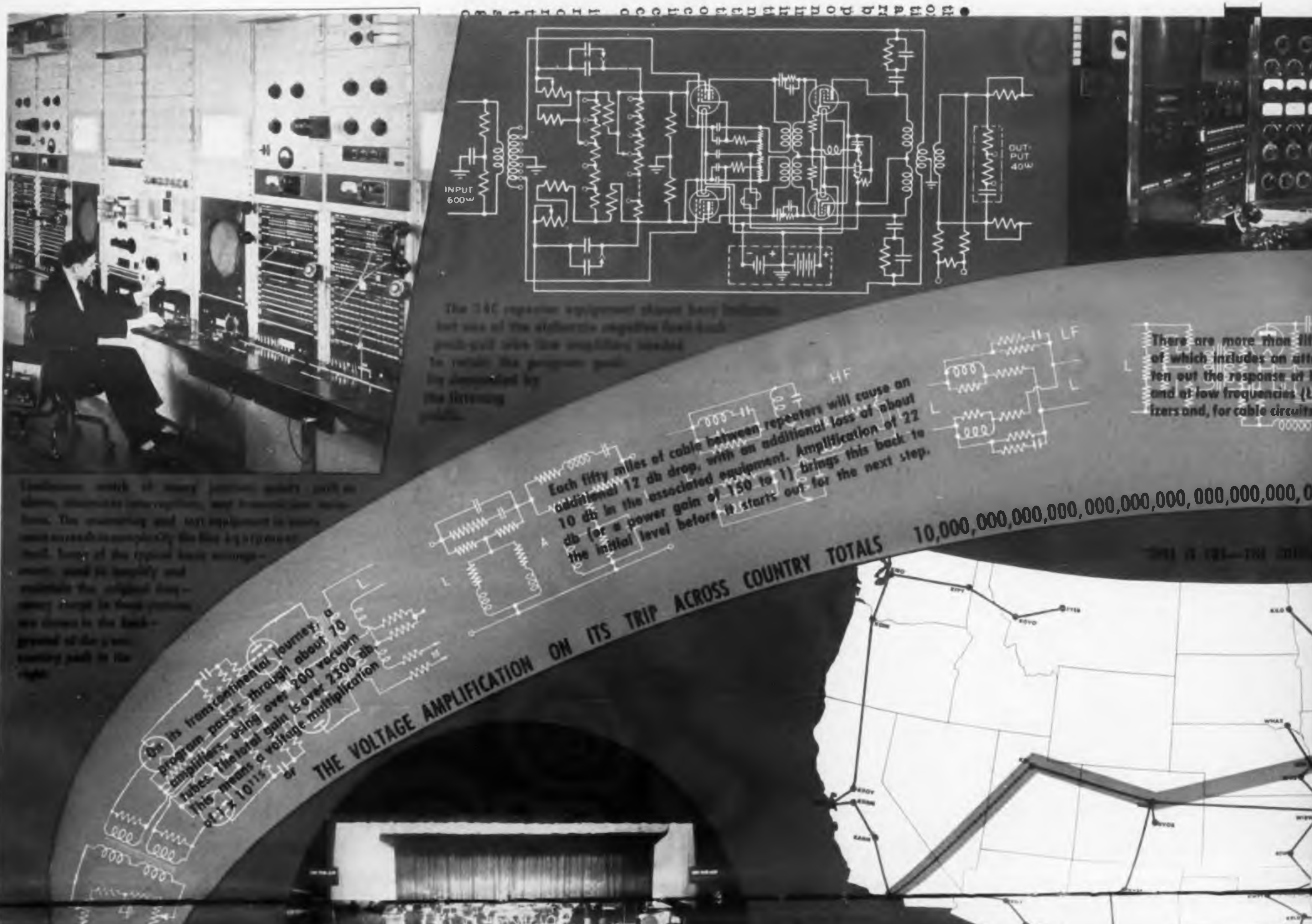
The minimum level applied to a line is limited by the possibilities of picking up noise—or another program. The maximum is limited by the possibility of crosstalk into other lines and by the introduction of distortion.

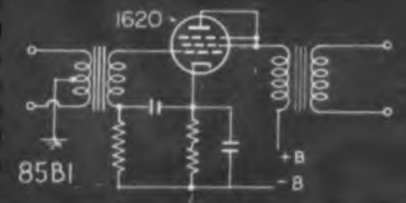
...00,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000, 000,000,000

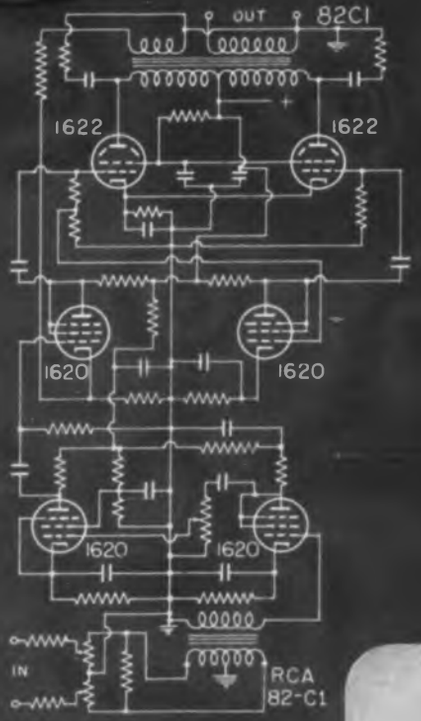
In each case the repeater amplifiers are of a type suited for open wire or cables as the particular circuit requires.

...HE BROADCASTING SYSTEM".

The ... program ... originating ... at different ... is now transferred to the WABC transmitter, on ...ng Island. Here the power is jumped to 50,000 watts, an increase of some 8,000,000 times


INPUT 600W
OUT-PUT 40W
HF
LF
Each fifty miles of cable between repeaters will cause an additional 12 db drop, with an additional loss of about 10 db in the associated equipment. Amplification of 22 db (or a power gain of 150 to 1) brings this back to the initial level before it starts out for the next step.
On its transcontinental journey, a program passes through about 70 amplifiers, using over 200 vacuum tubes. The total gain is over 2300 db. This means a voltage multiplication of 1×10^{115} or
THE VOLTAGE AMPLIFICATION ON ITS TRIP ACROSS COUNTRY TOTALS 10,000,000,000,000,000,000,000,000,000,000,000,000



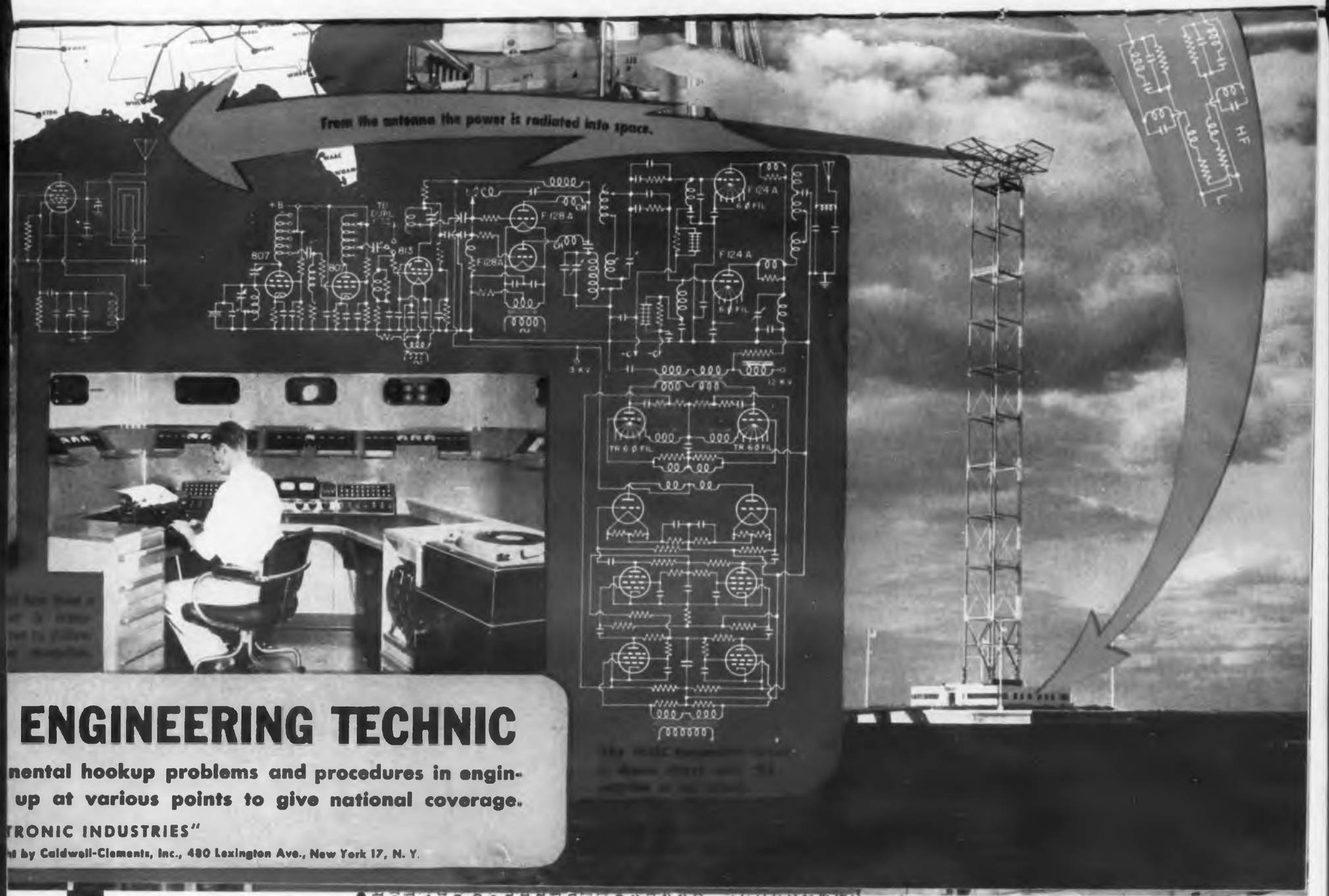


BROADCAST NETWORK

Calling attention to the many phases of transcont
eering a network. How energy levels are built

COMPILED BY "ELEC

Supplement to ELECTRONIC INDUSTRIES, APRIL, 1944 ★ Copyri



ENGINEERING TECHNIC

nental hookup problems and procedures in engin-
up at various points to give national coverage.

TRONIC INDUSTRIES"

d by Caldwell-Clements, Inc., 480 Lexington Ave., New York 17, N. Y.

ENGINEERING TECHNIC

In spite of the large number of key stations associated with each broadcasting network, most of the area of the country is dependent on stations that cover local areas. Because of the networks, local stations are not circumscribed as to selection of talent and program material from a single metropolitan area, but programs from any part of the country become available to the system. In both cases the telephone company facilities are available with specialized services that will supply station links with any degree of quality. For adequate coverage of an area as large as the United States with a variety of programs, by far the most effective and economical general service at present is provided by the land-wire networks.

Lines link 900 stations

This Bell System network now links into several broadcasting chains the majority of the country's 900-odd radio stations. The circuits permanently in use for this purpose have a total length of about seventy thousand miles. Moreover, countless thousands of miles of telegraph, teletype, and telephone message circuits must be always ready for the control of quarter-hourly switching operations. More than 2,500 high-quality vacuum tube amplifiers are available as repeaters on the network circuits. About 1,000 Bell System transmission specialists are available for the constant operation and maintenence of the four major networks and some thirty regional "webs".

Most of the open wire and cable facilities used in providing his network service are set up to transmit to an upper frequency limit of about 5,000 cycles. However, when wanted, channels transmitting up to about 8,000 cycles can be provided. In designing amplifiers, cable and open wire installations, and all associated equipment, this practical ideal of an 8,000 cycle range has been kept in mind. It is appreciated probably only by the radio engineer that this higher fidelity has been attained in spite of the hundreds of amplifier stages that are involved where frequency limitations and distortions normally pile up in such cascaded systems.

In addition to considerations of frequency range, many other factors enter into the design and installation of program transmission circuits. One of these is the volume range. The maximum volume range of a large orchestra under normal conditions may be as much as 60 db, corresponding to an energy range of a million to one or even more. While reproduction of such a range might be a legitimate aim of radio broadcasting, the average room where radio listening is done can accommodate only about 40 db of range. Actually, the average radio broadcast uses some kind of volume compression for better coverage so the volume range actually heard from the receiver seldom exceeds 30 db.

In the upper left hand corner of the chart, photos and circuits show a few of the many parts of the radio transmission job handled over the telephone system. Across the background of the chart is a brown tinted information band, pointing out essential technical facts on the broadcast system and its interconnections—with particular attention to the energy handling characteristics of the vacuum tube amplifiers of the system.

It is a basic policy never to let the program volume reach too low a level or to get too far out of line with regard to its quality characteristics. Special amplifiers (see circuits on the background of the brown strip for basic details of typical arrangement of amplifier and characteristic-correction networks) are installed at 100 to 200 mile intervals on open wire lines, at more frequent intervals on cable circuits. They are equipped with equalizing networks that keep the low frequency end of the range at the required level (item L), and the high frequency end of the range up to normal (item H) and attenuation equalizers which compensate for temperature and other effects.

Fidelity maintained

An unavoidable effect encountered in long distance wire transmission of voice or music is "delay distortion". The middle range frequencies tend to arrive first, while the arrival of both the high and low frequency components is delayed. These effects become noticeable with overall delays greater than about 8 milliseconds at the upper limit of the band transmitted and about 15 milliseconds at 100 cycles, both referred to time of arrival of 1,000 cycles. Delay distortion is minimized as much as possible by careful attention to the design of amplifiers, lines and cables, loading coils, and other factors. Residual delay effects remaining in the circuits may be further reduced by a "delay equalizer", one type of which is shown in schematic form on the chart as a part of the back-

NATIONAL BROADCASTING SYSTEM—Facilities of NBC, of which WEAF New York is the key station, include this array of 145 affiliated stations

THE BLUE NETWORK—This network, with key station WJZ New York, now comprises a total of 181 affiliated stations, linked together by wire

ground of the brown tinted strip.

The chart does not touch on the elaborate system of cueing, network intercommunication facilities, test schedules, time checks and the auxiliary network coverage using point-to-point radio relay routes where programs jump from station to station on ultra-high frequency chains without wireline needs. In these and in many other facilities, the engineering features are ahead of the needs of present-day procedure, so that no matter what happens methods are available to meet future requirements.

At New York, the signal is delivered to Master Control at the same level as it was at the start (8VU) and can thus be handled as easily as locally produced program material. The block diagram here again shows only a few of the many channel control facilities available for monitoring, cueing, and the switching necessary before the program can be transmitted to the island home of the key station, WABC. Here for the first time, the program gets out of the small current level. As noted in the WABC simplified schematic (at the lower right) the signal is built up to modulate the pair of giant water-cooled tubes that energize the uniquely designed and located antenna, as shown.

All of this energy broadcast to the world is "spread pretty thin" by the time it reaches the outer fringe of its listeners, the many kilovolts at the start becoming a few microvolts at the receiving antenna. Here the problem is taken over by the engineers of the broadcast receiver industry who have developed many methods for building the signal up again to the required levels.

The object of all this is represented by a typical home scene at the lower center. The networks of the country, large and small, all combine to give the thirty-odd million receiver equipped homes of the country an array of talent and choice of programs that exceed the wildest plans of those who started the industry a couple of decades ago.

The CBS key station WABC transmitter, was designed so as to increase the primary area coverage by pushing out, to a greater distance, any fading area. The station was, therefore, located on a small island on Long Island Sound which was built up by a sea wall and a large fill-in which provided the foundation for the 410 foot mast with its special "top-hat" construction, shown on the chart. The Federal Type 162-A transmitter whose basic circuit is shown, delivers 50 kw. It consists of two Federal Type 124-A water-cooled tubes, operating as a Class C amplifier. Every provision has been installed to provide emergency service should anything happen to any of the facilities on the island. The program from the studio control desk reaches the island over wires by two different routes and if these should fail, there is the additional short wave emergency link operating on a frequency of 330.4 megacycles using the frequency modulation system.

Emergency equipment

Should power fail, the station can be operated from a gasoline engine-driven generator. The main transmitter, shown in the diagram, will deliver 50 kw at 100 per cent modulation using high level modulation. The building at the base of tower contains not only the transmitting equipment and the emergency transmitter, the spare gasoline generator equipment, but also heat exchangers which absorb the heat from the distilled water used for cooling the tubes, and living facilities for engineers.

The major networks, shown herewith and on the chart, are supplemented by numerous other local systems extending over a single area or section and provide individual stations with the best programs of the group. Each network shown in the maps, the Blue, Columbia, Mutual and National systems, are also linked with certain stations outside of the boundaries of the U. S., Canadian and Hawaiian, etc., are attached at particular times. Since programs can (and often do) originate at any point in the country, many auxiliary signal channels, even to the standardization of the operating clocks at all points, become necessary. These nationwide networks enjoy a reputation for regularity not exceeded anywhere else in the world.

CLOSE-UP of the 12-kv rectifier installed at Station WABC, Columbia Island, and manufactured by Federal Telephone & Radio Corp., an affiliate of IT&T

AUTOMATIC CALIBRATION

Motor driven recording system reads calibration settings precisely while dial is in motion

• An electronic means of replacing mental and manual operations requiring many operators was portrayed in one of its most spectacular roles, by Mr. David Sunstein, Philco engineer, at a meeting of the Philadelphia section, IRE, on March 2. Mr. Sunstein described an automatic calibrating circuit for wavemeters that recorded the dial readings for hundreds of calibration points of a precision wavemeter. These readings were not only recorded at a rate of 30 per minute with an accuracy of 0.01 but the interpolation constant, or the difference between each two readings was recorded at the same time, to permit further subdivision of the calibration intervals at a later time.

Readings memorized

The dial on the wavemeter must be read at several points: a slow drum dial (two digit) a fast moving dial (two digits) and a vernier attached to the latter(one digit) giving a five-place reading to be noted. The dial of the meter is continually moving during the calibration, the exact readings are caught "on the fly" and memorized by a bank of cold-cathode thyratrons (Type OA4), long enough to be transferred to automatic key-punch solenoids on an adding machine. The resulting instrument contains 126 tubes functioning in many ways throughout the circuit.

The equipment makes use of a number of novel and ingenious electrical circuits, accompanied by a precise mechanical set-up, since five-place mechanical accuracy requires the utmost precision, no matter where it is to be handled, electrically or mechanically.

The main principle makes use of the storage of the precise dial reading on the bank of the tubes, each time the emitted frequency passes through zero beat with the harmonics of a standard frequency. These harmonics are consecutively tuned in by synchronously moving tuning circuits, so that there is no ambiguity as to which harmonic is being read.

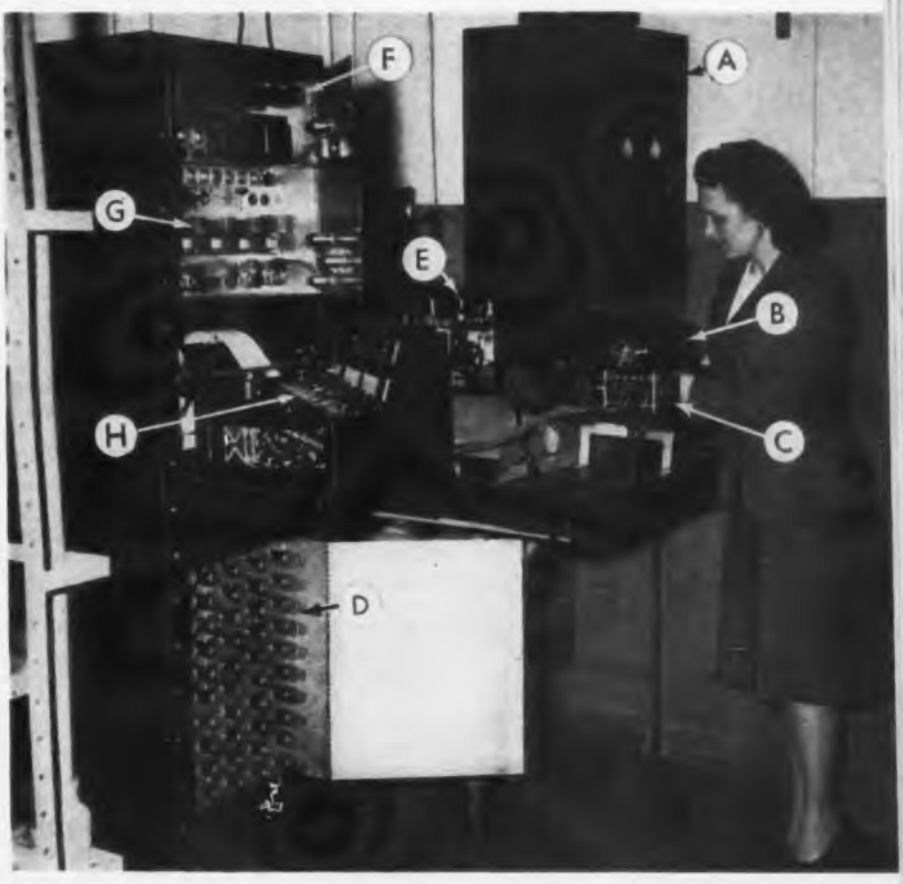
By a method of applying electronic differentiating circuits, the normally-broad zero beat signal envelope was sharpened by heterodyning the standard frequency with the moving frequency twice, with a 90 deg. phase shift between them, and recombining them so as to always produce a definite envelope pattern. The zone of action at the zero beat point was further sharpened by the use of "tripler" circuits after the first mixer.

By this combination, the zero beat point was consistently determined well within the space along the dial represented by a single vernier unit. The five recorded digits are thus set up on the thyratron bank and the recording mechanism sets to work. While the latter is functioning the wavemeter is rotated along toward the next calibrating point.

The calibrator is here shown in use. Here A represents a source of standard frequencies, consisting of precision crystal oscillators with their associated frequency dividers, calibrated against WWV, so that the exact frequencies needed during the calibration are at hand. At B is shown a frequency meter being placed on the calibrating stand, where it can be rotated continously from one end of each range to the other, by a motor-drive. This motor-drive transfers the dial readings into corresponding positions of the rotors of a five-bank synchronously-driven decade switch C. The beat frequency pulse that is produced each time the two frequencies meet as a zero beat, pass through corresponding contacts on the switch and set up individual tubes in the thyratron tube bank, shown at D.

The heart of system, containing the above-mentioned heterodyning and differentiating circuits, is shown at E, with its circuits kept in tune with the output of the frequency meter by geared con-

(*Continued on page* 198)



The Philco electronic recorder calibrating a Signal Corps frequency meter with completely automatic operation

Process CONTROL METHODS for INDUSTRIAL USES

by **RALPH R. BATCHER**
Consulting Editor

Part III—Reluctance-variation type converter units prove useful in many displacement measurements

● Methods have been shown previously in this series whereby small displacements of either a static or a vibratory nature could be amplified and measured by electronic means. These methods were the use of frequency changes in an oscillatory circuit and resistance changes in a special resistor unit.

The use of variations in the reluctance of a magnetic gap is also a popular electrical method of displacement study. It, also, is capable of showing static or dynamic movements. The reluctance changes may be utilized (1) as a change in the coupling between the primary and secondary of a transformer, Fig. 1a; (2) a change in inductance measured as such, in a bridge circuit, Fig. 1b; (3) as an inductance change which alters the frequency of an oscillator, Fig. 1c; (4) in conjunction with a permanent magnet as a generator of electromotive forces, Fig. 1d; or (5) as phase-shifting device, Fig. 1e.

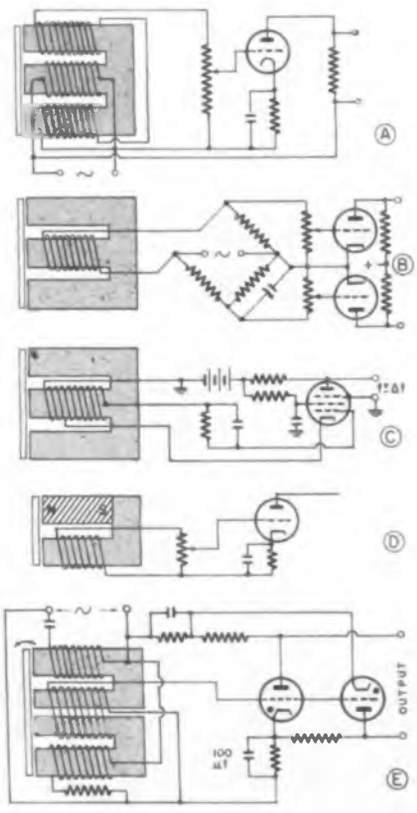


Fig. 1—Reluctance type units in five basic displacement measuring circuits

Most arrangements using the above methods can be assembled as low impedance devices, which permit their connection to electronic devices through rather long leads, at least when used at low vibrational speeds. The amplication circuits shown in Fig. I all use the above principles as pickup or conversion units and extremely small movements of the armature can be made to produce substantial output currents. All of these except C deliver a voltage variation which can be measured or further amplified (if necessary) for control purposes.

The circuit C, is an oscillator which produces a frequency change that is dependent on the movements of the armature. The variation of the frequency of the oscillator is not unlike that of the capacitance variation shown in Part I of this series, but here there are additional parameters due to the magnetic circuit and the frequency change is usually determined by experiment.

These devices must be carefully assembled and mounted to permit a permanent calibration of output in terms of movement. The central or magnetizing coil should have enough turns to produce saturation flux in the armature with no airgas. Any convenient coil can be used if a variable ac voltage of a suitable frequency is at hand to produce a saturation level found most satisfactory by test. The armature may be a part of the machine or device itself or it may be a separate disk or plate of steel suitably suspended across the open ends of the coil assembly so as to be controlled by the effect under investigation. In any case, resonance effects produced by the mass of the armature and the compliance of the spring must be entirely out of the range of the vibrational frequencies encountered. At low frequency vibrations, of a few excursions per second, a 60 cycle driving frequency may be applied, but in studying the usual machinery vibrations a higher frequency source must be applied. If a dc is applied to the input of system A, the resulting arrangement corresponds to that of D.

A variation of the arrangement shown in Fig. 1 can be made the basis for a great many industrial

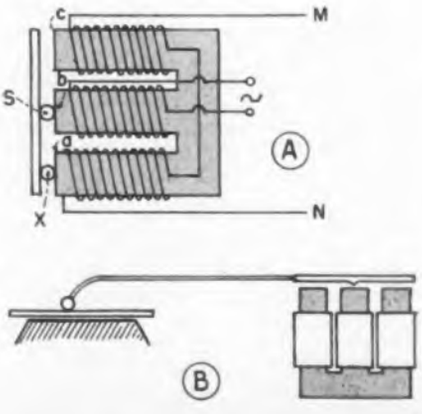


Fig. 2—Magnetic units used in production thickness-gaging applications

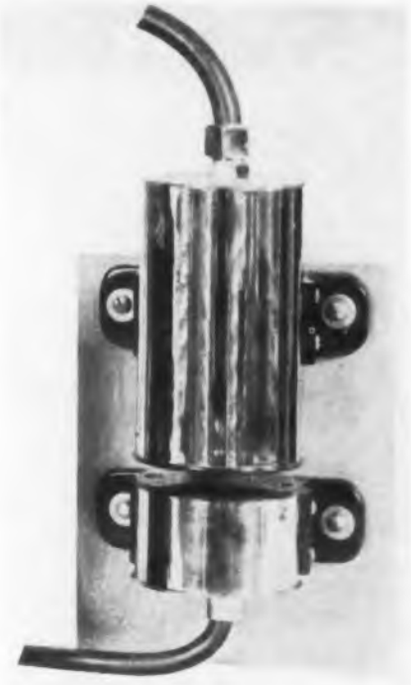


Fig. 3—Commercial thickness gage (G-E Co.) for metal foil measurements

test set-ups by the reversal of one of the coils on the outer legs of the magnetic structure, as shown in Fig. 2a. It is evident that as long as the airgaps at the ends of the structure are equal, no voltage will appear at the terminals MN.

Here assume the faces, a, b and c are ground perfectly in the same plane. A few examples of typical applications follow. At (b) in Fig. 2a, let S be a pin, wire or tube whose diameter is definitely known. It can be of magnetic or non-magnetic material but must be symmetrically placed at the center of pole b. At either end (such as at x), are placed the unknown or test pieces whose diameters are to be compared with S. These test pieces must be non-magnetic. As long as the armature is maintained in a parallel position with respect to the pole pieces, no output exists but with sufficient amplification, the slightest variation in the relative airgaps will cause a substantial reading on an instrument of a suitable type (ac milliammeter or oscillograph). It is also possible to place the standard spacer on pole c instead of on pole b.

A pivoted armature as shown in Fig. 2b, has an extension arm equipped with a roller. The unit is calibrated so as to continuously measure the thickness of any sheet material (paper, cloth, metal) as it comes from the rolls. The sheet passes between the roller and the anvil below it. This magnetic unit is not affected by any factor associated with the sheet being measured except thickness.

For the measurement of the thickness of non-magnetic materials (paint, lacquer, etc.) as a coat on a magnetic base metal, a variation of the magnetic assembly is preferred, as in Fig. 4. Here the airgap of an armature at one end is compared with that of the magnetic base for the paint, against which the core is placed. The secondary coils S and S′ should have identical construction and mounted series opposing, so that no secondary voltage appears with equal air gap.

In all of these, a small amount of initial unbalance can be compensated for by a resistance control. Since the phase balance in the two coils is upset by eddy currents in any non-magnetic material placed near the poles, all of these devices can be made to apply to non-magnetic conductors—brass, copper, aluminum, etc.

It is, of course, possible to mount the pickup coils anywhere in the magnetic circuit, if symmetry is maintained, electrically and magnetically. This means that the two equal secondaries can be mounted on the armatures. Since anything that upsets this field and shifts the flux to either coil, (either as to amplitude or phase) will affect the voltage balance, the principle can be extended to many commercial applications.

A particularly sensitive gage has been developed that will indicate small variations in the thickness of metal foil, even those as small as twenty-millionths of an inch. This gage shown in Fig. 3 uses the eddy current method of shifting the phase. A magnetic structure such as in Fig. 4b is used, wherein the gaps are balanced approximately against each other. The electrical balancing arms (with coarse and fine controls) are adjusted for a balance of the indicator pointer when a thin sheet of foil, possibly only 0.00025 in. thick placed in one of the airgaps. The sensitivity is controlled (by altering the 2160 cycle current through the driving coil) so that a full scale indication is produced when another sheet of foil (say 0.00045 in. thick is inserted. The so called "armatures" here do not move and no pressure jaws are applied to the material. It is of course necessary that the material under test be a conductor so that a phase-shift occurs (with non-magnetic materials) or a voltage and phase shift is produced (with magnetic materials).

If dielectric materials are to be measured, a high-frequency set-up can be used, since energy absorption at high frequencies produces an adequate shift. The problem of stray capacitances and the body effect of an operator's presence in the vicinity requires careful consideration here.

Although not a measurement of displacement changes, the eddy current variations noted in Fig. 4 can be used to compare the resistivity, shape, etc., of two non-magnetic elements, by their relative energy absorption from eddy currents. This is the principle successfully used in one industrial metallurgical test system.

A somewhat unusual method of indicating temperature is provided by mounting a bimetallic strip across the poles of a magnetic

(*Continued on page* 198)

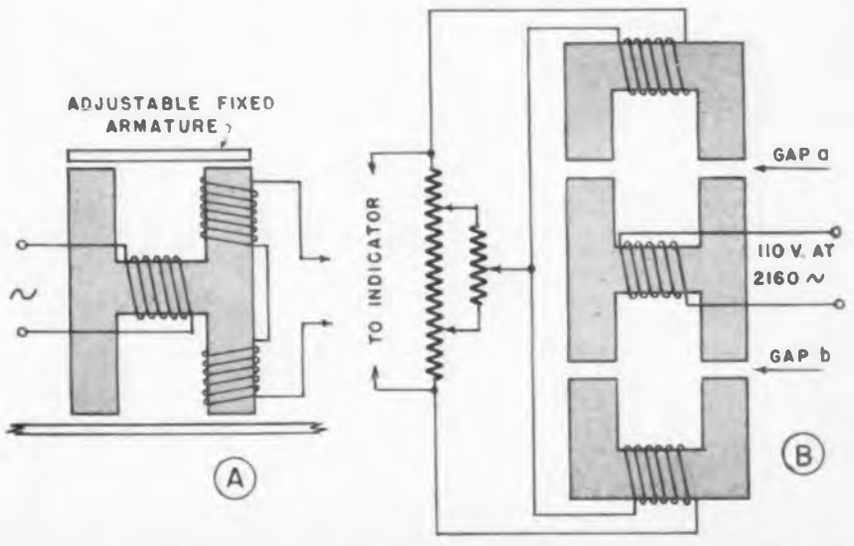
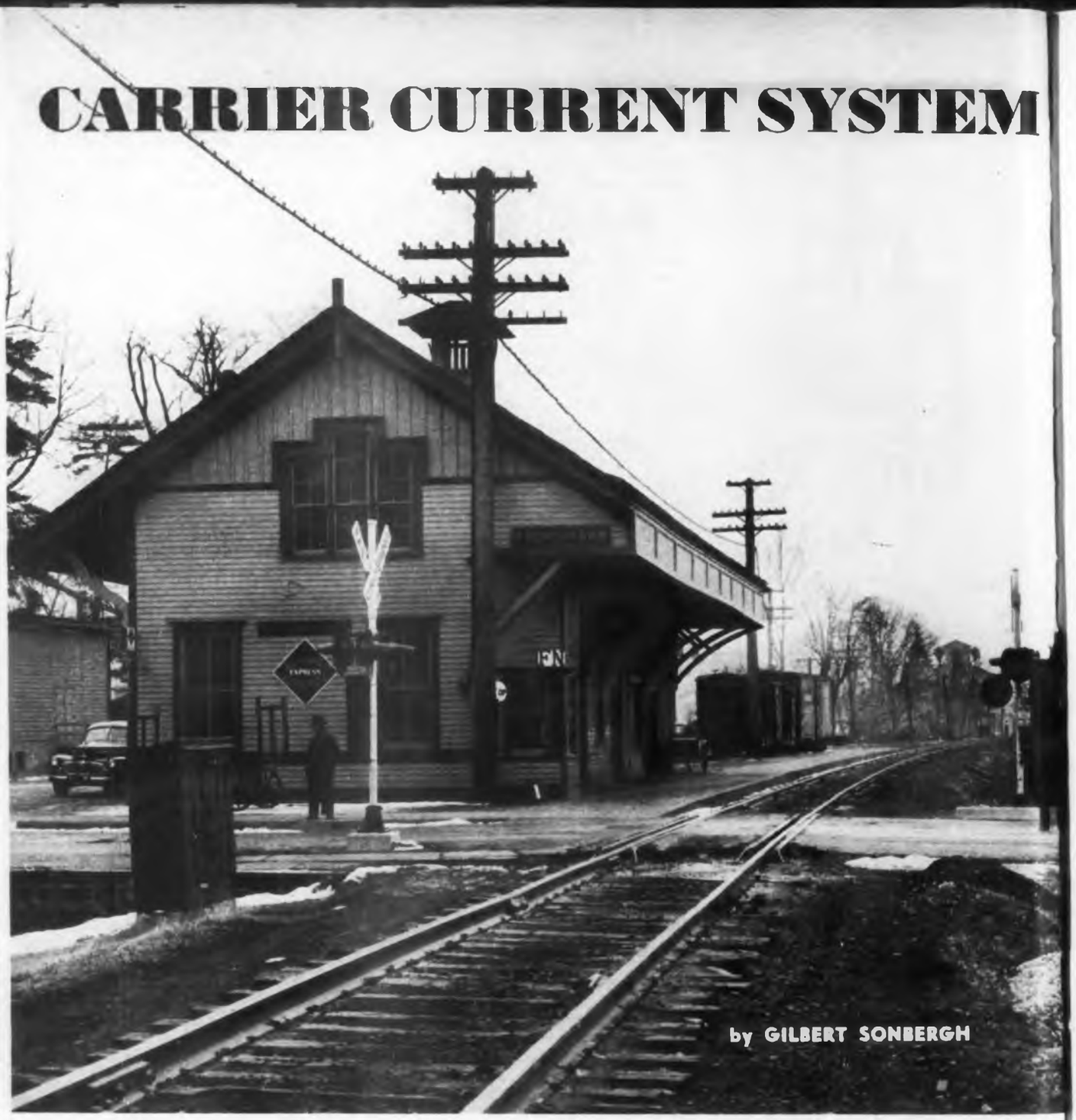


Fig. 4—Balanced-field type of thickness gages utilize changes in magnetic path, or else eddy current losses to alter a previously established null condition

CARRIER CURRENT SYSTEM



by GILBERT SONBERGH

Train telephone equipment installed at Frenchtown, N. J., block station of 67 mile branch line could provide communication with moving trains to 100 miles distant. Output energy is applied between line wire and section of track

● Since the first experimental installation of railroad radio equipment in 1914, dozens of such equipments have been put into service by almost as many different American railroads. Although most of the installations were for trial and experimentation, a few of them have been kept in permanent use. If future acceptance by the railroads parallels present technological development of the electron art, some form of radio train control will become standard practice.

Designed and installed by Union Switch and Signal Co., what many regard as the last word in train communications equipment has been installed and proved on the Pennsylvania Railroad's Belvidere branch, a 67-mile stretch from Trenton, N. J., to Phillipsburg.

The system includes a number of interesting features: (1) single sideband, suppressed carrier transmission on 5.7 kc; (2) 500 to 2,300 cycle audio band with pre-emphasis of the higher voice frequencies for noise reduction; (3) 1,050 cycle calling signal which also can be used to operate stop and go signals; (4) "radiation" confined, where necessary, to rails and ground paths.

For transmission from a cabin car or locomotive, one truck is insulated to allow direct coupling of the output energy into that section of track between the insulated truck and the nearest grounded truck. The two rails may be considered as in parallel. Heavy cop-

HELPS RUN "PENNSY" R. R.

Engineering details of the two-way carrier telephone design using rails as main signal-current path

per pipe from the insulated truck through the output transformer to the uninsulated truck forms a transmitting "loop." With the rails between the two trucks representing the major portion of the impedance of the loop, about 80 per cent of the power in the output circuit actually goes into the track itself. The current in this short length of track is on the order of one-half to one ampere with full modulation. Over 90 per cent of the power entering the track is lost at this point, due to the impedance mismatch between the short section of track (considered now as the source) and the rest of the track and ground circuit looking in either direction (considered as the load).

Signal current path

The track in both directions, together with the surrounding ground, may be considered as an infinite number of conductance paths connected in shunt with the directly energized track under the caboose or locomotive as diagrammed in Fig. 1. Some signal current therefore can be detected and measured in any nearby section of rail. The receiving "antenna" consists of two pickup coils mounted close to and inductively coupled to the rails.

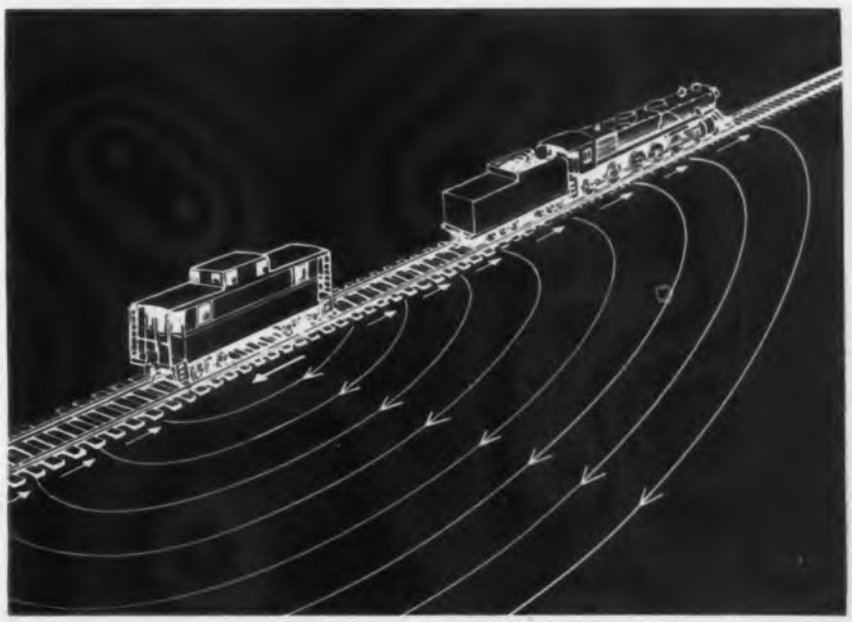
Useful range of the earth-conducted signal energy for voice communication depends of course upon signal-to-noise ratio. In relatively quiet areas, this comes to about 1½ miles if no paralleling line wires are present. Actual signal current in the track is about one-half microampere, some four times the level of background noise in the band of frequencies capable of interfering. When line wires parallel the track, two way communication is possible between moving trains up to ten miles apart, or between a moving train and a wayside station 100 miles away.

The circuit diagram of a complete two-way locomotive equipment is shown in Fig. 2. In the transmitter section, operative when the "press to talk" push-button (PB1) energizes relay DR, the output of a single button telephone-type carbon microphone is fed to the grids of the modulator tubes in push-pull. At the same time, the 5,700 cycle carrier from the oscillator tube is fed to the grids in parallel. In a theoretically balanced circuit, such an arrangement produces modulation containing both side-bands but no carrier. The lower side-band and any remaining carrier are filtered out by the band-pass filter following. The output stage consists of four 6L6's in push-pull parallel, coupled to the sending loop and track. The white lamp, mounted on the control panel, flickers with voice modulation to indicate to the operator that he is "getting out." Push button 2 transmits a calling signal sent as a single frequency 1,050 cycles above the carrier and received as a 1,050 cycle note.

A received signal is picked up by the coils at top left in the diagram. The receiver is normally operative when the main switch is closed. The single side-band signal goes through two stages of tuned carrier frequency amplification to the grids of the push-pull triode demodulator stage. Some of the carrier frequency from the oscillator tube is injected into the grids in parallel. The following band-pass filter removes any undesired carrier from the demodulated signal. The filter output drives the output tube, supplying a loudspeaker or telephone-type receiver.

The necessarily wide range of signal voltages encountered demands an efficient automatic volume control. Since there is no carrier, the AVC moreover must operate on speech frequency signals integrated over an appreciable period of time. The twin triode at the extreme left provides this delayed AVC action. A portion of the demodulated signal is taken from the band-pass filter input to feed the grid of the right half of the tube, connected as a triode voltage amplifier. The cathode of the left half of the tube is maintained at a positive potential determined by the tap D on the voltage divider under no-signal conditions. When the peak

Fig. 1—Diagram of current flow through rails and shunting earth paths when track section under caboose is source of signal current, applied between trucks



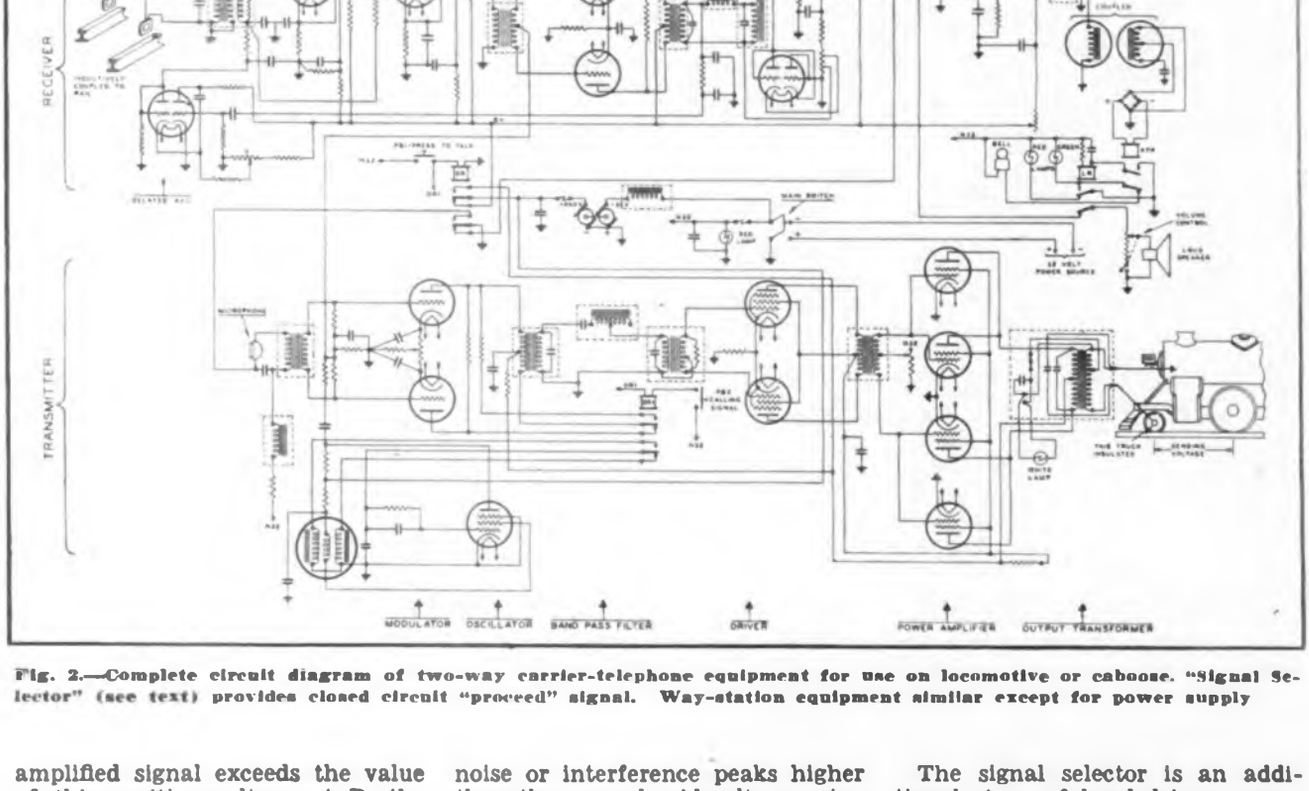


Fig. 2.—Complete circuit diagram of two-way carrier-telephone equipment for use on locomotive or caboose. "Signal Selector" (see text) provides closed circuit "proceed" signal. Way-station equipment similar except for power supply

amplified signal exceeds the value of this positive voltage at D, the cathode of the left half of the tube goes negative with respect to its plate. Plate current flows, negative bias is applied to the grids of the carrier frequency amplifiers, and the RC circuit charges to provide the necessary time delay.

The peak limiter stage operates to squelch any short, high-voltage noise or interference peaks higher than the normal grid voltage swing allowed on the output tube. A twin triode tube is connected as two diodes "back to back" across the output auto-transformer of the band-pass filter. A bias voltage selected for each tube by the taps on the cathode resistor of the output tube, determines the signal voltage at which the limiter begins to short circuit the filter output.

The signal selector is an additional stage of hard-driven, power amplification, sharply tuned to 1,050 cycles, whose rectified output operates relay KPR on receipt of the calling signal. This charges the condenser in the RC circuit shunted across relay LR, which closes. The green signal lamp remains lighted as long as the 6,750 cycle signal is being received. When

Signal selector operation

When push button PB2 is closed at the calling station, relays DR and DR1 are energized. The former puts the transmitter into operation, while relay DR1 increases the carrier oscillator frequency by 1,050 cycles and cuts out one of the push-pull modulator tubes, allowing the signal frequency of 6,750 cycles to be amplified and transmitted. At the receiving station, this signal is detected as a 1,050 cycle calling note.

The signal selector tube, with its associated apparatus, is sometimes included in the carrier telephone equipment, particularly where high ambient noise conditions make desirable a calling gong instead of the 1,050 cycle note in the loudspeaker or telephone receiver. It is also useful to provide a continuous proceed or stop signal to the locomotive engineer.

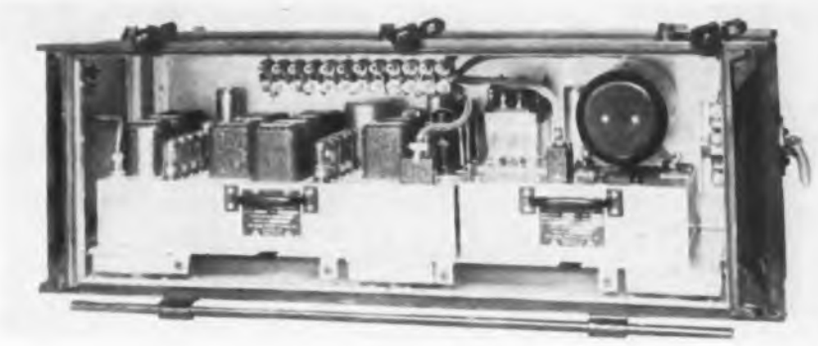
Freight conductor talks with block operator for train orders. Loudspeaker in background provides calling signal

Receiving coil mounted close to rail. Receiver and transmitter in box over drivers, visible at extreme top right

the calling station releases push button PB2, relay KPR is de-energized. Relay LR remains energized long enough to complete the circuit through the bell, which sounds.

When the shunt condenser discharges, the relay opens, the red lamp lights, and the loudspeaker circuit is completed for receipt of voice signals. A tube or component failure in either calling or receiving apparatus thus results in failure to receive the green signal in this "self-monitored" system, a vital consideration in any type of railroad signaling equipment.

The signal selector cannot be operated accidentally by short pulses, continuous voice frequency or by other wide-band interference because of the combination of tube saturation, sharp band of response, and time delay in the relay circuit.



Open equipment case of train-borne set, above, showing units in place. Out of case, below, are transmitter and receiver (on same base at left) and power supply

Design details

In a system using track as the medium of transmission, theory and practice show that attenuation of track current is roughly proportional to the square root of the frequency. Thus, the lower the frequency the better. However, the noise level in the track is greater for lower frequencies. Early experiments were directed at using voice frequencies alone, without carrier, but were abandoned because of interference with parallel telephone circuits and because of the high noise levels prevailing at low speech frequencies, due to power frequency harmonics and commutator "hash."

The carrier method was then adopted. The frequency of 5,700 cycles represents a careful compromise between attenuation of the signal and pickup of noise. Improving signal-to-noise ratio was an important factor also in the decision to utilize the single side-band, suppressed carrier type of emission. With a balanced carrier-suppression circuit, all of the transmitted power is put into the single side-band. It is at the same time possible to reduce the receiver bandwidth, resulting in considerably less noise pickup for a given signal strength.

Equipment for train communication in block station at Frenchtown, N. J. From top down, receiver, transmitter, and power supply

The audio channels pass voice frequencies from 500 to 2,300 cycles, or a band of 1,800 cycles, which affords practically complete intelligibility and reasonably natural reproduction of the voice. A further great improvement in signal-to-noise ratio is achieved by pre-emphasis of the higher voice frequencies in transmission and de-emphasis in reception. Since the average acoustic power in the voice at 500 cycles is several times greater than at 1,500 cycles and above, a transmitter adjusted for complete modulation at the lower frequencies will be operating at greatly reduced efficiency in the higher ranges.

To make all components of the voice frequencies modulate the transmitter to the same extent, the audio circuits are designed to provide about 40 per cent of full sensitivity at 500 cycles, with the gain gradually increasing to 100 per cent for 1,400 cycles and above. At the receiving end, the audio is designed to amplify the lows and attenuate the highs, restoring the normal energy distribution to the received voice signals. The net result is equivalent to turning down a heavy tone-control on receiver noise pickup without affecting the quality of the voice signal, resulting in a two to one improvement in the signal-to-noise ratio.

Operation of system

The equipment consumes about 150 watts for receiving and 550 for transmitting. Power at 32 volts for filament and motor-generator plate supply on train-carried equipment is furnished on the locomotive by the headlight generator and in cabooses by storage batteries. The way-station equipment differs from the train-borne sets chiefly in that the power supply is designed for 110 volt operation, in the method of mounting, and in details of the auxiliary equipment such as speaker, microphone, controls, etc.

The Belvidere branch of the Pennsylvania Railroad is equipped with ten locomotives and ten cabin cars carrying the carrier-telephone sets. The block station at Frenchtown, N. J., about one third of the way from Phillipsburg to Trenton, is equipped with a stationary set and is capable of communication with trains anywhere

(*Continued on page* 190)

ARMY RADIO PRODUCTION

by MAJOR GENERAL W. H. HARRISON
Chief, Procurement and Distribution Service
Office of the Chief Signal Officer

Great quantities of radio equipment required for administration and rehabilitation activities abroad

● Down through the ages, communications have constituted the nerve system of man's economic, as well as military life. Periods of national emergency emphasize the tremendous importance placed upon adequate acquisition and employment of communication materiel of advanced design.

In this, the fifth major war of our national life, the globe-wide extent of our military actions has made it imperative that our fighting forces be provided with staggering quantities of equipment and supplies.

Signal units have been with the first waves in each landing, are in the front lines of each fighting front, and man a vast communication system connecting all parts of the world.

The communication equipment and supplies, designed and produced for, and used by these troops, are equal to, or better than, that of any army in the world. The design, production, distribution and much of the operation of this materiel, is the job of the U. S. Army Signal Corps. The foot-soldier in the most advanced outpost, the men in tanks, planes and jeeps, the commanders of all echelons, and even the morale building V-Mail, depend upon adequate and timely production. This involves tons upon tons of equipment and supplies, consisting of tens of thousands of different items, costing from a few cents to more than a hundred thousand dollars each.

The gigantic communications procurement program, summed up in the term "logistics," required contracts for over three and a half billions of dollars in calendar year 1943. The load for 1944 threatens to exceed this value especially regarding component or piece parts.

During the peace years of the twenties and thirties the Signal Corps prepared for a possible emergency through Procurement Planning. This forethought paid high dividends during the early phases but the enormous spread and unprecedented tempo of this war has caused procurements over three times as great as contemplated.

The procurement plans were based upon the rapid conversion to military designs and the maximum utilization of existing resources, composed in the order of importance and use of productive plants, materials, manpower and money. Based on this conversion, which provided immediate production and the maximum of education, it was planned to expand existing, and create new, facilities until the productive capacity was sufficient as to type and quantity to meet the projected requirements.

"5 and 10" expansion

In the later part of 1940 and the early months of 1941, the Signal Corps used an estimated "yardstick" for the expansion program of "5 and 10." This is, the initiation of projects to give a production capacity of five times the 1940 capabilities, but such projects to be so designed as to permit doubling even this large rate, to provide a ten times normal capacity. This two-step policy was adopted on three principles:

1. Obtain the maximum production increase in the shortest practical period.
2. The base obtained through peacetime procurement and educational orders could support only a limited amount of expansion without dangerously watering management, engineering and production.
3. The logistics of the portending conflict would axiomatically depend upon military strategy and tactics as yet indeterminate.

Pearl Harbor found this expansion program initiated but far from consummated. Considerable results had been achieved through the impetus of foreign procurement and

This Signal Corps photo, made under battle conditions in North Africa, shows a regimental radio installation in ditched position, back from the beach

Installed in a Nissen hut in Iceland, this combination of an R-339 and BC-340 transmitter is capable of a total output of 10 kilowatts

supply, but it takes time for the placement of bricks and mortar, for the production and installation of machines and equipment, for the training of personnel, and the establishment of designs and flow of required materials. Funds had to be obtained in unprecedented values. Expansion procedures, including governmental financing, had to be established and worked out. Design, procurement, production and inspection organization had to be expanded over night not only to care for the ultimate rates, but to an extent sufficient to obtain the initial high peak of planning and production. It was necessary liberally to over-expand these units to provide for initial inexperience and the peak effect.

If the load could have been delayed and leveled out, the production capacity required would have been smaller and the expansion projects reduced. However, the waging of War is, of necessity, a dictatorial action; time was the limiting factor. It was imperative that large productions be obtained requiring that the rates be stepped up and facilities established without delay.

Looking back, we see that these early plans were sound, considering the indeterminate factors involved. The "10 times" projects are now coming into fruition. Across the board, our condition as to the procurement of communications equipment and supplies has greatly eased, and systematized.

By the middle of 1943 we had passed through the phases of:—

1. Initial, stop-gap procurements.
2. Rushed new designs.
3. Large facility expansions.
4. Radically insufficient material supplies, requiring rigid control and allotment; and entered the period where personnel was a major factor. It was time, therefore, to shift the emphasis to full and efficient utilization of all capabilities, to obtain gigantic productions, and provide communications materiel on the basis of "Enough and on Time" not for defensive but for offensive action.

To permit obtainment of this vast new objective, the Signal Corps started to reorganize in July of 1943, not with the limited viewpoint of clearing out deadwood and failures, but rather to bring to bear the full force of shock troops specializing in production, the ammunition of the day. It was, and is, realized that the rapid changes in strategy and tactics, the extension of activities to new corners of the world and the ever present need to lead the enemy in design will continue

(*Continued on page 206*)

From Iceland comes this view of an emergency transmitting and receiving installation, set up for use in case of a break-down in the main station

MULTIWINDING MOTORS

by **EDWARD M. GLASER**
Senior Electrical Engineer, Kollsman Instrument Div., Square D Co

Part II—The use of drag cup motors as a component of control circuits produces many unusual effects

● The vacuum tube has been used satisfactorily in so many control problems that it is considered as being able to handle almost any kind of a job that comes up. This is true because the vacuum tube can work with so many other forms of equipment. Many prewar novelties have found important applications in military equipment and a large number of other devices have received attention by application engineers and precise and accurate designs have brought out their greatest possibilities. In Part I (March, 1944, Electronic Industries) a few details of certain small motor applications, as components in electronic circuits, were outlined. A somewhat different arrangement, the drag cup motor is shown to add ingenious features to control problems, and may point out immediate possibilites in certain problems. Several typical uses are outlined.

Fig. 1—The rotor and magnetic circuit of a drag cup motor

Drag cup motors are low-inertia, accurately balanced 2-phase induction motors, designed for servo or follow-up applications where overshooting or hunting must be kept at a minimum. The rotor, consequently, is very light, consisting of only a nonmagnetic cup on a shaft. The cup rotates between a conventional distributed pole 2-phase stator and a fixed, round lamination stack which is used to complete the magnetic circuit, as shown in the photograph, Fig. 1.

When run on a single phase supply, a capacitor is used to obtain a 90 deg. phase shift for producing the 2-phase rotating field. This field induces voltages in the drag cup, setting up eddy currents which react with the air-gap flux to produce motor torque. As many poles are induced around the cup as there are poles on the stator. The Q of standard squirrel-cage induction motor windings changes greatly between stand-still and full speed so that it is often necessary to use one phase shifting condenser for starting and another for running. However, in drag cup motors the Q changes only slightly with speed so a single condenser chosen for some intermediate operating point serves very well for all speeds. The reason for the small change in Q is the much greater air gap required by the drag cup construction — the actual air gap on each side of the cup plus the thickness of the cup.

While the torque/inertia ratio is the greatest for aluminum cups, motors with copper cups have a greater torque although obtained at the expense of higher inertia. The increase in torque amounts to 20 or 25 per cent. Fig. 2 shows the comparison of aluminum and cop-

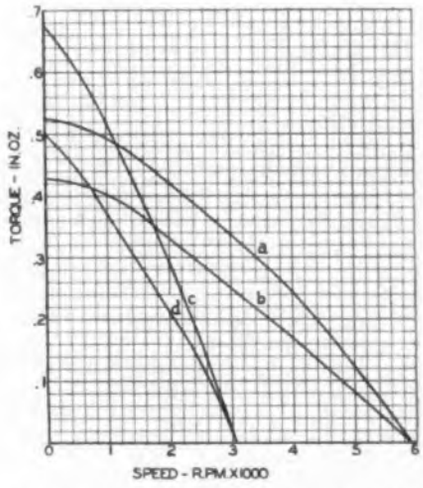


Fig. 2—Torque vs. speed relations for the type 776 drag cup motor. Curves *a* and *c* for 400 and 60 cycle copper cups, curves *b* and *d* for aluminum cups, at same frequencies

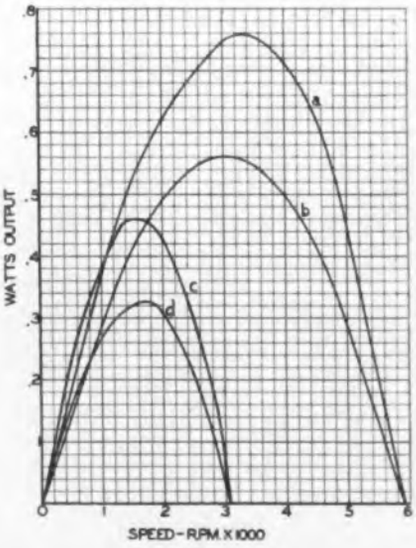


Fig. 3—Power output curves for same motor. The curves are for the same conditions listed in Fig. 2

FOR ELECTRONIC USES

per cup rotors in torque-speed curves for both 60-cycle and 400-cycle motors of the same size. The 60-cycle motors have 2-pole armatures and the 400-cycle motors, 6-pole. Fig. 3 shows similar curves for power output vs. speed. For a greater output these motors have

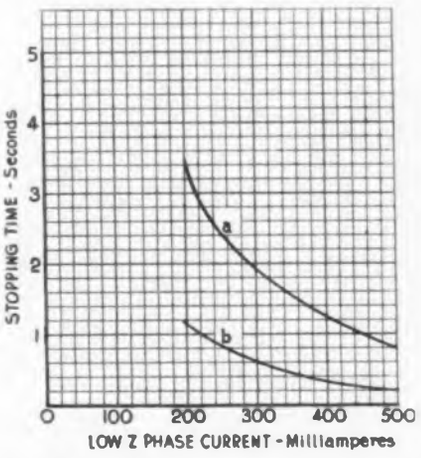


Fig. 4—Braking characteristics of an unloaded 400 cycle drag cup motor running at 5900 rpm. (a=copper, c=alum. cup). Coasting time shown after opening the high impedance winding

the same frame size but a longer stack.

Full use may be made of magnetic braking with one phase continuously energized, as the motors will not run single phase. The braking characteristics of aluminum and copper rotors for a typical 400-cycle motor are shown in Fig. 4. Additional braking may be obtained when necessary by adding dc in series with the ac supply to one phase. This braking action is similar to that in rotating eddy current disks in watt-hour meters. It was shown in Fig. 2 that the maximum torque occurs at the starting point. This fact combined with the good braking action and low inertia make it possible for the motor to reverse very rapidly. Hence, its suitability for plugging or follow-up service.

In a split-phase circuit, the temperature rise at stall is approximately equal to the rise running free. This allows the motor to be stalled for long periods with full voltage applied. Coolest operation occurs at the maximum power output, but the difference is usually less than 10 deg. C.

An unusual electronic application of drag cup motors makes use of another characteristic. When one phase is excited from an ac supply and the motor is driven, the rotor, in turning, develops a quadrature voltage which is coupled into the second phase in proportion to the speed of rotation. Thus the motor functions as a variable coupling device or induction generator. The voltage is not quite zero at stall because of a small amount of magnetic leakage which seems to exist in all motors. Also, the voltage characteristic is not quite linear, falling off at high speeds as shown in Fig. 5. The copper cup gives more voltage but less linearity.

Control circuits

A few typical control circuits for drag cup motors are shown in Figs. 6 to 9. Fig. 6 shows the basic SPDT reversing circuit. One phase winding is connected directly across the power transformer for constant excitation while the other phase is switched to the upper or lower half of the transformer for phase reversal. The capacitance C is the phase shifting element for obtaining a 90 deg. time phase difference in the two motor windings.

In Fig. 7 the manual reversing switch has been replaced by a pair of saturating reactors. The motor

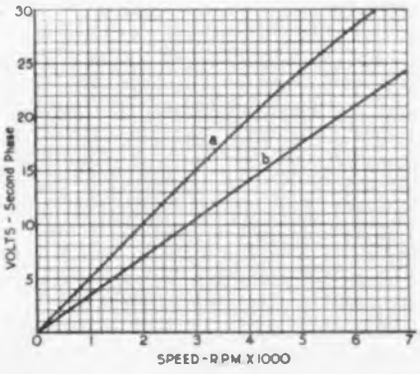


Fig. 5—Quadrature voltage and speed relations in drag cup motors when one phase is energized at 115 v. 60 cycles. *a* refers to a copper cup, *b* to aluminum

speed and direction are controlled by varying the amount of dc in the reactor windings. Either thyratrons or power tubes can be used, the control characteristics depending upon the saturation curve of the chokes, type of tubes and their

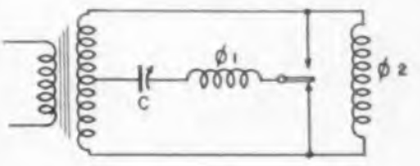


Fig. 6—Circuit with manual switch for speed reversal

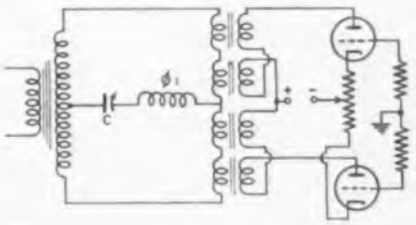


Fig. 7—Electronic circuit using saturating reactors to provide control of speed and direction. Second phase winding is connected across primary or secondary of transformer

operating points and those of the motor itself. It is important that feedback of voltage from the motor circuit to the tube circuit be prevented. This condition may be satisfied by using special chokes or by using two equal chokes with one winding of one choke reversed with respect to the same winding of the other choke. Two such pairs are required.

Fig. 8 shows a bridge type photoelectric control circuit using thyratrons operating directly from the ac line. A push-pull class B output transformer serves to match the thyratrons to the motor. Illumination of one phototube will run the motor, the speed varying in approximate proportion to the amount of light; illuminating the other phototube will reverse the motor. With both phototubes equally lighted, or with no light at all, the motor receives no voltage on the controlled phase and so remains at stand-still. This assumes

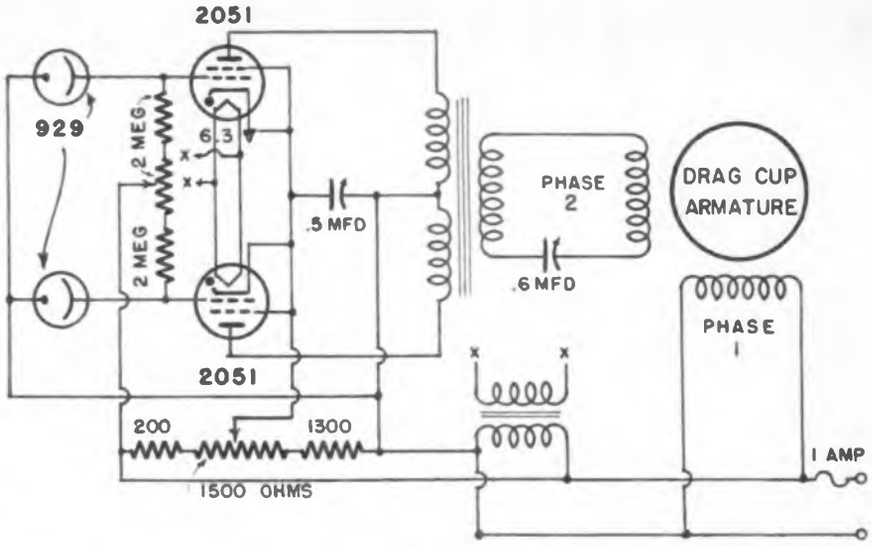


Fig. 8. Shifting the motor speed and direction, by photocells provides a versatile arrangement for the automatic control of numerous industrial processes

CHARACTERISTICS		TYPE NO. 776-05	TYPE NO. 776-015
Frequency -	Cycles per second	60	60
Voltage Phase 1:	Source V1 - Volts	115	115
	Terminal E1 - Volts	126	125
Voltage Phase 2, V2 -	Volts	115	115
Current Phase 1, No Load -	ma	65	63
Current Phase 2, No Load -	ma	42	41
Resistance Phase 1 -	ohms	1100	1100
Resistance Phase 2 -	ohms	1485	1485
Impedance Phase 1, (Average) -	ohms	1940	2018
Impedance Phase 2, (Average) -	ohms	2805	2895
Condenser C, Phase 1 -	mfd	1.0	1.0
Power, Input -	watts	8.3	8.15
Power Factor (Average)		.67	.70
Number of Poles		2	2
Temperature Rise -	Degrees C	63	61
Speed, No Load -	rpm	2930	2930
Torque, Stalled -	Inch Ounces	.50	.356
Moment of Inertia (of weight) -	g.cm.^{2}	2.56	6.67
Stopping Time, No Load One Phase Energized -	Seconds	.2	.4
Reversing Time -	Seconds	.12	.2
Length (over-all) -	Inches	2.750	2.750
Diameter, Max. outside -	Inches	2.750	2.750
Weight, Complete Motor -	Ounces	11.7	11.8
Weight, Shaft Assembly -	Ounces	.390	.490

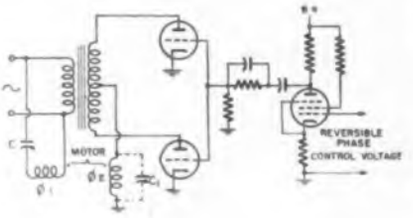
the phototubes and thyratrons are enough alike in characteristics to be satisfactorily balanced by the 2 meg. potentiometer in the grid return.

The 0.5 mfd. capacitor across the "B" supply gives correct phasing of the thyratron control circuit which is necessary to stop the tubes from firing. The 0.6 mfd. capacitor, in combination with the other phase shifting circuit elements, provides the 90 deg. time phase shift for optimum motor output.

Fig. 9 shows another type of motor control circuit in which a certain amount of motor power is sacrificed for improved braking characteristics. The circuit resembles a full wave rectifier with a live negative and grounded positive. Either power tubes or thyratrons may be used but a phase control system must be used with the latter.

At zero position on the control element both tubes are partially energized, with full wave rectified ac flowing through phase 2. When the control element is moved in a positive direction one power tube will become more conducting, the opposite tube less conducting. The motor will then develop a torque approximately proportional to the displacement of the control element. Moving the control element in a negative direction will cause the motor to develop a torque in the opposite direction. If the control is moved to zero the dc components of both tubes will add to produce a very effective dc (full wave) braking action. Some motor power is lost because of the wave form distortion produced by the half wave rectifier.

Fig. 9. Grounded input motor control circuit utilizing dc braking. C is motor phasing capacitor, and C_1 (optional) provides tuning



CHARACTERISTICS		TYPE NO. 723-05	TYPE NO. 723-015
Frequency -	Cycles per second	60	60
Voltage Phase 1:	Source V1 - Volts	115	115
	Terminal E1 - Volts	178	174
Voltage Phase 2, V2 -	Volts	115	115
Current Phase 1, No Load -	ma	61	58
Current Phase 2, No Load -	ma	84	81
Impedance Phase 1, (Average) -	ohms	2995	2940
Impedance Phase 2, (Average) -	ohms	1411	1429
Condenser C, Phase 1 -	mfd	.7	.7
Power, Input	watts	9.25	9.28
Reversing Time -	Seconds	.15	.2
Weight, Complete Motor -	Ounces	14.9	15.1

SIGNAL CORPS HEADQUARTERS EQUIPMENT MEETS TESTS IN SERVICE

Considered the best field radio equipment at the front in the Mediterranean theater, the mobile headquarters radio stations, developed by the Army Signal Corps —the SCR-299, SCR-399 and SCR-499,— have proved the real answer to long distance communication and have rendered exceptional service under the most severe combat conditions both in the African and Italian theaters. In addition, the SCR-299 stations have formed vital links in the Pacific theatre with General MacArthur's forces.

The SCR-399, which is a new and improved version of the SCR-299 had been developed and tested by the Signal Corps and was produced and shipped overseas during the North African campaign so that the SCR-399 is now being operated in the Italian campaign. The SCR-499 is a companion set for airborne transport and includes all the principal components of the SCR-399 except that none of the radio equipment is installed in the cabin-like shelter and the power unit is not installed in the trailer. With canvas cover provided as a protection for the major radio parts, the SCR-499 can be transported by air or other means to a desired destination where this station then can be quickly set up as a field radio station either in a shelter, tent or a vehicle.

The SCR-399 has a frequency range extended beyond the frequency complement of the SCR-299 and its mobility was increased by the development of the cabin-like shelter which can be mounted on the bed of a standard 2½-ton truck. Previously for the SCR-299 stations, specially-designed panel trucks were used, which meant that the SCR-299 was less easily maneuvered and its vehicle was

(*Continued on page 202*)

OSCILLATOR Fundamentals

by J. P. JORDAN

Industrial Heat. & Weld. Eng. Div., General Electric Co.

A refresher on the principles governing the generation of high frequencies for use in industrial applications

● To apply electronic equipment properly, it is desirable that one have a mental picture of the theory of vacuum-tube oscillators. The following is an attempt to present this theory in such a way that it will aid in the formation of mental pictures best adapted to this purpose without attempting a rigorous or complete analysis.

The major element in any oscillator is not the tube but the resonant circuit. The vacuum tube could be replaced by other elements, such as the various types of gaps, and the circuit would still oscillate, but no oscillator for the services mentioned could operate without some form of a resonant circuit.

Now if an inductance and a capacitor are connected in parallel, a curious situation exists at some one frequency at which the X_L equals the X_C. Since the one varies directly and the other inversely with frequency, there must be some one frequency at which equality will exist. This frequency is called the resonant frequency. To determine its value X_L can be equated to X_C and solved for f as in equation 1.

With no resistance present at the resonant frequency, the current I (Fig. 1) in the line feeding the circuit would be zero (Eq. 2), whereas the current flowing in the inductor (I_L) and the capacitor (I_C) would equal the applied voltage (E) divided by their individual impedances ($X_L$and X_C) (Eq. 3).

When a resistance is inserted in either branch, the current (I) no longer is zero but has a component in phase with the applied voltage sufficient to supply the energy loss in the resistance. Eq. 4 is a solution of this circuit (Fig. 2) at the resonant frequency. In this case, the circuit could be thought of as a very high power factor load containing a resistance r and an impedance x, as in Eq. 1a and 1b. For small values of R, the input is still essentially resistive and the voltage

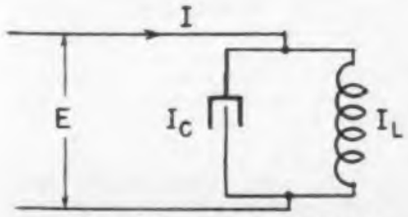


Fig. 1—Basic oscillating circuit

$$X_L = X_C = 2\pi f L = \frac{1}{2\pi f C} \quad (1)$$

$$\text{or} \quad f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$I = \frac{E}{\frac{-X_L X_C}{jX_L - jX_C}} = E\,\frac{jX_L - jX_C}{-X_L X_C} \quad (2)$$

$$= E\,\frac{0}{-X^2} = 0$$

$$I_L = -I_C = \frac{E}{X_L} = \frac{E}{-X_C} \quad (3)$$

$$I = \frac{E}{\frac{L}{RC} - j\sqrt{\frac{L}{C}}} \quad \text{at Resonance} \quad (4)$$

E times the current (I) will approximate the power dissipated in the resistance due to the current I_L.

However, note again that the current through the inductance (L) or the capacity (C) is a function only of the applied voltage (E) and the impedance, and does not flow through the external circuit. The product of this current, I_L(or I_C) times the voltage (E) is termed the circulating kva which can assume considerable magnitudes with very small values of input current (I). This circuit is sometimes referred to as a "tank" since it stores energy.

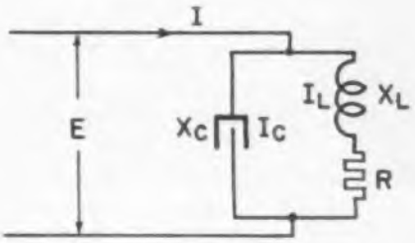


Fig. 2—Oscillating circuit with resistance

Assume that now a dc supply is connected to this resonant circuit through a switch which can be operated very rapidly. If this switch were operated at the resonant frequency of the circuit, it is obvious from the equations given previously that high circulating currents would flow between the capacitor and the inductance, but the current through the switch would be only such as to supply the losses in the circuit.

This scheme has several disadvantages, among which is the fact that if the circuit through the inductance is broken for any reason, the inductor will be at full dc potential. However, by shunting the switch across the dc supply and interposing a capacitor between the switch and the resonant circuit, similar results can be obtained.

In Fig. 3, when switch S is open, the voltage builds up across C, through L and L_1. However, for the first instant of time, the inrush current causes nearly the full volt-

(*Continued on page* 170)

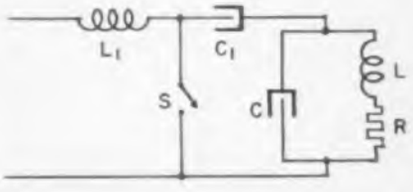
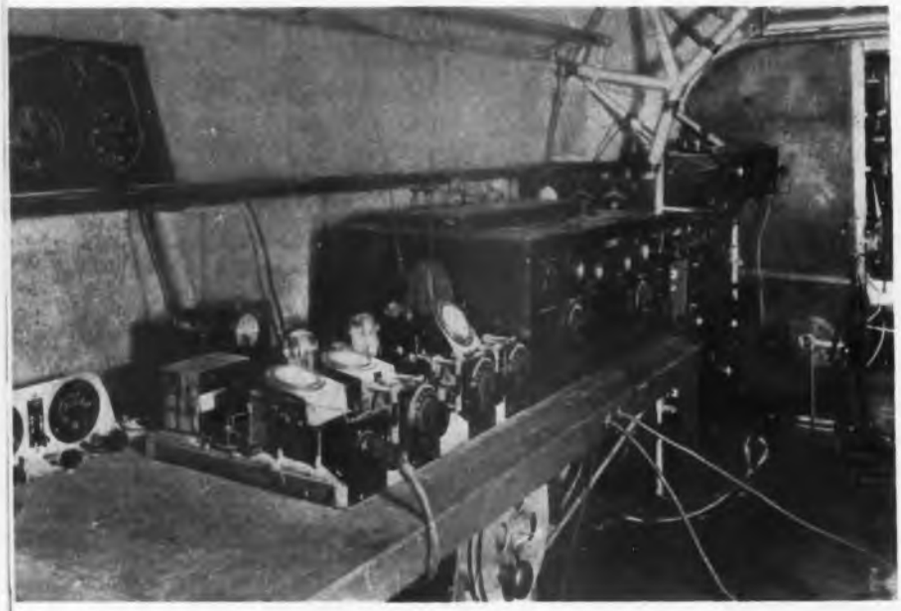


Fig. 3—Basic oscillating circuit with the function normally performed by a vacuum tube represented by the switch S

AACS—WORLD'S GREATEST



With stations in 52 count totals over 15,000, Airforce

● Little has been made public about the Army Airways Communication System. And not all of the story can be told now. Yet AACS is the world's largest communication system, dwarfing all commercial radio communication systems combined, by comparison. In this vast global network there are today more than 15,000 officers and men.

In the United States, AACS maintains stations in 48 states and these are tied into a radio network that includes stations in 52 foreign countries. Indicating the truly world-wide character of the system, AACS divides the globe into operating regions. There are 23 of these Regions of Operations, located in every civilized country and some that are not so civilized.

Army Airways Communications System operates as an individual unit under Army Air Forces Command. Air Communications Officer Brigadier General H. M. McClelland and his organization perform the staff functions for AACS. This means that for equipment and communications planning, as well as training and organizational procedures and requirements, the Air Communications Officer is responsible.

The specific function of AACS is to maintain control over all army aircraft while in motion. This means clearance for take-off, weather reports, position reports, flying the AACS directional beams, check-in at destination and landing operations. Also a very considerable

Upper—This typical Army Air Force communications station, part of the 13th Ferrying Squadron Operation Control, is located in Sookerating, Assam, India

Center—Not all the AACS work is done on the ground. Research and development goes on in the air as well. This is a flying research laboratory, set up in the cabin of a Fokker C-2 ship used for experimental purposes

Lower—Another AACS outpost radio communications station. This one works regularly with similarly arranged stations in India

SYSTEM

ries and a personnel that network is truly global

amount of point-to-point traffic having to do with army aircraft is handled. In other words, AACS control towers start every ship on its mission and then watch it until that mission is completed and the ship is safely on the ground again.

Originally, which means before Pearl Harbor, AACS relied entirely upon half a dozen powerful intercontinental transmitters, operated at the time by CAA and functioning primarily as weather and traffic stations. They were located in New York, Honolulu, San Francisco, New Orleans, Anchorage, Alaska, and Everett, Washington. Year and a half ago these stations were turned over to the Army Air Forces and tied into the AACS network.

Wherever a new airstrip is established, or as was the case in Guadalcanal, taken over from the enemy, there an AACS station is established for the guidance and control of army aircraft. When a New Georgia landing field was snatched from the Japs, an AACS station was installed and operating within a period of a little over 24 hours.

With personnel ranging from four to 150 or more, AACS stations effectively cover the world and the system is rapidly reaching its goal which is to supply United States and Allied pilots with weather information and standard operating procedure on beams and homing beacons in every corner of the globe.

(*Continued on page* 234)

Upper—Part of the extensive radio equipment that is carried by AACS ships. This particular installation shows the arrangement used in a Curtiss A-12

Center—Where operations require, portable equipment is set up in vehicles; this one, showing the operating position, is in a jeep

Lower—This US Airforce photo was made in Grand Rapids, Mich., and illustrates another type of portable transmitting and receiving equipment that can be set up in a hurry and put in operation quickly for temporary communication service

PRODUCTION

1. Above: Aligning jig for welding mount of 1.4-volt tube to base leads is a long arm pivoted at bench to swing tube into exact position between welder electrodes. Developed at Tung-Sol, Newark, N. J.

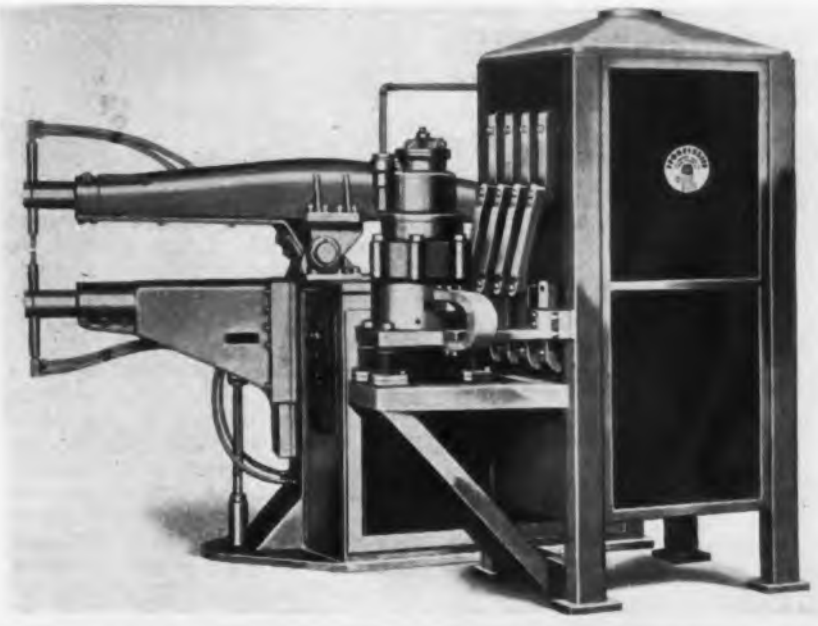
2. Top left: Servicing short cut is illustrated by design of amplifier mounting brackets in North American Philips 35 mm. projector. Flick of thumb allows entire chassis to rotate, exposing all components

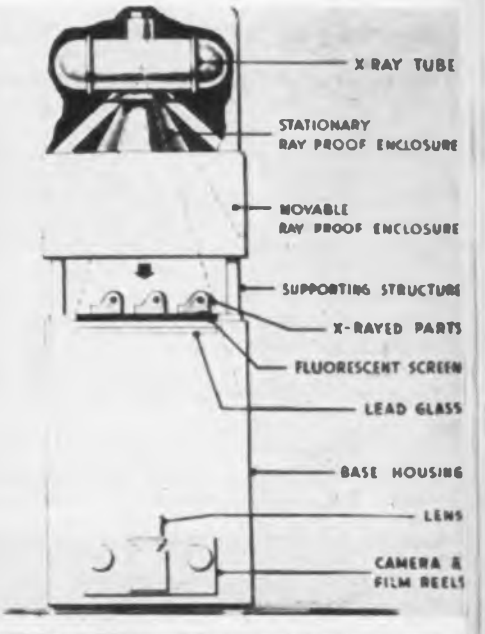
3. Center: Synthetic made by Resistoflex Corp., Belleville, N. J., replacing rubber aligning ring in clinching operation at RCA tube plant, lasts 20 times as long

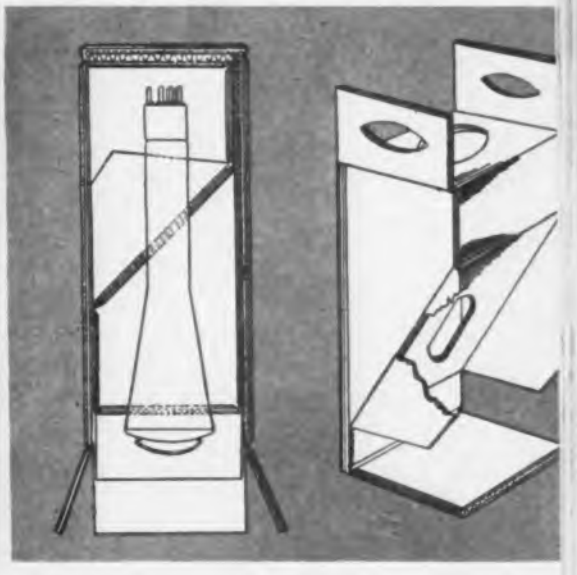
4. Left below: Forming press for small parts has Resistoflex compar cemented to jaws for longer life, better action

5. Below: Visiting vet points out urgency of military needs to radio-plant workers at Snyder Mfg. Co., Philadelphia. Many manufacturers have improved morale and speeded production by bringing soldier or sailor to tell workers their work is important to prosecution of war

IDEAS AND TECHNICS







6. Top left: DC welder powered by storage batteries solves power line shock problem. Developed by Progressive Welder Company

7. Left center: New type weighted grip on Burgess Vibro-Tool makes work easier, faster, giving better balance and penetration

8. Left: G-E insulation tester gives one c-r tube trace on electrically symmetrical motor windings, double on defective

9. Top right: Industrial X-ray unit (Westinghouse) makes radiographs on 35mm. film for a nickel each instead of $1.50

10. Right center: One piece c-r tube carton devised at National Union reduces required shipping space and cuts labor

CHEMICAL ANALYSIS BY

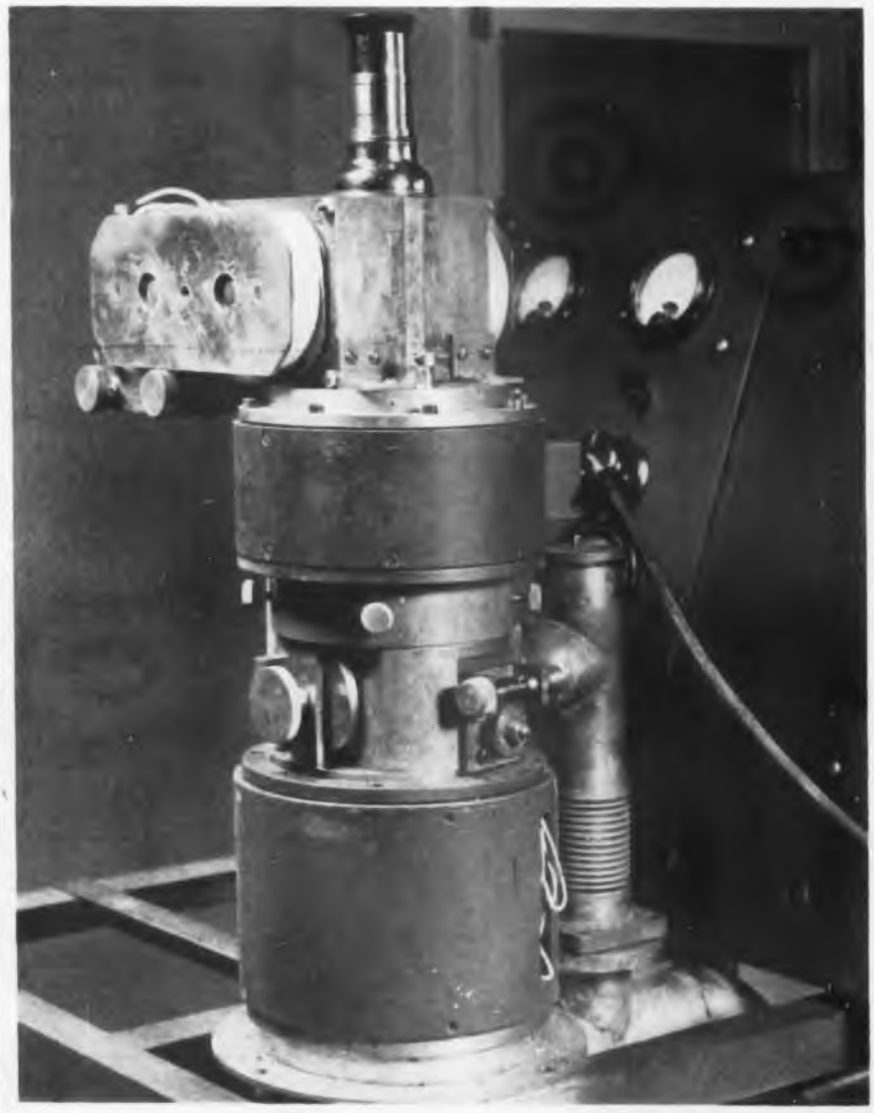
Slowing up of electrons as they pass through test specimen measured and made to reveal its atomic structure

● The past decade has seen an exceedingly rapid growth of the development and use of electronic tools in all sciences. One of the most spectacular of these is the electron microscope which, with its extremely high resolving power, is able to project man's vision further than was ever before possible. Now we are able to view at tremendous magnifications many of the previously invisible viruses, structures of bacteria and chemical particles. Seeing these minute bodies, however, is by itself, not usually enough for the solution of the research problems connected with them. Research workers who have had some experience with the electron microscope are finding that its greatest usefulness lies in the guiding of other experiments and in the rapidity with which results of these other experiments can be observed and checked.

This situation has been a challenge to the scientists developing the electron microscope for they have realized that the high resolving power of an electron stream and the nature of the interaction between electrons and matter might very well be exploited in new instruments to perform some of these associated experiments.

The electron microanalyzer is just such an instrument. It was developed in answer to the scientist who, on looking at an electron micrograph, remarks that he can see the size, shape and structure of the minute bodies but would like to know the chemical composition of the individual structures. The electron microscope cannot answer his question and if the bodies have a complicated structure, there was —prior to the microanalyzer—no apparatus which had any possibility of answering him.

Physical appearance of the electron microanalyzer, which resembles its predecessor, the electron microscope, from which it was developed, and constructed

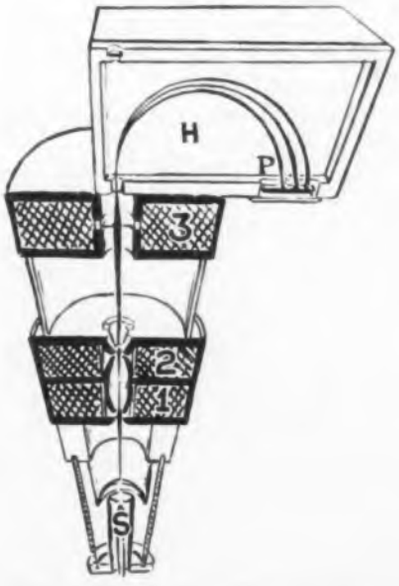


Analyzer construction

It is too early to say how well the electron microanalyzer answers him but at least the fundamental possibility is there and interesting results are being obtained with the experimental instrument which has been built in the RCA Laboratories at Princeton by Dr. James Hillier, one of the pioneers in electron microscopy.

The electron microanalyzer is an outgrowth of the electron microscope and uses a number of the same principles. In fact it has included in its structures an electron microscope which enables the scientist using it to observe the specimen at high magnification in order that he may select the particle, structure or area of which he desires an analysis. Once the desired area is selected controls are manipulated which transform the instrument into an analyzer to provide the scientist with the required analysis.

ELECTRON MICROSCOPY



Diagrammatic cross-section showing inner construction of microanalyzer

The electron microanalyzer consists of a large vacuum tube constructed similarly to an electron microscope. In fact many of the parts used were salvaged from electron microscope developmnet work. The control panel can be seen behind it thongh the power supplies which operate it are not shown. Illustrated diagrammatically, is a cross-section of the electron microanalyzer. S is a small intense source of electrons which is reduced several thousand times by means of the magnetic electron lenses 1 and 2 thus forming a finely pointed electron probe or needle close to the specimen.

Two purpose probe

In the operation of the instrument the probe is used for two purposes. The first of these is for the observation of the specimen by what is known as the shadow type electron microscope. In this mode of operation the point of the probe is adjusted so that it is slightly below the specimen so that an enlarged shadow of the specimen is projected on the screen at the top of the instrument.

The shadow image produced in this way displays surprisingly good definition and is quite practical for high magnification viewing of the specimen. By means of the shadow image the part of the image to be analyzed is selected and moved to the center of the field of view.

The point of the probe is then gradually brought closer to the plane of the specimen. As this is done the shadow image is seen to grow in magnification until as the probe is brought into coincidence with the specimen the selected point which occupied the center of the field has been magnified until it covers the entire field. Under this condition the electron probe is passing through only that area of the specimen which has been selected and everything is ready for making the analysis.

Making the analysis

In any type of analysis it is necessary to use some characteristic property of the material as a means of identifying its components. In the electron microanalyzer that characteristic property is the slowing up of the electrons which takes place when they pass through the specimen. Physicists have known for a long time that each chemical element should slow some of the electrons by a very definite amount characteristic of the element. That is, if we send a lot of electrons, all traveling at one speed, through the specimen, we should find on measuring the speeds of all the electrons after they have left the specimenthat there are groups which have been slowed up by definite amounts characteristic of the elements present. The magnetic lens 3 and analyzer head H of the microanalyzer perform this function.

The electrons leaving the specimen are collected by the third lens and passed into a chamber which is transversed by a uniform magnetic field. This magnetic field bends the paths of the electrons into large circles; the size of the circle depending on the speed of the electrons. The fast electrons travel in large circles and vice versa. Thus, the magnetic field is really a gadget for sorting the electrons according to their speed.

Electron speed

Now, if a photographic plate P is placed half way around the circle the groups of electrons traveling with different speeds will hit the emulsion and make exposures in different places. This produces what the scientist calls an "electron velocity distribution." By measuring the positions of the lines on the photographic plate they can tell how much the electrons have been slowed up in each group and hence, what elements in the specimen were responsible for the slowing up.

Thus, by using the modern technic of electron microscopy and electron optics, an instrument has been devised which will enable scientists to add one more bit of information to that which they are obtaining from the electron microscope. In other words, they will be able to add chemical symbols to their electron micrographs, giving a new significance to the size, shape and structure they see with their eyes.

In describing his microanalyzer to the Electron Microscope Society of America in New York last month, Dr. Hillier was careful to point out that the experimental unit was being used first to test the physical theories on which its operation depends and that at this early stage in its development one must be very careful in predicting the value of his new instrument. The fact remains, however, that results of real physical significance have already been obtained and that any new instrument which has yielded information regarding the submicroscopic world of the past has quickly found use in the practical world.

Sketch showing the principle on which the microanalyzer operates

Fig. 2—Thermoanalysis apparatus, useful in determining temperatures at which chemical changes occur in metals and minerals

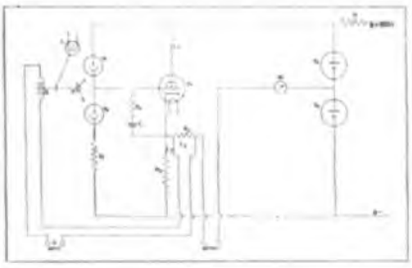


Fig. 1—Photoelectric balancing circuit

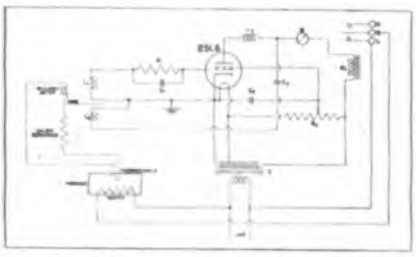


Fig. 3—RF oscillator type control

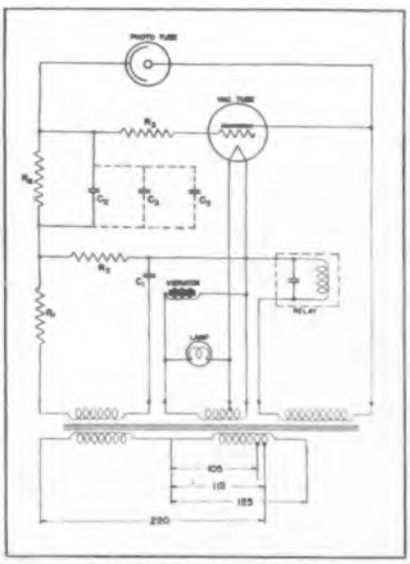


Fig. 4 — Photoelectric control for automatic regulation

● This article is concerned primarily with applications of electronic devices that have been found useful in metallurgical research in ore dressing, hydrometallurgy, pyrometallurgy, electrometallurgy, and physical metallurgy. The first four fields do not lend themselves to such diverse applications as does physical metallurgy, but such apparatus as electrostatic separators, automatic furnace controllers, induction furnaces, rectifiers, microscopes, and X-ray diffraction units are used widely and involve electronic devices. Also in the associated chemical work, titrimeters, conductivity bridges, colorimeters, pH meters, and polarographs employing electron tubes find extensive applications. In physical metallurgy, especially in studying many special and unusual problems, electronic devices are very useful; some of these instruments and those mentioned above will be described.

Probably the most important factor in metallurgical work is the measurement and control of temperature, and the range to be covered is wide. Measurements involving temperatures from 0 deg. to 1200 deg. C. are common, while some problems require the measurement of temperature differentials in the order of 0.1 deg. C. Direct measurements of these temperatures can be made readily by resistance thermometers or thermocouples, but a self-balancing photoelectric potentiometer has been found convenient for these measurements. It requires no manipulation and can be used for recording the temperatures on oscillographs, recording milliammeters, or any type of recording mechanism requiring not more than 10 milliamperes of energizing current.

The circuit diagram of such a potentiometer is shown in Fig. 1. The plate current from tube V_3 passes through a standard resistor R_s, and the potential drop in R_s is used to buck the unknown potential e. The plate current i_p is controlled by the bias on the grid of V_3, this bias being in turn controlled by the relative amounts of light falling on photoelectric tubes V_1 and V_2. The galvanometer, G, is connected between the unknown potential e and the standard resistor R_s; light from lamp, L, is reflected from the galvanometer mirror onto each of the photoelectric tubes.

Thus, if the potential drop in R_s is less than the unknown potential e, the galvanometer will deflect so as to reflect more light onto V_1. The grid bias of V_3 will become more positive and the plate current i_p will increase until a point is reached where the potential drop across R_s will balance the potential e. The current through R_s and meter M_1 is then proportional to the potential e.

Automatic operation

This whole operation is completely automatic and very rapid. The damping circuit C_1, R_s damps out oscillations of the galvanometer. The plate current through V_3 will range from 3 to 13 milliamperes, of which 3 milliamperes pass through R, and 0 to 10 milliamperes through R_s. By varying the value of R_s, the instrument can be made to measure potentials from less than 1 millivolt to more than 1 volt.

The effect of the restoring force of the galvanometer has been neglected. Actually, exact balance between e and the potential drop across R_s is not possible because some current must flow through the galvanometer to maintain the necessary deflection. In an actual instrument, the galvanometer deflection required to change the plate current from 3 to 13 milliamperes was only 1 millimeter at a meter distance corresponding to a

in Metallurgical Research

by E. V. POTTER
U. S. Bureau of Mines[1]

Describing electronic devices in laboratory work and control applications in industry

voltage across the galvanometer of 1.4 microvolts. Thus the error introduced in the measurement of e is a maximum of 1.4×10^{-6} volts and is less than 0.1 per cent for ranges of potential of 1 millivolt or more. The error in reading the current in meter M_1 is thus the controlling factor.

This instrument has been used for measuring and recording furnace temperatures up to 1200 deg. C. and for measuring temperature differentials from 1 deg. to 25 deg. C. when used with chromel-alumel thermocouples. The instrument has one definite advantage over regular potentiometers in that the current through R_s can actually reverse polarity. Thus, if voltage e should change polarity, plate current i_p will become less than 3 milliamperes and the current through R_s will reverse direction. The range of the instrument is limited in this direction, however, but can be extended to meet the requirements of special cases.

These instruments have been found useful for determining temperatures at which structural and chemical changes occur in metals and minerals. The proper temperatures for heat-treating metals can be determined and unknown minerals can be identified by the transition temperatures. Fig. 2 shows the apparatus used for making these determinations; a laboratory model of a photoelectric potentiometer is show at the upper left.

Furnace control

The accurate control and regulation of furnace temperatures is very important in all metallurgical processes and research, and a wide variety of instruments has been developed to maintain constant temperatures or to vary temperatures automatically according to a predetermined time schedule. These instruments generally utilize the expansion of metals, generation of an emf by a thermocouple, or the change in resistance of an electrical conductor to actuate the controlling mechanism. All these actuating methods can be used with electronic devices, but electron tubes are most generally used in conjunction with thermocouples or resistance thermometers.

A common type of controller uses a thermocouple, a millivoltmeter with a metal vane mounted on the pointer, and a vacuum-tube oscillator. The tuning and feedback coils of the oscillator are so arranged that the vane moves between them and the change in the oscillator plate current from the oscillating to non-oscillating condition or the change in plate current with change in frequency is used to actuate a relay and regulate the power to the furnace.

A typical circuit diagram is shown in Fig. 3. The oscillator circuit is so arranged that the coupling between L_1 and L_2 prevents the circuit from oscillating when the vane is not between the coils. At low temperatures, the plate current through M_1 is high and the heat is turned on. As

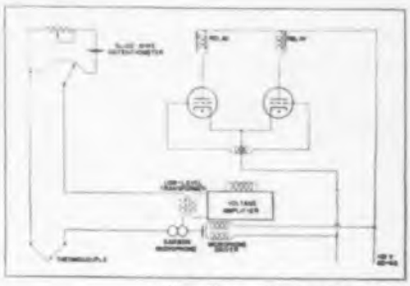


Fig. 5 — Potentiometer type unbalance recorder

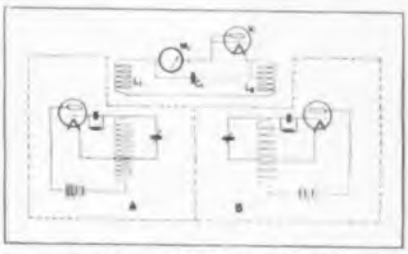


Fig. 6—Frequency shift indicator

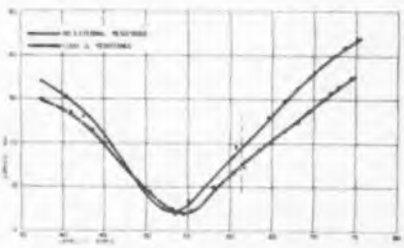


Fig. 7—Pullout current curves for frequency shift indicator

Fig. 8—Type of apparatus used for measuring damping, or the rate at which vibrational energy in a body is converted into heat

soon as the vane enters the space between coils L_1 and L_2 and the coupling between L_1 and L_2 is decreased sufficiently, the tube will begin to oscillate; this causes the plate current through M_1 to decrease suddenly, opening the relay and turning off the power. Another arrangement is to have the tube normally oscillating with a low plate current, so that the oscillations cease when the vane reduces the coupling between L_1 and L_2; the sudden increases in plate current operate a relay which turns off the power.

Another variation of this general type depends upon frequency change caused by change in capacitance when the vane changes position; the change in plate current associated with the change in frequency activates the power relay.

Automatic variation

The potentiometer type of controller is accurate and has found very wide use. The emf of a thermocouple is balanced against the voltage drop in an adjustable slide-wire resistor, any difference between the two potentials being used to activate the control mechanism. These controllers can be sub-divided into two groups, one in which a galvanometer is used to detect the unbalance between the potentials and activate the controls, and another in which the unbalanced potential itself is used to activate the controls. The first group includes instruments mechanically activated by the galvanometer as well as those in which a light beam reflected from the galvanometer mirror activates the controller.

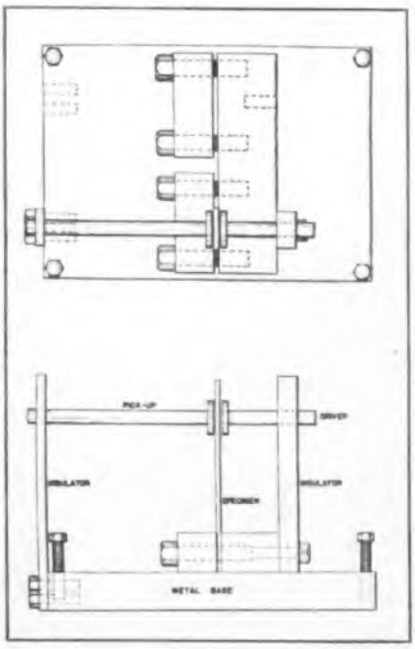


Fig. 9—Flexual damping apparatus

ELECTRONIC APPLICATIONS IN METALLURGY

1—High-voltage, low-current rectifiers for use with electrostatic separators, X-ray diffraction units, and electrostatic precipitation equipment.

2—Low-voltage, high-current rectifiers to replace motor generator sets in electrolytic processes.

3—Electron microscopes.

4—X-ray tubes for both hard and soft radiation for radiography and diffraction analysis.

5—Photoelectric cells for colorimeters for chemical analyses, densitometers for spectrographic and X-ray measurements, color analyses, and smoke detectors.

6—Cathode ray tubes for use as oscillographs and visual detectors.

7—Stroboscopes for observing the behavior of structures and materials under dynamic conditons.

8—Furnace controllers using vacuum tubes and photoelectric cells, and many other appliations using combinations of various types of electronic circuits and devices to perform special operations.

A typical diagram of the latter type is shown in Fig. 4. When no light is shining on the photocell, the grid bias on the vacuum tube is sufficiently negative to prevent any appreciable flow of plate current through the relay. When the galvanometer deflects enough to reflect the light beam onto the photocell, the grid bias becomes more positive, and the plate current in the vacuum tube increases suddenly to 15 milliamperes or more, activating the relay.

The light beam is in the form of a rectangle, about 2 millimeters wide and 15 millimeters high, and a shield over the photocell provides a sharp edge so that a motion of the galvanometer sufficient to shift the beam less than its width will cause the relay to open or close. This type of controller is sufficiently sensitive to operate in a temperature range of 1 degree C.

There are two controllers that use the unbalance in voltage between the thermocouple and a potentiometer to actuate the controls without a galvanometer. One of these types is shown in Fig. 5. The direct-current unbalance potential between the thermocouple and the potentiometer is converted to an alternating-current voltage by means of a carbon microphone alternately compressed and released at 60 cycles per second. The converted voltage is fed through a step-up transformer to the voltage amplifier and then to the grids of two thyratrons. Depending on the polarity of the direct-current unbalance voltage, one thyratron or the other will fire and activate a relay to turn the heating power on or off.

Another type accomplishes the same result by using a 60-cycle-operated vibrator to apply the unbalance voltage alternately to one of two windings on a transformer. An alternating-current voltage is produced in the secondary, which after amplification can be used to activate two thyratrons just as in the circuit discussed above.

For recording temperatures

Another type of controller uses the variation in resistance of a resistance thermometer to operate the control circuit. The thermometer is one arm of a Wheatstone bridge, the bridge being in balance at the desired temperature. Any deviation of the temperature from this value will unbalance the bridge, producing a potential across the detector junctions of the bridge. This potential is amplified and used to excite the grids of two thyratrons as in the controllers described. Unbalance in one direction will cause one thyratron to conduct plate current while unbalance in the other direction will cause the other thyratron to conduct plate current and operate a relay.

Each of these three types of controllers is also used for recording temperatures. In the first two, the relays are replaced by a motor that rotates the slide on the potentiometer slide wire so as to restore balance. A pen attached to the slide arm can then be used to record the temperature. In the Wheatstone-bridge type the motor is used to vary a resistor in the bridge circuit and restore balance; a pen attached to the resistor or motor records the temperature.

All the instruments described so far have been intended for use in recording or measuring temperatures or maintaining temperatures at fixed values. With little change they can be adapted readily for operation on predetermined time-

(*Continued on page* 216)

FM FOR WAR WORKERS

• Industrial music usually means in addition to the amplifiers and speakers, one soundproof room for turntables and mike and a girl to run it. A somewhat different system is currently used with complete success by over forty Chicago manufacturers.

FM station WWZR, owned by Zenith Radio Corporation, replaces the girl and the turntables. Six times daily, WWZR broadcasts special programs for war workers on 45.1 mc.

Industry in general, although convinced of the value of music-while-you-work, seems to operate on the hit-or-miss method in choosing selections to be played. Violet Kmety, program director, claims that the best production-increase resulting from such random selection of music amounts to about eight per cent.

In fact, she says, some types of music, such as vocals and boogie-woogie, make workers nervous and reduce output.

Scientifically planned music schedules have proved themselves to be nearly twice as effective, chalking up increases in production of fifteen per cent or more in the Chicago plants using the series.

Chief advantage of FM over AM for this service is better reception under static and interference conditions from motors, fluorescent lights and other sources which might make ordinary radio an impossibility.

Ordinarily, the plant music is received during lunch hour and fatigue periods. Selections are keyed to the idea of reducing fatigue, particularly during those times of the working day when production normally falls off as much as forty per cent. Variations in workers' reactions result in the fact that music which is ideal during certain hours of the day may actually be harmful at others.

Favorites with the workers are dance tunes of the "hit parade" type. Patriotic selections, waltzes, and marches are also on the preferred list.

The War Production Board recently asked 76 war plants employing over a half-million workers, "Does music increase your production?" Only one negative reply resulted. Now that the "music idea" is generally accepted, advantages of the "FM idea" originated by WWZR may supply the answer to technical and economic problems of many small plants in congested areas.

Modulation equipment and 1 to 5 kw rf amplifier stages of FM Station WWZR

Control desk and transcription turntables at WWZR

View of 108 kw 9,000 volt three phase power supply

Front view of the fifty kw amplifier stage

SCORING STAGE DESIGN

Cylindrical splays control reverberation time and an unusual mixer permits recording three sound tracks simultaneously

● Columbia Pictures built a scoring stage in 1935 engineered to incorporate the latest principles of acoustic design known at that time. The volume of this stage was approximately 75,000 cu. ft. and was enough for a maximum of 25 musicians, employing the rule-of-thumb figure of 3000 cu. ft. per musician. Although highly satisfactory, particularly for orchestras of 15 to 20 pieces, this stage later proved inadequate when orchestras of 35 to 50 men were to be accommodated. Until space could be found to construct a larger scoring stage, the Columbia Sound Department was compelled to adopt temporary measures to minimize the undesirable quality of sound resulting from overcrowding the stage and to seek means for increasing its reverberation time, particularly in the mid range and at the high frequencies, since these periods were considerably lowered by the presence of a large group of people in the room.

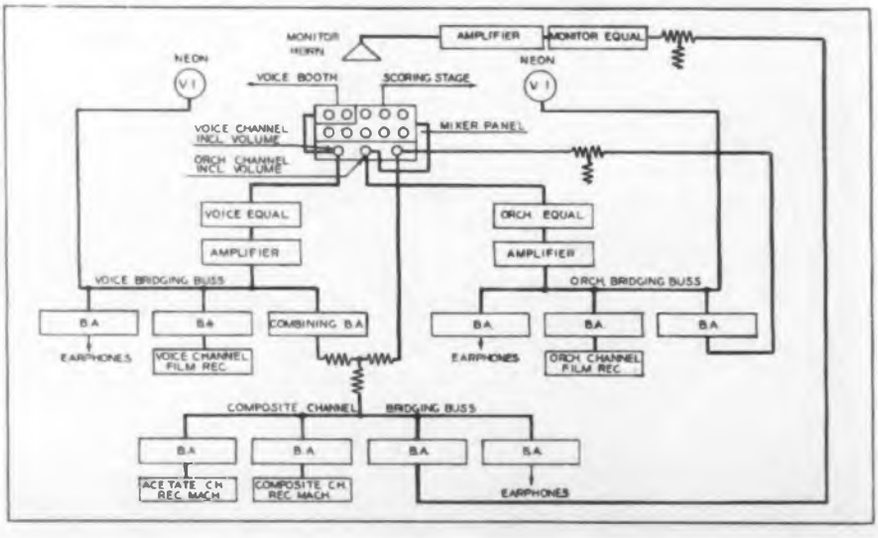
To reduce the somewhat undesirable effects of the low frequency reflections in the studio, the back wall and one third of each of the adjacent walls were considerably deadened by covering these surfaces with 4 in. of mineral wool. To increase the reverberation time which had been still further reduced by this treatment, wooden columns of various diameters were stationed around the walls of the orchestra shell. These columns ranged from 2 ft. to 3 ft. in diameter and from 10 to 20 ft. in height and were placed at a distance of from 3 to 5 feet from the walls of the stage.

This treatment improved the acoustics of the studio considerably and made it possible to record orchestras up to 35 pieces with reasonable satisfaction. Simultaneously, the beneficial effects resulting from the introduction of the columns in the room were discussed with both ERPI and RCA acoustic engineers and it was generally agreed that the idea had merit. Soon after, in 1938, Paul E. Sabine[1] wrote a paper entitled "Effects of Cylindrical Pillars in a Reverberation Chamber" which theoretically and experimentally supported the idea of using cylindrical pillars for the improvement of sound decay characteristics in a room. However, due to the fact that the columns reduced the volume of the room and were seriously interfering with the seating capacity of the orchestra, this arrangement was considered only a temporary remedy.

Between 1939 and 1940, Walt Disney studios, in conjunction with RCA acoustic engineers,[2] built two scoring stages using cylindrical splays in the bandshell. These stages, probably the first local music recording studios utilizing curved wood surfaces in the orchestra shell, employed two different

Front few of the scoring stage showing the use of curved splays of different diameters around walls, designed to control reverberation and sound decay

Fig. 2—Schematic of the special mixer panel with which three separate sound tracks may be recorded simultaneously, and any one later replaced with another



by JOHN P. LIVARDY,*
and M. RETTINGER**

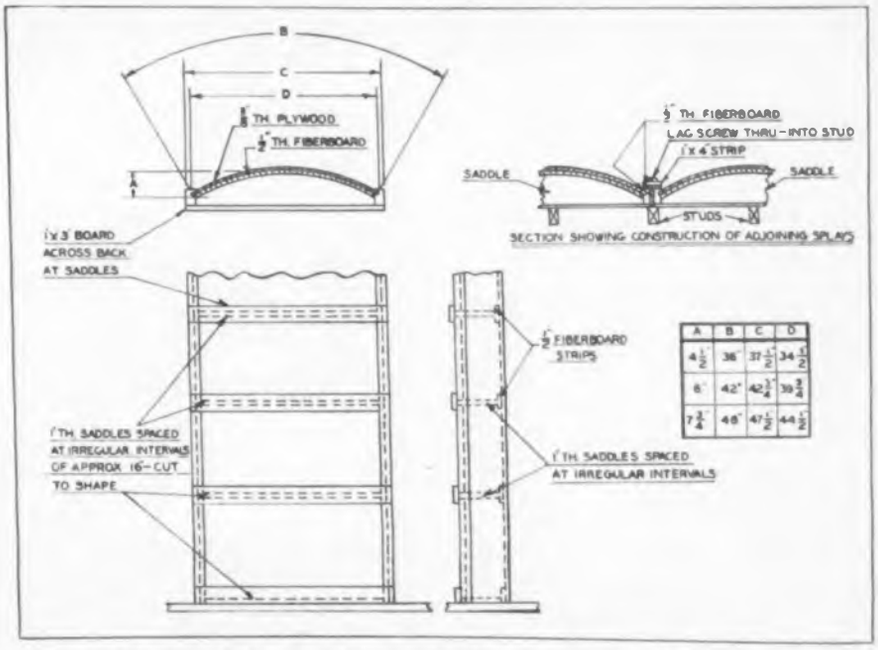


Fig. 1—This sketch shows the type of splay construction at present in use in the Walt Disney studios and also in the Paramount and Columbia stages

constructions for the convex splays. While plywood was used for both types, the curved surfaces in the first stage consisted of two ¼ in. sheets nailed securely to so-called saddles or horizontal planks of wood cut to the cross sectional shape of the splay. The second type of splay consisted of a single sheet of ⅜ in. plywood sprung into 2 by 3 in. upright wood studs containing a ⅜ in. groove as shown on Fig. 1.

In 1940, the space limitations of the Columbia scoring stage necessitated the conversion of an existing small production stage into a scoring stage to allow the recording of larger sized orchestras. The volume of this room was about 110,000 cu. ft. thus offering facilities for the recording of orchestras of about 35 pieces. For the acoustic treatment of this stage, the use of curved splays as used in the two Disney stages was considered desirable.

While at the Disney Studio both the walls and the ceiling of the bandshells consisted of convex splays, due to the low ceiling of the production stage, it was not found practical to supply a splayed canopy for the orchestra shell of this second Columbia scoring stage. The curved flats were therefore installed on the walls only, in clusters of 16 ft. x 16 ft., each made up of individual units 4 ft. x 8 ft. at right angles to each other.

*Sound Department, Columbia Picture Corp.
**RCA Victor Division, Hollywood, California.

Construction advantages

While the advantages of curved splays have lately been discussed in some detail in two articles,[2] it may be well to summarize the outstanding qualities of this construction.

1. More uniform distribution of sound pressure due to the longer wave front of the reflected sound, a factor of particular importance in connection with high frequencies. As is well known, the wave front of a beam of sound reflected from a convex surface is considerably longer than that from an equally large flat surface provided that the wavelength of the incident sound is small compared to the dimensions of the reflecting surface. Depending on the frequency, an increase in wave front length of from 2 to 3 times over that from a flat surface can be realized in this manner, assuming, of course, that the source of sound is at that same distance from both surfaces.

2. Creation of surface sources of sound. The increase of diffusion of sound in the room obtained in this manner is of importance for the low frequencies and is of special help in not making the microphone position critical for optimal pickup. It should be noted that the creation of surface sources can be obtained only when the splays are able to vibrate, as otherwise they would act as pure reflectors. It should further be observed that wood represents the preferred material for this pur-

(*Continued on page* 210)

Rear view of the sound stage showing acoustical treatment of the walls and the method of arranging the sound controlling cylindrical splays

1. Paul E. Sabine "Effects of Cylindrical Pillars in a Reverberation Chamber" Journal of the Acoustical Society of America, July 1938.

2. John E. Volkmann "Polycylindrical Diffusers in Room Acoustic Design" Journal of the Acoustical Society of America, June 1942, Volume 13, No. 3.
M. Rettinger "A Modern Music Recording Studio" Journal of the Society of Motion Picture Engineers, September 1942, Volume 39, Pages 186-194.

TUBES ON THE JOB

Electronic Divining Rods

A boon to municipalities and public utilities, various types of tube-operated finders and locators enjoy ever increasing use. When a water or sewer pipe or electrical conduit is buried underground, everyone seems to think it's buried for good. Over the years, engineers change jobs, memories fade, and maps have a way of disappearing.

Several electronic principles contribute to these various types of underground research. Most usual is the high frequency magnetic field common to military mine-detectors. When the field coil passes over buried metal of any kind, the oscillator is unbalanced and the amplified indication noted as a variation in audio tone, in tube plate-current, or both. The instrument illustrated, made by Fisher Research Laboratory, Palo Alto, California, locates ferrous and non-ferrous metal pipes or objects at walking speed, and is commonly used for finding curb, street, meter, and drip boxes.

When a buried water or oil pipe develops a large leak, surface indications usually appear. Such indications, however, may be whole blocks from the actual points of leakage. Exploratory excavation is expensive, especially when offending mains are beneath eight inch concrete highways. Many leaks give no surface indication at all, resulting in a 24-hour "unmetered user" from the utility's point of view. For such work, a high gain audio amplifier and a flat crystal pickup come to the rescue. Spotting the exact location of a suspected leak is accomplished by placing the pickup on the ground or pavement above the pipe at a number of successive intervals, to find the point of maximum leak-sound output. A ten position filter allows tuning of the amplifier to the leak for noise reduction.

Above: Lead detector hears hiss of escaping water. Below: Transmitter-receiver type equipment for finding buried pipes and cables

Called the "M-Scope," a special transmitter and receiver combination finds wide application to the locating of buried pipes, cables, pipe bends, dead ends, valves, etc., and is useful for detecting unknown metallic hazards in the path of excavating machinery. Operation is based on the fact that the transmitted signal reaches the receiver a short distance away with a given volume and plate current meter-reading. When a buried pipe or other metallic path intervenes, the signal strength at the receiver is markedly increased. The units may be mounted on parallel "handles," closely coupled for use by one operator in certain kinds of work. "Electronic location" has saved countless man-hours in the service of utilities, government, industrial plants, and construction contractors.

Above: Electronic box locator in use

Lowers Chicken Mortality

A year-long study in 400 chicken, duck and turkey hatcheries has demonstrated that ultra-violet rays reduce poultry mortality as much as 68 per cent. Dr. Harvey C. Rentschler, director of the Westinghouse Lamp Division Research Laboratories, reports:

"Sixty per cent of chick mortality occurs within the first sixteen days. Germ-killing rays of short wave ultraviolet are helping to reduce these losses. In addition, the small amount of Vitamin D wavelengths generated by bactericidal lamps reduce the growing time of young birds—an important factor today when feed is so scarce."

In a carefully controlled test of two brooding houses, identical except that one contained the bactericidal ultraviolet Sterilamps, Rucker's Imperial Breeding Farm and Hatchery, Ottumwa, Iowa, reported 68 per cent lower mortality and 50 per cent fewer culls and runts—or discards—in the house employing the lamps. Birds in the irradiated unit grew to range size in five weeks, compared with eight weeks for the unirradiated birds.

Rucker's found it possible to raise 1,000 pullets per brooder in the irradiated buildings, as against 750 in the brooders without lamps. Otherwise, the same sanitary measures were employed in both houses. The test involved 11,000 chickens.

New Electronic De-Icer System

Successful operation of the familiar rubber "boots" installed along the leading edges of military and commercial aircraft for ice removal depends upon very careful timing of the inflation cycle. Standard practice has fixed the cycle at approximately 40 seconds, assuming a uniform accumulation of ice.

However, neither the rate of formation nor the type of ice formed is a fixed quantity. Best ice removal is accomplished if at least one-eighth of an inch of ice is allowed to form before inflation of the de-icer boots. If the inflation occurs too early, tensile strength of the ice layer is not sufficient to keep it intact while the expanding rubber breaks loose from adhesion to the ice, and little "islands" of "crazed" ice remain. Further accumulation of ice builds on the islands a flexible layer which

is impossible to dislodge. Subsequent cycles of inflation of the boot are ineffective because the stretch of the rubber localizes in the areas between the islands without disturbing their adhesion. A new system of ice removal, developed by Eclipse-Pioneer division of Bendix Aviation Corp. and the B. F. Goodrich Co., incorporates a number of interesting improvements, one of which is an adjustable electronic timing control.

Basically, the electronic timer consists of a single 2050 thyratron, resistance - capacitance combinations to control firing time, and the associated relays and switches which allow selective operation of different sections of the solenoid controlled pneumatic system. The condenser is charged at each operation of the boot or boots selected and holds the grid of the thyratron negative for a length of time variable between zero and 60 seconds by switching to any one of six different resistors in the R-C timing circuit.

Radio Controlled Crewless Tanks

Another more or less "secret" weapon has been turned loose by the Germans on the beachhead below Rome, reports the "New York Times." It is a ground-hugging, remote - controlled tank carrying 1,000 pounds of high explosive to its target, where it can be exploded at will.

It is reported that at least fourteen of the crewless machines—which the Russians call "beetles"—have been knocked out by Allied artillery before they reached our lines.

Each of the tanks carries an antenna which links it to human control. Unlike the glider bomb, it does not explode on impact but depends on the pushing of a button.

The Allies' command on the beachhead has learned that the 309th Armored Grenadier Regiment, formerly stationed around Berlin and Spandau, brought these tanks to Italy. This regiment had been on demonstration duty, showing various types of new equipment and tactics.

British Television Network

A scheme for television, covering 85 per cent of Britain's homes, which could operate nine months after the war, has been drawn up by the radio industry and put before the Government Committee on Television. If the scheme goes through it would mean that, instead of one television diffusion station at Alexandra Palace there would be about 13, each relaying programs from a BBC main station, to which they would be linked either by land line or radio.

A member of the Television Commercial and Development Committee reports: "We aim to give employment to all those in the industry and in the Services who have been working on radio and television devices during the war.

"An improvement in circuit design is enabling us to give a much livelier picture than was possible previously. It won't be a bigger picture. It is now possible to get in a small room practically the same impression as in the circle at a first-class cinema. There is no question of flicker now. The range will be the same, about 35 miles, but with rediffusion stations it will be possible to get first-class reception practically anywhere in the country. The price we aim at for a television receiver is approximately $125 plus a further $40 if ordinary radio reception is desired as well."

Steel that Rings the Bell

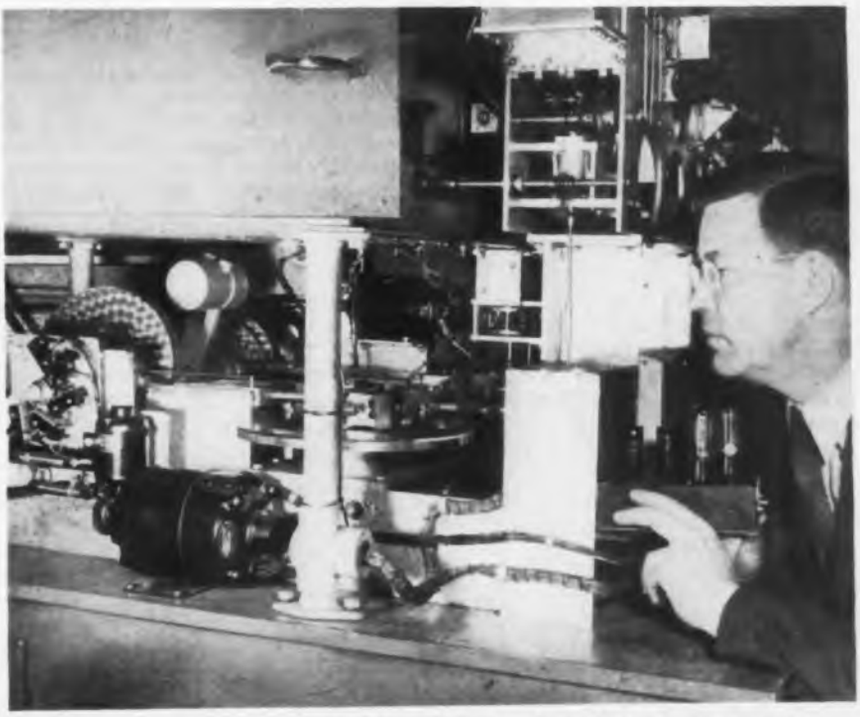
A properly made cast or machined steel part will have a characteristic "ringing" frequency when struck or dropped on an anvil, as reliable a guide to its quality as the sound of a coin "bounced" on the counter. With vacuum tube amplification combined with sharp filtering designed to operate a relay controlling a green "okay" lamp, the idea has been developed into a production line test set-up for 20mm. high explosive shells before loading. Shells with any imperfection might be liable to the danger of exploding prematurely inside or just outside the barrel of the gun, ruining it and the crew. A microphone near the anvil on which the shell is dropped picks up the "signal". If the shell is good, its sound will be of the correct frequency and duration to light the green lamp.

More Efficient Turbines

More power from less fuel is the objective of this calculating machine, shown with T. M. Berry, General Electric Co.

Turbine nozzles must be superstreamlined for maximum efficiency. Steam races through the nozzles at 1200 miles an hour, 12 times the speed of a hurricane. In this test compressed air, substituted for steam, is blown at various pressures through a sample nozzle and the machine measures, records and adds up energies at various points on the nozzle.

The turntable center turns, and the varying pressures move the small upright wheels back and forth on it. The rotation of these wheels is conveyed by rotating shafts of polarized light to two photoelectric tubes. The tubes control a series of cams and gears known as a servo-mechanism which operates the printer immediately above Mr. Berry's head. The printer adds up energies and indicates over-all energy loss, data which becomes the basis of turbine design improvements leading to greater efficiency.



Set-up for turbine nozzle study, as shown, leads to design improvements

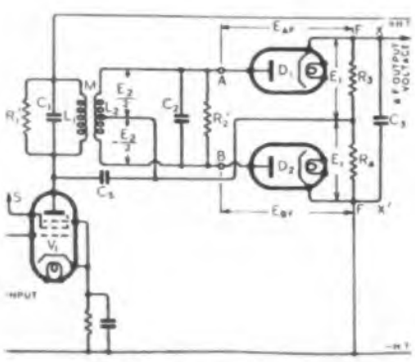
SURVEY of WIDE READING

Electronic news in the world's press. Review of engineering, scientific and industrial journals, here and abroad

On Quartz Crystals

R. Bechmann (Hochfrequenztechnik und Elektroakustik, Leipzig, Germany, Vol. 61/1, 1943)

A systematic account of data on longitudinal oscillations of X and Y cut quartz crystal plates and rods is given for the frequency range of from 50 kc to 300 kc. Frequency as a function of the characterizing angle, temperature dependence of frequency, equivalent inductance and resistance for thin rods and plates are shown in graphs and tables; computed and measured values are compared. The influence of the crystal mounting and of the thickness of the electrode layers is discussed.



Conventional phase discriminator

The Phase Discriminator

K. R. Sturley (Wireless Engineer, London, February, 1944)

Linearity of output voltage with change in input frequency and frequency-to-amplitude conversion efficiency of the phase converter circuit in an FM receiver are studied.

The formulas indicate that the primary voltage E_1 must increase as the applied frequency departs from the center frequency F, if a linear response characteristic is to be secured. This entails a coupling coefficient $k = M(L_1L_2)^{-\frac{1}{2}}$, greater than the critical, between primary and secondary. The greatest linear range, covering frequency deviations of from 0 to 0.5 F/Q, is obtained for $k = 2/Q$, $E_2/E_1 = 2$, $L_2/L_1 = 1$, where Q is the magnification of the primary and secondary circuits.

Maximum frequency-to-amplitude conversion efficiency, however, is obtained for couplings less than the critical, i.e., $k=1/Q$, and a suitable compromise between the two incompatible requirements has to be found, sacrificing some of the maximum efficiency and some of the linear range. For optimum design, it is recommended a choice of $k = 1.5/Q$, $E_2/E_1 = 2$, and $L_2/L_1 = 1.77$.

Processing of Glass for Tubes

R. L. Breadner and C. H. Simms (General Electric Co. Journal, London, Vol. XII, No. 4, 1943)

Radio tubes, cathode ray tubes, electric lamps and other electronic devices are characterized by the sealing of metallic conductors through the glass wall of an envelope to produce a vacuum-tight joint. Essential properties of different types of glass at various temperatures are given; particularly, the thermal expansion coefficient which is of great importance in strain considerations at the adjacent surfaces.

It is pointed out that the most satisfactory joints are obtained by so selecting the thermal expansion coefficients of metal and glass that when the joint is cooled, the glass in the vicinity of the metal is under slight compression. If the two coefficients vary widely, it is still possible to join glass and metal successfully, provided the metal is sufficiently ductile to be deformed by stresses smaller than the yield point of the glass. Copper, when suitably shaped, is a metal which fills this role admirably. Examples of matched combinations are given in the table.

The formation of metal oxides during the glass-to-metal sealing process and its consequences are discussed. The color indicates the thickness of the film, and the permissible color range is stated in the table. The shapes of and the strains in the three main types of joints, rod, cylinder, and disk, are discussed in detail. Methods for the treatment of glass and the consequent design of glass working machinery are explained.

Measuring Color Response of Photocells

G. N. Patchett (Electronic Engineering, London, February, 1944)

Among several applications of the cathode ray oscillograph described in the article, one deals with the determination of the color response of a photoelectric cell.

A disk-shaped color filter corresponding to the spectrum is rotated between a mask and a photocell so that at any given instant only light of one color from a lamp impinges on the cell. The time base of an oscillograph, to the vertical plates of which the output of the photocell is connected, is synchronized with the rotation of the filter. Small, dark, radial sectors on the filter, which cut off the light

Processing of glass for tubes

Metal		Glass		Colour of Cold Seal
Type	Coeff. of Expansion per Deg. C.	Type	Coeff. of Expansion per Deg. C.	
Tungsten	4.4 × 10⁻⁶	Pyrex W.1	3.5 × 10⁻⁶ 3.9 × 10⁻⁶	Light Brown to Straw
Molybdenum	5.5 × 10⁻⁶	H.H.	4.5 × 10⁻⁶	Dark to Light Brown
Platinum	8.9 × 10⁻⁶	L.1 (Matched Seal) Almost all glasses if Platinum specially shaped	9.1 × 10⁻⁶	Bright Metal
50% Nickel-Iron	9.4 × 10⁻⁶	L.1	9.1 × 10⁻⁶	Medium to Light Grey
25% Chrome-Iron	10.5 × 10⁻⁶	X4 or X8	9.6 × 10⁻⁶	Medium to Light Grey-Brown
Copper	16.7 × 10⁻⁶	Almost any standard glass if metal specially shaped		Bright Red to Gold

"I understand, Colonel, that you're interested in performance!"

There is a time and place for everything. Oscar's single-minded enthusiasm might have been better timed. On the other hand, his point is well taken.

In manufacturing electronic tubes, performance is the ultimate goal. To assure uniform reliability, Hytron tubes are painstakingly produced to standard factory test specifications tighter than customer tolerances. Then for the final verdict on actual performance, we turn to you who design, build, and operate the intricate electronic tools of war.

Those using Hytron tubes such as the 1616, OC3/VR-105, and OD3/VR-150, will not be surprised to discover that these tubes have earned the reputation of being the best in the industry.

You owe it to yourself to become familiar with these and other popular Hytron tubes, many of which appear on the Army-Navy Preferred List.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

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BUY ANOTHER WAR BOND

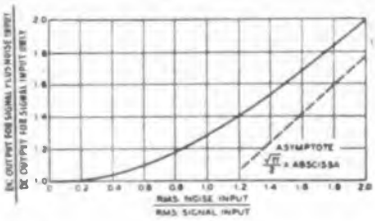
beam completely, are used for the calibration of the time axis.

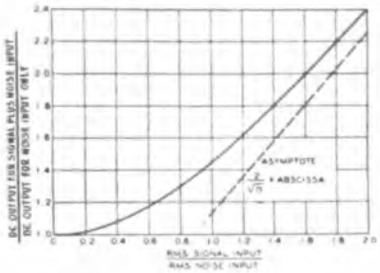
If quantitative results are required as distinct from comparative results, a correction must be applied for the color distribution of the lamp, unless this has been allowed for in the construction of the filter disk. Alternatively, the color distribution of the light source may be determined if the response of the photoelectric cell is known.

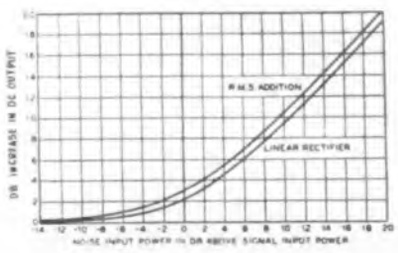
Response of Rectifier to Signal and Noise

W. R. Bennet (Journal of the Acoustical Society of America, January, 1944)

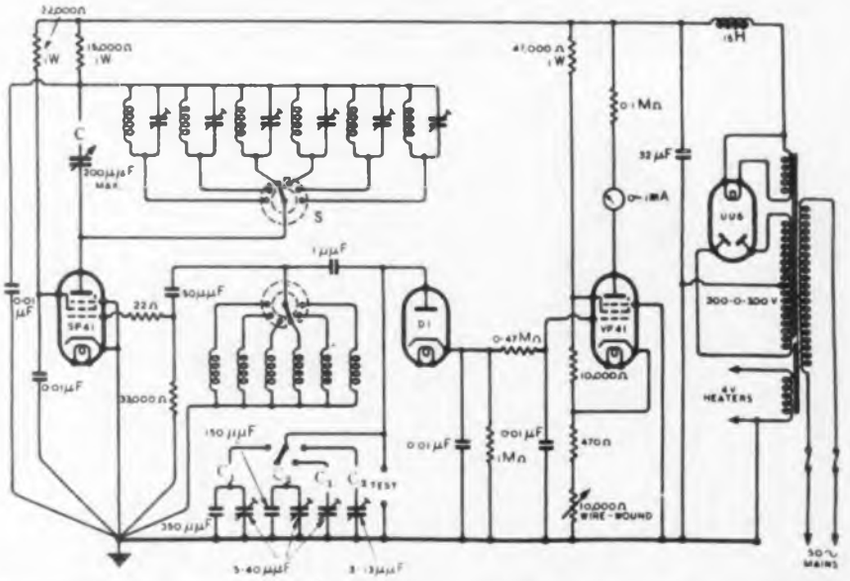
The output of a linear half wave rectifier is computed when the input contains both a sinusoidal signal voltage and random noise voltage amplitudes. To derive the average value of the current output amplitude or the dc response, the probability functions, i.e., an expression for the frequency of occurrence, for signal and noise input voltage amplitudes are computed. From these expressions, the probability function for the amplitude of the combined signal plus noise input voltage is obtained. The assumption that the rectifier is linear then leads to an integral which yields the dc output current; series expansions for the evaluation of this integral are given, provided either signal or noise voltages are comparatively small.







Above: Figures 1, 2 and 3



Scale connected to capacitor C in oscillator of inductance meter is so calibrated that unknown inductance is given by difference of two readings

In Fig. 1, the ordinate is the ratio of the average output current for signal plus noise input to the average output current for signal input only; the abscissa is the ratio of the rms noise input to the rms signal input. In Fig. 2, the ordinate is the ratio of the average output current for signal plus noise input to the average output current for noise input only; the abscissa is the ratio of the rms signal input to the rms noise input. Fig. 3 shows the increase in combined output power with increase in noise input power expressed in decibels below or above signal input; the two curves correspond to the output of a linear half wave rectifier and to simple power addition of the inputs, respectively.

By a different mathematical procedure and assuming an input represented by a finite Fourier series with arbitrary amplitudes and arbitrary but incommensurable frequencies, the spectral distribution of the sinusoidal components in the rectifier output is studied. Curves are shown illustrating the noise power resulting from the beat frequencies between signal frequency and noise frequencies, and between different noise frequencies.

Measuring Small Inductances

R. F. Blackwell and D. J. Becker (Wireless World, London, Feb., 1944)

An instrument for the rapid measurement of the inductance L in μH and self-capacitance C_o in $\mu\mu$F of coils from 1 to 1000 μH has been designed. The largest observed error in the inductance measurement was 0.5 per cent.

Switch S permits any of six coils to be connected into the tuned plate circuit of the oscillator pentode so as to change the range of the oscillator frequencies. A variable capacitor C provides for continuous variation within the frequency ranges. The output from the variable frequency oscillator is fed into a parallel tuned circuit consisting of the unknown coil and either of two known capacitors C_1, C_2 switched across the coil in turns. Two pairs of known capacitors covering two ranges are provided. C_1 and C_2 have values of 40 and 20 $\mu\mu$F respectively for coils from 1 to 100 μH, and 400 and 200 $\mu\mu$F for coils from 100 to 1000 μH; stray capacitances and diode input capacitance are included in these values.

The frequency of the oscillator is varied until resonance, as indicated by the tube voltmeter, is obtained in each case, and two readings, X and Y, are taken on the specially calibrated scale of capacitor C. It is shown that if C_1 and C_2 are chosen so that

$$C_1 = 2C_2, \text{ then}$$

$$L = X - Y \quad \text{and}$$

$$C_o = \frac{C_2(2Y - X)}{X - Y}$$

provided the scale of the oscillator capacitor C is so calibrated that an inductance of value X or Y μH connected in parallel with a capacitance of C_2 $\mu\mu$F would have a resonant frequency equal to the oscillator frequency. It will be seen that the unknown inductance is given by the difference of two readings.

The dimensions of the apparatus, its performance and calibration procedure are described in detail.

(*Continued on page* 204)

SINCE 1897

STUPAKOFF

Products for the World of Electronics

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STUPAKOFF *Ceramic* INSULATORS

STUPAKOFF produces a complete line of precision made, "radio grade" insulators, made of Steatite and other ceramic materials. Stupakoff insulators are subjected to the most severe laboratory and field tests, to assure their unfailing performance in actual service.

The dependability of Stupakoff Ceramic Insulators is the result of a combination of important factors. They include the absolute control over raw materials, modern manufacturing facilities equipped with precision tools, correct engineering, and most important of all, the invaluable experience and knowledge gained through years of producing ceramic insulators. This experience is available to you upon request.

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STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

WHAT'S NEW

Devices, products and materials the manufacturers offer

Fluxed Wire Solder

A new type of fluxed wire solder, which contains flux in longitudinal grooves on the surface rather than in the conventional core, has just been placed on the market. The new material, called Fluxrite is put out by National Lead Co., 111 Broadway, New York. Since the flux is outside rather than inside, it liquefies and flows onto the work before the solder melts. This insures thorough and complete fluxing and results in stronger and better solder joints.

In addition to pre-fluxing, the new solder provides an unbroken flow of flux. An additional advantage comes from the fact that the flux supply being outside the wire, is always visible. The new product, which contains a recently developed special flux, comes in the same diameters as regular cored solder. It is available in two compositions designated as Red Stripe and Green Stripe. These designations refer to the color of the flux which has been specially dyed in each case for easy identification.

Dual Coil Relay

To meet the demand for a small power relay with sensitive (½ watt) operation, Allied Control Co., 2 East -End Ave., New York, has developed a new dual coil unit, model BOY. Through the use of double coil construction, the power consumption required for satisfactory operation has been reduced over single coil relays of equal load capacity, thus making this type of unit suitable for use in plate circuit applications where the limited amount of current is insufficient to operate a single coil power relay directly. The two coils may be connected in series for operation at one voltage and in parallel for a second voltage; or one coil can be used for operation while the other is used for holding. The relay has a semi-balanced armature construction and is built to withstand 10 G's. Coils are cellulose acetate sealed to withstand salt-spray and high humidity. Dimensions are 1-⅝ x 1-⅞ x 1-½ in., and the weight is five oz.

Tube Voltmeter

A new probe designed for greater convenience and efficiency especially at high frequencies such as those encountered in frequency modulation and television design and test work is being supplied by Alfred W. Barber Laboratories, 34-02 Francis Lewis Blvd., Flushing, N. Y., as a unit of their wide range vacuum tube voltmeter. This probe is cone shaped with the "high" terminal in its nose. This permits extremely close connection to be made to the circuit under test which is very important at high frequencies. The probe is molded from low-loss material, thereby reducing loading on the circuit under test to a minimum. The probe being attached to a four-foot cable permits the voltmeter proper to be placed in the most convenient position on the test bench. The voltmeter measures voltages from 0.1 to 100 volts at dc, ac and rf frequencies to over 100 megacycles.

Isolating Transformer

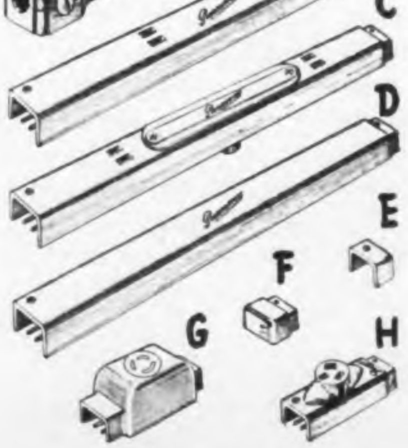
The isolating transformer which was designed for use in connection with the testing of radio and communication equipment has a secondary that is completely enclosed in a copper shield. Secondary terminal connections are provided by means of a lead shielded cable, the sheath of which is integrally joined to the copper enclosing shield of the secondary winding. Normally rated at 2 kva, the unit is capable of handling an over-load of 50 per cent or a total load of 3 kva. The regulation of the transformer is 1 per cent at 1 kva. The lighting in the shielded test-room, the use of soldering irons, instruments and various types of test equipment may be operated from the shielded secondary of the transformer without causing objectionable voltage drop. The instruments or equipment may be used as the need requires, the load being switched on and off without affecting the relatively constant voltage. Acme type T-4173 weighs approximately 123 lb.; the unit is 18¼ in. in length x 9¼ in. ht. and an overall width of 10 7/16 in. with mounting centers of 6 15/16 in. x 9⅛ in. Manufactured by Acme Electric & Mfg. Co., Cuba, New York.

Cable Clamp

A new cable clamp, a compression type with all parts mounted or ringed on the cable axis for faster assembly time, is being manufactured by the Oxford-Tartak Radio Corp., 3911 S. Michigan Ave., Chicago. All parts are locked by a simple push-together and turning motion. The finished unit is twist-proof, rupture-proof and waterproof. The clamp may be used for all wiring systems—single or multiple conductors with flexible or rigid coverings.

Wiring System

Pierceway wiring system rapidly supplies electrical outlets so that production changes can be made in a fraction of the time formerly required. When additional benches are set up and outlets are needed, the feed section is connected to the line, the plastic duct sections are joined and mounted by means of strap hangers and the bench is ready with outlets at intervals of 8 in. Should further production changes occur, the sectional nature permits quick dismantling and 100 per cent salvaging of parts. This system may be used for supplying current for fluorescent lighting. Manufactured by Walker-Jimieson, Inc., 311 S. Western Avenue, Chicago 12, Ill.



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Complete details are available on request—for quick reference some of Polystrene's outstanding values are given here:

Dielectric Constant	
	2.5 to 2.6 at frequencies 10^{6}
Power Factor, 60 cycles	.0001 to .0003
10^{3} cycles	.0001 to .0003
10^{6} cycles	.0001 to .0008
Dielectric Strength, Volts/Mil ⅛" thickness	
Short time	500 to 700
Step by step	450 to 600
Volume Resistivity, ohms-cms	10^{17} to 10^{19}
Heat Resistance	150°F to 175°F
Softening Point	190°F to 250°F
Specific Gravity	1.05

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Send for complete data giving physical properties of Acadia Polystyrene, plus a table of specifications on its electrical properties.

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DC Motor

An aircraft type direct current series motor is now being manufactured by the Alliance Mfg. Company, Alliance, Ohio. The unit operates continuous duty on 13 volt dc source at 7.4 amperes delivering a full 1/12 hp at 7,500 rpm. The motor is light weight with sturdy, totally enclosed, ball bearing construction. It measures overall less the ¼ in. diameter shaft extension, 4-5/16 in. in length by 2¾ in. diameter and weighs but 3½ lbs. Low temperature rise permits operation under high ambient temperatures.

"Hi-Stress" Speed Nut

A new "Hi-Stress" speed nut, conforming to AAF specification No. 25531, has been developed by Tinnerman Products, Inc., 2111 Fulton Road, Cleveland 13, Ohio.

It is a light weight, one-piece integral unit with low installation torque that allows speedier insertion of screws and bolts. It is interchangeable with nut plate AN362, for high temperature applications in all structures. Retains its self-locking torque even after many removals.

HF Motor Generator

A new line of high frequency motor generators is being developed by the Kato Engineering Co., Mankato, Minn. The machine shown is a motor and a generator with frames cast integral. The cores of the motor and generator are two distinct armatures but are mounted on one common shaft. A great many combinations of ac voltages and frequencies can be had in this unit such as either 400 or 800 cycles. Also motor winding may be tapped to deliver 60 or 120 cycles at either 1800 or 3600 rpm. Voltages from 60 volts on the tapped winding to 250 on the 800 cycle winding. Capacities up to 1000 watts

INSULATED IRON CORES

- ✔ Iron core insulated from screw, keeping screw out of coil field.
- ✔ Increases "Q" 30 points or better.
- ✔ Reduces distributed capacity of coil.
- ✔ Reduces hand capacity effect where screw is not grounded.

MOLDED IRON TRANSFORMER CORES

. . . another Stackpole development in powder metallurgy. Designed for transformers and chokes where constant inductance is required over a given frequency range—also where constant inductance, limited only by the saturation point of the core, is needed for various currents. This saturation point can be predetermined to meet specific conditions

Stackpole Insulated Iron Cores mean new standards of efficiency for applications such as antenna or oscillator coils; I-F transformers of either top and bottom-tuned or top-tuned types; permeability tuning (either audio modulation or frequency modulation): transmitting tuning and others. The insulation is bonded to the core to form an integral unit, and may be any length from ¼" up to 1". Core diameters of .198", .250", and .365" are produced as "standard", although other diameters are available.

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may be furnished. Motor can be wound for dc voltages 110 or 220 volts dc input. This can also be furnished at three phase at slightly lower capacities. Voltage regulation is approximately 6 per cent at 120 cycles and 24 per cent at 720 cycles. Frequency regulation is 1.6 per cent at 1000 volt-amperes. This unit is light weight, compact, being approximately 16⅝ in. long, 8¾ in. wide, 13¼ in. high and weighs approximately 110 lbs.

All Frequency Receiver

The new Harvey-Wells Model AR-10-A all-frequency receiver features beacon band coverage from 195 to 425 kc with "spot tuning" on 278 and 271 or any other two specific frequencies, communications band coverage from 2500 to 4500 kc and from 4500 to 8000 kc with pre-tuned circuits for twelve crystal controlled frequencies anywhere in the 2500 to 10,000 kc band, two rf channels obtaining for day frequencies from 4.5 to 10 mc and night from 2.5 to 4.5 mc, image attenuation greater than 65 db and sensitivity such that an input of two microvolts modulated 30 per cent at 400 cycles produces an output of 50 milliwatts at a signal to noise ratio of 6 db. The receiver

weighs 24 lb. Other characteristics include a single tuned circuit between antenna and grid of frequency amplifier; three antenna input terminals, the low frequency antenna input circuit designed for 100 mmf—10 mmf, high frequency antenna input circuit connected through a selector switch and associated circuits, and loop input on beacon band, its circuit consisting of coupling transformer and trimmer designed to operate on Sperry or similar loop; tuned loop amplifier between coupling transformer and rf amplifier of the receiver; two stages of rf amplification with six tuned circuits operating at 4.55 kc; automatic volume control maintaining audio level output constant—6 db for input voltages from 5 to 100,000 microvolts, and is used on communication frequencies as well as on the two "quick shift" beacon frequencies. Manufacturer is Harvey-Wells Communications, Inc., Southbridge, Mass.

Transmission Line Calculator

A useful calculator for solving radio transmission line problems has just been placed on the market by the Emeloid Co., Inc., Arlington, N. J. It is fundamentally a special kind of impedance coordinate system mechanically arranged with respect to a set of movable scales to portray the relationship of impedance at any point along a uniform open wire or coaxial transmission line to the impedance at any other point as well as to the several other electrical parameters. These other parameters are plotted as scales along a radial arm and around the rim of

Furnatron*

FOR ACCURATE AUTOMATIC FURNACE CONTROL

The answer to fluctuating temperatures in resistance-type electrical furnaces is provided by the new Westinghouse-developed electronic device—Furnatron*. This regulator operates to provide accurate control of the alternating current reaching the furnace, and is equally adaptable for single-phase or three-phase systems.

Furnatron is available as a separate regulator or as a complete control unit, panel mounted. The complete unit normally consists of the Furnatron regulator, a controlling pyrometer, control switches, and, in certain cases, an anode transformer. If desired, meters to indicate the power flowing into the furnace can be incorporated in the panel.

The Furnatron system of controlling the furnace temperature is the most accurate available today. Its speed of response is limited only by the pyrometer and furnace itself. For complete details, call your nearest Westinghouse representative. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania. J-60546

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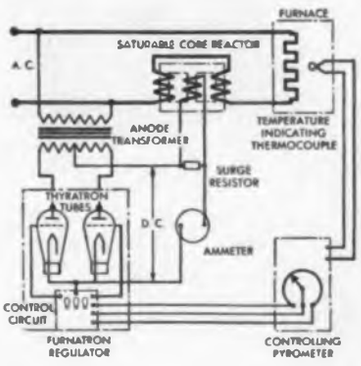
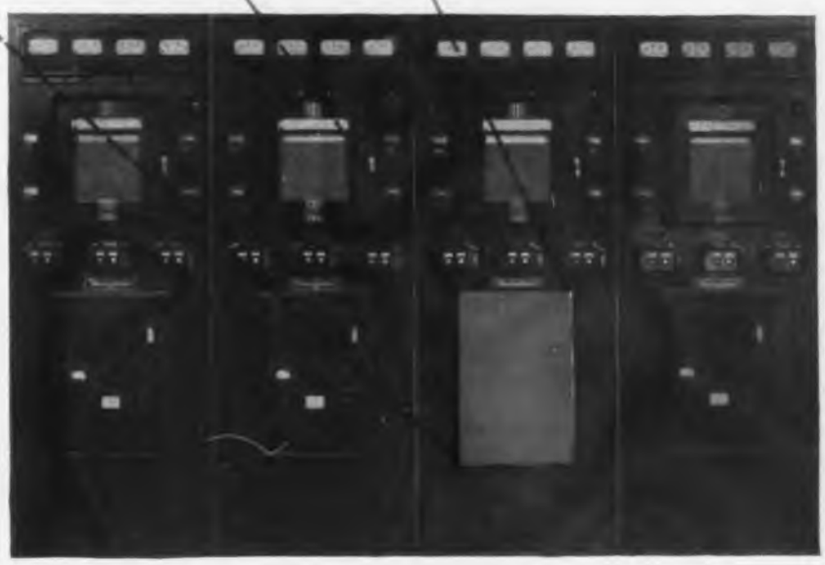


HOW THE FURNATRON WORKS

Fundamentally, the Furnatron regulator automatically controls the saturation current of a saturable core reactor connected in the furnace element supply line. The Furnatron functions as an electric rectifier, to supply d-c power to reactor core, and thereby adjust the line voltage to the furnace. The flow of current is adjusted automatically, in accordance with the indications of a controlling pyrometer which operates in conjunction with a thermocouple in the furnace.



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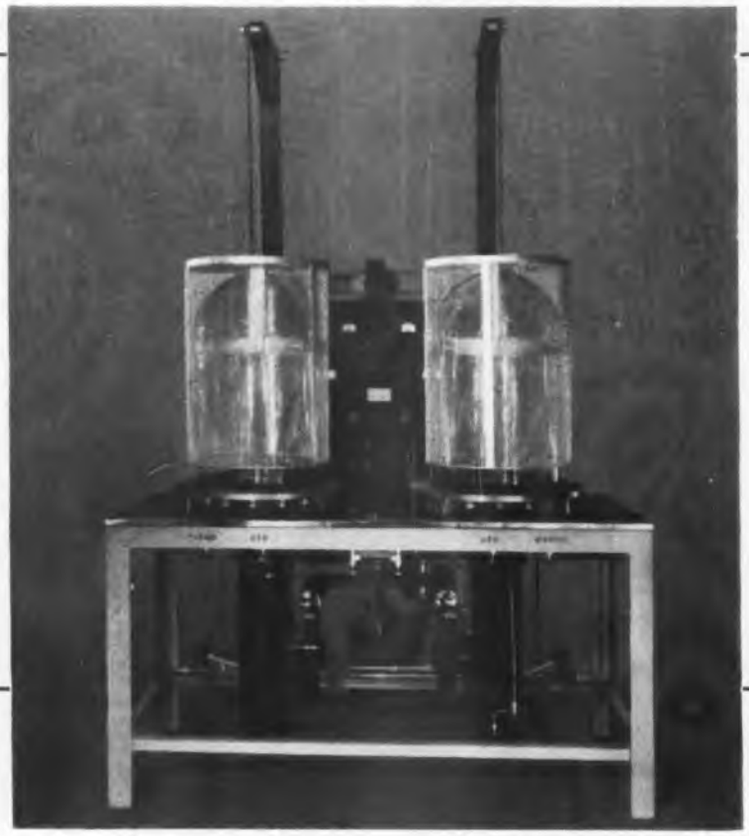

DPI Vacuum Coating Unit, Model LC2-500

INDUSTRIES in both the optical and electrical fields will find many uses for Distillation Products' *Vacuum Coating Unit LC2-500*—a two-chamber, high-capacity production machine for the deposition of thin films. It produces coatings of great uniformity and purity on a variety of materials, including glass, metals, and plastics.

This is one of several complete coating units available for war purposes. If your production involves treatment of materials by evaporation of metals or salts, Distillation Products, Inc., can advise you on the machine best suited to your needs, and assist in the design of auxiliary equipment. Submit your problem today.

Features of Model LC2-500 Twin chambers and pumps completely isolated, assuring simplicity of operation. Gauges and meters held to a minimum by use of switching devices. Standard accessories include *Metal Diffusion Pump MC-500; Baffle WB-10; Pirani Gauge PG-12; Ionization Gauge DP-100;* complete electrical equipment for the control of pumps and auxiliary devices.

DP INC HIGH-VACUUM HEADQUARTERS

DISTILLATION PRODUCTS, INC.

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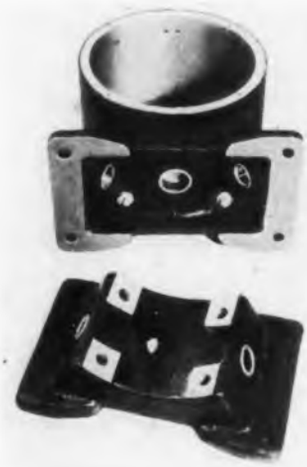
the calculator, both of which are arranged to be independently adjustable with respect to the main impedance coordinates. All of the parameters are related to one another and specific solutions to a given problem are obtainable through the use of an adjustable cross-hair index.

The more important parameters which are plotted on the calculator include (a) impedance and reflection coefficient at any point along the line, (b) length of line between any two points in wavelengths, (c) attenuation between any two points in decibels and (d) voltage or current standing wave ratio.

This calculator is 9 in. in diameter, and is made by emeloid tempered fabrication methods.

Acetate Grommets

Spun acetate grommets are being produced by Precision Paper Tube Co., 2035 W. Charleston St., Chicago 47, Ill. Manufactured of acetate film, spirally wound and laminated for strength, these grommets provide good insulating properties



combined with the non-shatterable toughness of the material. Light weight, resistance to oil and moisture, the grommets are supplied with one end spun, inserted in place, and subsequently spun over on standard drill press equipment.

Black Light

Black light, the invisible ultra-violet rays that light up instrument dials in the cockpit of airplanes will now be generally available. The development of a plastic filter transmitting these invisible ultra-violet light rays, from a visible white light fluorescent lamp and filtering out of the visible light, is the achievement of Lion Mfg. Corp., 135 So. La Salle St., Chicago, Ill. The plastic filter can be used with any size fluorescent tubular style lamp or circular type. It is also available for the two and four watt BP 12 fluorescent airplane lamps and 4 watt T5 six inch lamps.

Control Instruments

Chronotrols to control heating or cooling are built around an established line of pyrometers, potentiometers, thermometers and resistance thermometers, all of which employ an electronic principle of effecting temperature control. They provide automatic temperature regulation. The temperature cycle desired is cut on a disk, and its rotation by a synchronous motor moves the temperature setting lever of the control instrument. Chronotrols are offered in 25 models, including

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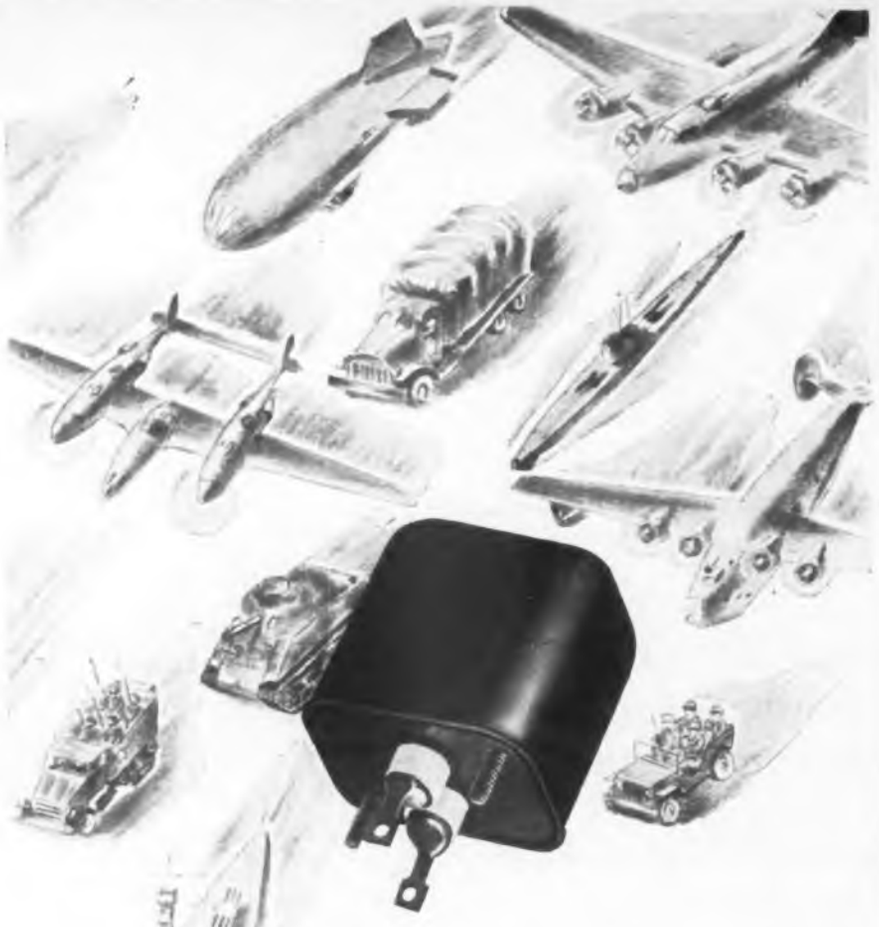

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Chicago Transformer has contributed many features of importance to their design, manufacture and improvement.

CHICAGO TRANSFORMER

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ten for proportioning control and others for two-position on-off and three-position on-intermediate-off control for high- and low-temperature applications. Thermometer models are available in recording as well as indicating types. Absence of mechanical linkage between the measuring and control sections makes possible instant response of the instrument's control unit to changes in temperature noted by its sensing unit. The frequency of oscillating current flowing between pick up coils, mounted on the temperature control setting index, is changed when a control flag mounted on the pointer or pen arm is moved between the coils by a temperature rise, or is moved from between the coils by a temperature drop. This frequency change in the control circuit governs the output current of a vacuum tube, acting to open relay contacts which, in turn, operate fuel valves or switches. Manufacturer is Wheelco Instruments Co., Harrison and Peoria Streets, Chicago.

Cycle Timers

Haydon Mfg. Co., Forestville, Conn., is producing a complete line (No. 5800 Series) of continuous running repeat cycle timers with either ac or dc operation. These timers are available with from one through eight switches. The appropriate motor speed is selected (most popular speeds from 8 rpm down to 1 revolution per month), according to the timing cycles desired. Precision snap switches are used, single or double throw, ten amp capacity at 110 volts ac. Specially cut cams are available for various combinations of "On" and "Off" cycles covering a range of from more than one actuation per second down to one per month. Timers are available on various commercial ac voltages and frequencies as well as on dc, the wide range of speeds being secured through Haydon sealed-in, lubricated gear trains. They are designed to meet any desired pattern of electrical impulses in virtually any overall interval for radio keying, industrial timing, etc.

High Voltage Capacitor

This newly designed capacitor for high voltage applications, has a value of 0.01 mfd. at 40,000 v dc. It was built for a special application of the electron microscope. Other features of this unusual

capacitor are its capability of continuous operation at 80 deg. C. and of withstanding total submersion and heavy surges. The case is welded steel measuring 4 11/16 x 5¾ x 7 in. high with a stand off insulator 8⅛ in. high, of the Solder-Seal type. Manufactured by Industrial Specialty Co., 1725 West North Ave., Chicago 22, Ill.

IS HIGH FREQUENCY HEATING NEW?

NO! IT'S NOT NEW TO US! FOR OVER 23 YEARS OUR HIGH FREQUENCY HEATERS HAVE BEEN FAMILIAR TO LEADING VACUUM TUBE MANUFACTURERS AS "BOMBARDERS"

High frequency heating may be "something new" to manufacturers who have *recently* entered this field. But we have been pioneering in design and manufacture of high frequency heaters for *23 years.*

However, because so many users are *new* users, unfortunate ERRORS are being made, both in choice of equipment and in application. Too many users are operating costly, power-wasting "misfit" units . . . machines NOT designed for their particular needs.

Our equipment is the result of 23 years of specialized knowledge and pioneering. Our machines afford advancements which overcome widely prevalent errors in design and construction. Compare our experience with that of others. You can benefit by what it has taken us almost a quarter of a century to learn.

Don't buy high frequency (induction or dielectric) heating equipment until you have investigated the production economies and other advantages offered by our wider range of units — designed for YOUR specific applications.

Write for details today. It will pay!

Our equipment offers you a selection of frequencies up to 300 megacycles — and the following power range, with stepless control from zero to full load:

1 Kw
2½ Kw
10 Kw
12½ Kw
15 Kw
18 Kw
25 Kw
60 Kw
100 Kw

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Spectacular strides — as spectacular as the mosquito boat's record — have been made in applying electronics to war needs. But it wasn't an overnight job!

Years of work, study, research and experiment came first. That's why Bell Sound Systems were so quick to contribute so much to wartime needs — Bell was among the first to probe the future of electronics by applying its principles to practical jobs . . . by pressing ahead with new ideas and improvements. Bell technicians gained years of priceless experience, and were ready to meet the new demands.

The electronic wonders that BELL Sound Systems are performing in war, promise even greater advances in sound amplification, transmission and recording for tomorrow. And BELL Sound Equipment will play as aggressive a part in peacetime progress as it has in furthering electronics' contribution to Victory!

BELfone inter communication systems offer every type of service for *instant speaking* contact between all executives in any business firm or manufacturing plant—or between individual executives and any number of subordinate stations. Write for details.

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Tab Wire Markers

This tab or apron type electrical conductor identification marker was created to fill the need for sufficient area on which to imprint adequate identification markings, in those cases of very fine or small diameter conductors, such as sizes smaller than No. 10. It provides accommodation for any required imprinting, while in all other respects possessing the resistant properties of standard varnished cotton tubing. Manufacturer is Wm. Brand & Co., 276 Fourth Ave., New York.

High Voltage Resistors

Meg-O-Max resistors are formed of a series of pressed and sintered ring-shaped segments electrically joined in such a way as to cause the units to be non-inductive. Finished units are encased in an hermetically sealed, rugged glass envelope provided with ferrule terminals. The result is a rugged construction capable of withstanding aircraft vibration tests, salt water immersion tests, and mechanical shocks produced by rapid acceleration. The resistors are used as high voltage bleeders, and as coarse-accuracy meter multipliers for voltage indicators. Other present applications include use in high-voltage networks, measuring equipment, rectifier systems, high-voltage voltage dividers, and as broad accuracy meter multipliers. Available in two lengths: Type 1, 5-9/32 in. long and having a range of from 3600 ohms to 100 megohms; and Type 2, 9-25/32 in. long, having a range from 6800 ohms to 100 megohms. Made by Sprague Specialties Co., North Adams, Mass.

Bushing Cement

Dolph's No. 16-A bushing cement was originally designed to cement transformer leads into porcelain bushings. Because of its unusual properties, it is well adapted for use as a permanent sealer for cable joints, boxes, instruments and for other similar applications. It is a black compound, having excellent adhesion to metal and porcelain and has a low coefficient of contraction. It becomes extremely hard and will stand the strain of rapid temperature changes. Because it is both oil and waterproof, it will prevent oil leakage and water seepage. The cement is homogeneous and retains its uniformity during melting, thereby eliminating the possibility of caking during the melting process. The material will not foam when it is heated. The melting point is 265 deg. F. (Ball and Ring) and it has a pouring temperature of 400 deg. F. It is made by John C. Dolph Co., 163 Emmett St., Newark 5, N. J.

High Quality Amplifier

The Langevin Co., Inc., 37 West 65th St., New York has just developed a new amplifier styled Type 101-A. A feature is good low-frequency waveform at high output levels. Inherent noise level is 68 db unweighted below full output of plus 47 vu at 2 per cent rms harmonic distortion. With an input impedance of 600 ohms, the gain is 60 db. Using bridging input, the gain is 46 db. Output impedance is adjustable 1 to 1000 ohms.

Sealed Transformer

A new hermetically sealed transformer, designated "Type S," has been developed by engineers of the Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles. The new transformer is of rugged construction having a case of cold drawn copper cadmium plated steel. It uses a terminal molded into a plastic block which has a metal flange molded into its periphery. This flange is then soldered into the case. This new construction offers great flexibility in number and arrangement of terminals. "Vac-sealing" impregnation process is used, insuring impregnation without solvents or other deleterious material present inside the coil.

Sheet metal

Illustrated are a few of the many fabricated sheet metal products we have made for leading manufacturers; some characterized by extreme precision, others held to gauge limits.

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ASSOCIATION NEWS

AIEE at Boston, April 19-20

A two-day technical meeting of the American Institute of Electrical Engineers, North Eastern District, will be held in Boston, Mass., Wednesday, April 19 and Thursday, April 20. Meeting headquarters will be at the Hotel Statler.

Electronic topics scheduled are as follows:

Wednesday, April 19, 10:00 a.m.

High-Frequency Cable Design and Testing. N. D. Kenney, P. W. Ware, Simplex Wire and Cable Company

Design of Variac Transformers. Edward Karplus, General Radio Company

Thursday, April 20, 9:30 a.m.

Electronic Session, T. S. Gray, presiding

Development of Excitron-Type Receiver. H. Winograd, Allis-Chalmers Manufacturing Company

Ignitrons, Their Development and Uses. J. C. Cox, Westinghouse Electric & Manufacturing Company

Operation of Rectifiers Under Unbalanced Conditions. M. M. Morack, General Electric Company

A Graphical Analysis of the Voltage and Current Wave Forms of Controlled-Rectifier Circuits. P. T. Chin, E. E. Moyer, General Electric Company

Electronic Control for dc motors. B. J. Dalton, General Electric Company

Broad-Band Carrier System for Telephone Cables. J. P. Thurber, New England Telephone and Telegraph Company

Thursday, April 20, 2:00 p.m.

Electronic Heating. H. M. Chatto, General Electric Company

NEMA Establishes Information Bureau

The nation's electrical manufacturers established a new type of public information center for the industry March 15. The scope of the bureau, known as the Electrical Manufacturers Public Information Center, 155 East 44th St., was defined by Leonard Kebler, president of NEMA, and by W. J. Donald, managing director of NEMA. The Center has assembled all available facts, human interest and statistical, about the industry—its products, history of its growth, wartime activities and future. A photograph library and an index of industry motion pictures also are being organized.

Background material and special sources of information will be provided, on request, to writers, editors and other qualified individuals and groups. Periodical releases will be issued. John M. Moorhead, formerly of The New York Herald Tribune and The Kansas City Journal, is in charge of the Center, which is sponsored by the National Electrical Manufacturers Association.

Electronic Show Corporation

The National Electrical and Electronic Show Corporation is the new name of the former National Electrical Radio & Television Show Company, 480 Lexington Ave., New York, N. Y., according to Ralph Neumuller who is secretary and active head of the company, as well as executive director of the Electrical and Gas Association of New York City. It was under the auspices of Mr. Neumuller's show organization that many of the highly successful electrical and radio shows were put on in Grand Central Palace and elsewhere, prior to 1936. Rumor around New York electrical circles is that a big electronic exposition is being planned for the postwar period, although no announcement concerning such a show is obtainable from Showman Neumuller at this time.

Radar Queen!

Chicago Radio & Radar Manufacturers Assn. held a "Radar Week" and a "Radar Queen" contest. Each factory elected its own Radar Queen, and from some fifty of these factory queens, this All-Chicago Radar Queen was chosen

Conventions and Meetings Ahead

National Association of Broadcasters (535 Fifth Avenue, New York). April 10-13, Waldorf-Astoria, New York.

Electrochemical Society (Colin G. Fink, Columbia University, New York), Spring Convention Meeting, April 13-15, Milwaukee.

Society of Motion Picture Engineers (Harry Smith, Jr., Hotel Pennsylvania, New York, N. Y.). April 17-19, Hotel Pennsylvania, New York.

Society for Measurement and Control (New York Section Meeting). April 25, New York.

National Electrical Manufacturers' Association (W. J. Donald, 155 East 44th Street, New York). April 23-27, Chicago.

American Physical Society (Karl K. Darrow, Columbia University, New York), New York. April 27-29, Pittsburgh.

American Mathematical Society. April 28-29, New York, Chicago, Berkeley, Calif.

American Institute of Electrical Engineers (H. H. Henline, 29 West 39th Street, New York); North Eastern District Meeting, April. Boston; Summer Technical Meeting, June 26-30, St. Louis, Mo.; Pacific Coast Technical Meeting, Aug. 29-Sept. 1, Los Angeles.

Institute of Radio Engineers (330 West 42nd Street, New York). May 3, New York.

Acoustical Society of America (Wallace Waterfall, 120 South LaSalle Street, Chicago), May 12-13, New York.

American Society of Mechanical Engineers (Ernest Hartford, 29 West 39th Street, New York), Semi-Annual Meeting, June 19-20, Pittsburgh.

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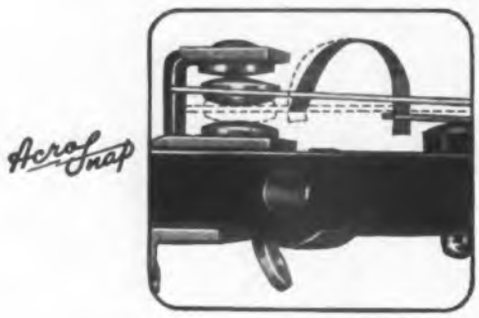
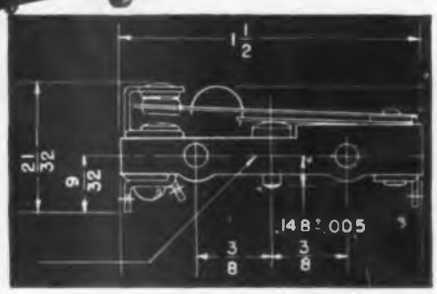
the Rolling Spring



THE GREATEST THING IN SNAP ACTION SWITCHES

Midget Switch illustrated one-fourth larger than actual size.



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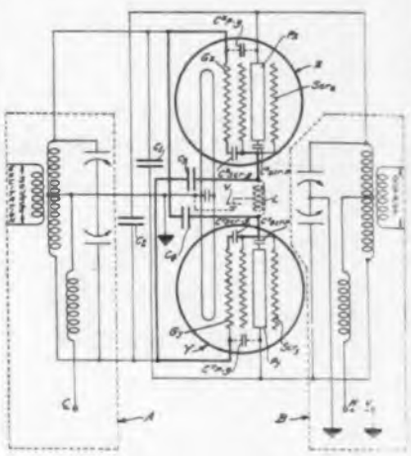
NEW PATENTS ISSUED

HF DEVICES

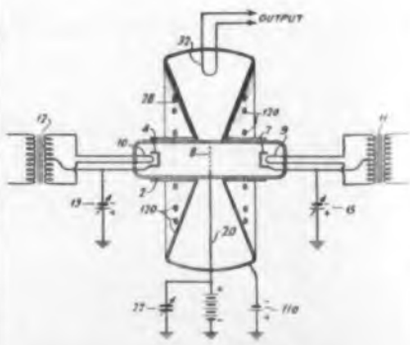
HF Compensating Network

The bridge network shown in heavy lines is provided to eliminate the effect of induced radio frequency voltages V at high frequencies so that the screen grids are maintained at zero radio frequency potential for all frequencies. This network is used in addition to conventional neutralizing condensers C_g, C_p. If pentodes are used, a further capacity bridge, balancing the radio frequency voltages caused by the effective inductance of the suppressor grid leads, is added. H. Romander, Federal Telephone and Radio Corp., (F) Aug. 24, 1942, (I) Jan. 4, 1944, No. 2,339,542.



UHF Oscillator

To generate uhf oscillations, electrons emitted by cathode 4 are caused to vibrate backwards and forwards past a gap in cavity resonator 28. Grid 8 is positive with respect to cathodes 4 and 7 (which may be a negative plate) and extends across the entire cross-section of tube 2. Consequently electrons having passed grid 8 are slowed up and pulled back through the grid, and by their oscillations inductively excite resonator 28 and are made to oscillate at the resonant frequency of the cavity resonator 28. A high-frequency high-power output is thereby produced. Frequency control by comparison with a crystal oscillator may be provided. Modulating voltages can be applied to the grid 8; by suitably controlling the modulating voltages, the output of the oscillator will be frequency



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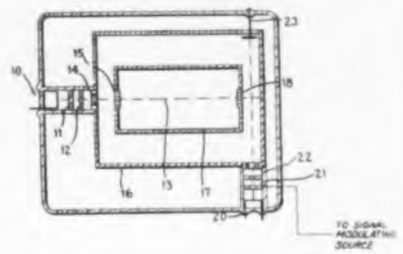
modulated and substantially free of amplitude modulation. The cavity resonator may be arranged so that the gap is unsymmetrical to the grid or entirely on either side thereof. H. Tunick, RCA. (F), April 17, 1941, (I) Dec. 21, 1943, No. 2,337,214.

Modulating Cavity Resonators

To vary the resonant frequency of a cavity resonator, the dielectric constant within part of the cavity is varied by a changing space charge in the form of a modulated electron beam which is provided by cathode 20, accelerating and signal electrode 21, concentrating elec-



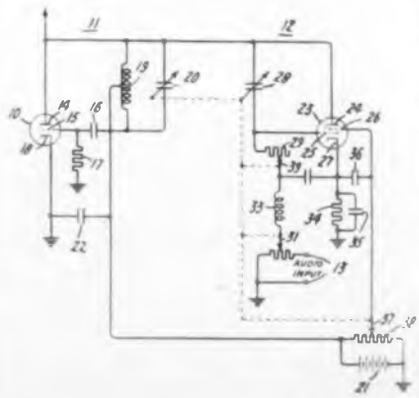
trode 22 and plate 23. In the case of a single resonator, modulation of the auxiliary beam will result in frequency modulation of the high frequency output, while in a double resonator it will give an amplitude modulation owing to the detuning of one resonator with respect to the other, probably combined with some degree of frequency modulation. J. H. Fremlin, International Standard Electric Corp. (F) Dec. 10, 1940, (I) Jan. 4, 1944, No. 2,338,237.

FM AND PHASE MODULATION

Frequency Modulator

In frequency modulation transmitters where the average frequency is variable over a substantial range, it is undesirable to have the modulating effect of the reactance circuit vary widely with adjustment of the frequency of the master oscillator circuit. The modulating effect depends upon the ratio of the effective capacitance of the reactance circuit 12 to that of the master oscillator tuned circuit 11. To adjust the effective capacitance of reactance circuit capacitor 28, or any of the contact arms 31, 37, 39 is varied. Either one or several of these possible control elements are mechanically linked with capacitor 20 to maintain the amount of modulation constant over the entire frequency range of capitor 20. A. Alvira, General Electric Company. (F) Aug. 17, 1942, (I) Jan. 18, 1944, No. 2,339,608.

(*Turn page*)



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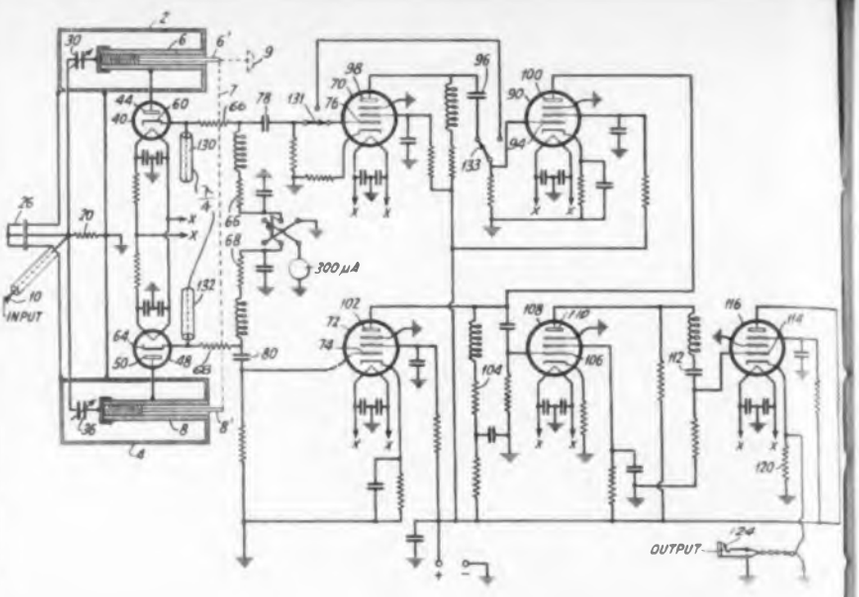


FM Monitor

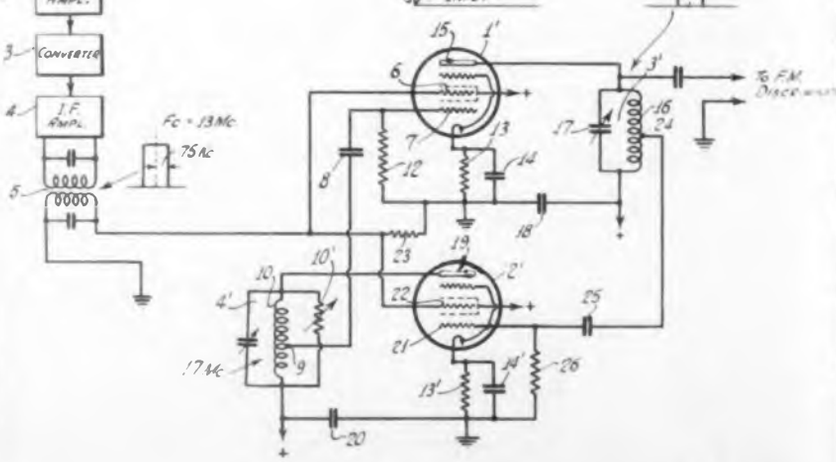
Two quarter wave concentric-line resonators 2, 4 act as discriminators; they are tuned an equal amount off resonance, one above and the other below the mean frequency of the modulated wave. Both resonators may be tuned simultaneously by control 9. Diode rectifiers 40 and 48 provide amplitude modulated outputs across resistors 66 and 68. One of the following amplifiers has an extra stage to invert the relative phase of the voltages. The outputs derived from the plate 100 of amplifier 90 and plate 102 of amplifier 72 are combined in resistor 104 and fed to further amplifier stages. A kinescope monitor or oscilloscope may be used at output 124 to determine if the signal is being transmitted through the relay station properly. Amplitude variations are in push-push on the amplifier stages 70 and 72 as well as on rectifier stages 40 and 48 and are cancelled out. By operating switches 131 and 133, amplitude modulation present on the transmitter may be detected. The diode output can be used for automatic frequency control. H. E. Goldstine, RCA, (F) June 18, 1940, (I) Nov. 16, 1943, No. 2,334,190.

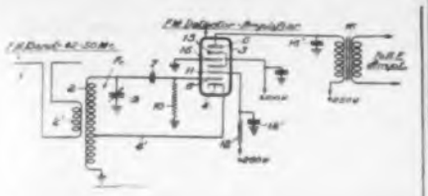
Reducing Degree of Frequency Or Phase Modulation

Intermediate frequency is fed to both converter tubes 1′ and 2′ and the output of each tube is fed to the other; their resonant circuits 3′ (4Mc) and 4′ (17Mc) are adjusted to provide a re-entrant system for the intermediate frequency (13Mc) so that oscillations will be sustained. The conversion gain of the converter tubes is assumed to be greater than unity. The low-frequency tuned circuit 3′ will have the higher selectivity and a change in frequency of the incoming signal will cause a larger frequency change in circuit 4′. In both circuits, the frequency deviation of the input signal will be reduced more than the accompanying reduction in carrier frequency. The amplitude of the oscillations is insensitive to amplitude variations of the carrier input. M. G. Crosby, RCA, (F) Feb. 11, 1942, (I) Dec. 14, 1943, No. 2,336,926.

Discriminator Circuit

Electrode 11 functions as the plate of a local Hartley oscillator producing carrier frequency oscillations of constant amplitude. At the grid 6, these local oscillation voltages combine with the FM input voltages. Their vector sum will depend on their phase difference, and being the effective grid voltage it controls the current to plate 5; the phase or frequency variation of the input will be converted into amplitude modulation. It is stated that the amplitude-frequency characteristic is linear over a band of 500 kc at 42 mc. Super-regenerative detection is produced by network 7-10 having a long time constant to quench the local oscillations.

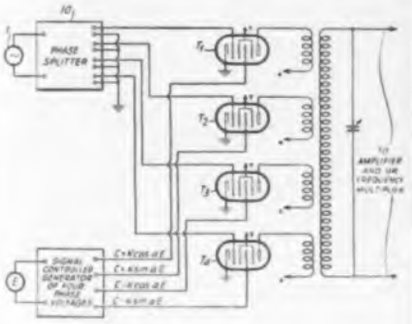




at a super audible rate. If a separate rectifier is provided, the time constant of the network 7-10 is made considerably shorter. S. Hunt, RCA, (F) June 19, 1941, (I) Dec. 21, 1943, No. 2,337,392.

Phase Modulator

A large phase modulation is obtained without any accompanying amplitude modulation. The system introduces the same amount of phase deviation regardless of the carrier wave frequency. The voltage from constant carrier frequency source 1 is split by phase splitter 10 to produce a four phase output to the first grids of amplifier tubes T_1, T_2, T_3, T_4. The amplification factor of these tubes is controlled by the voltages on their second grids depending on the modulating voltage E as indicated. Provided only T_1 conducts, the other tubes being biased beyond cut off, the current induced in the output LC circuit will have a definite phase, provided only T_2 conducts the output current phase will be shifted 90 deg. Assuming both tubes are conducting, the output current phase will depend on the



relative amplification of the two tubes; by suitably varying the amplification factors, the output amplitude may be maintained constant while the phase of the output current continuosly shifts through 90 deg. In general, if the amplification factor of any two tubes is kept at zero, a suitable variation of the amplification factors of the two active tubes will result in swinging the output voltage through one quadrant. It can be shown that a linear variation of the phase angle with modulating voltage E and constant amplitude is obtained if the second grid voltages have the form indicated on the diagram, a and K being constants and C the initial bias which is equal to the cut off bias. The amplification factor is assumed to change linearly with the voltage applied to the second grids.

The four phase displaced voltages may be obtained by photocell-moving mirror arrangements. The mirror is moved by the modulating voltage and its reflecting surface has an approximately sinusoidal shape. Alternatively, a cathode ray tube with several plates may be used for the production of these voltages. W. van B. Roberts, RCA, (F March 10, 1939, (I) Dec. 21, 1943, No. 2,337,272.

Cathode Ray Tube

In cathode ray tubes including an electrostatic shield between two deflector plates to split the electron beam, the deflector plates collect secondary electrons emitted from the electrostatic shield. To avoid this it is proposed to carbonize the surface of the metallic electrostatic shield

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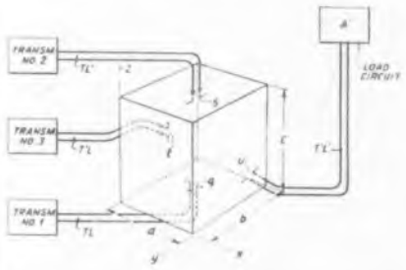
and/or to extend it towards the cathode beyond the entrance edges of the deflector plates. Also an apertured disk electrode may be mounted normally to the axis and close to the edge of the electrostatic shield; the disk is at the same potential as the shield. As many as possible of the conductors which are connected to either deflector plate are electrostatically shielded from the electrostatic shield. A tube embodying the features of the invention is shown and described. E. E. Shelton and H. Moss, A. C. Cossar Limited, (F) July 22, 1941, (I) Dec. 14, 1943, No. 2,336,895.

Coupling Circuit

Several sources of oscillation of different frequencies are to be coupled to a load in such a manner that there is negligible interaction between the different sources. The invention is shown ap-



plied to a transmitters-antenna system. It is possible to excite three independent different types of waves to simultaneously exist in a cavity resonator; their frequencies depend upon the dimensions of the resonator, a, b, c. Input dipoles q, s, t, are arranged at right angles to one another and parallel to axes x, y, z, respectively, they each excite standing electromagnetic waves having an electric field parallel to the dipole. The resonator is so designed that the wave whose electric fields are parallel to the x, y, z axes have fundamental modes of oscillations whose frequencies correspond to the frequencies of transmitters 1, 2, 3. The standing waves produced in the resonator will be independent of one another and will not interact so that there will be no coupling between the three dipoles. The output energy is derived from the dipole u which is so positioned that its axis makes equal angles with the three coordinate axes x, y, z; equal excitation from all three types of waves will then be fed to dipole u. If the angle is changed, differing amounts may be taken of the three wave types. If one embodiment, transmission line T'L' is coupled to another cavity resonator by a dipole arranged at equal angles to all three axes so as to excite all types of waves. Three loads are selectively coupled to this resonator, i. e. with their coupling dipoles parallel to the three axes, and are each excited by a different wave length. Again, no appreciable interference between the three load circuits takes place. P. S. Carter, RCA, (F) Jan. 10, 1941, (I) Dec. 21, 1943, No. 2,337,184.

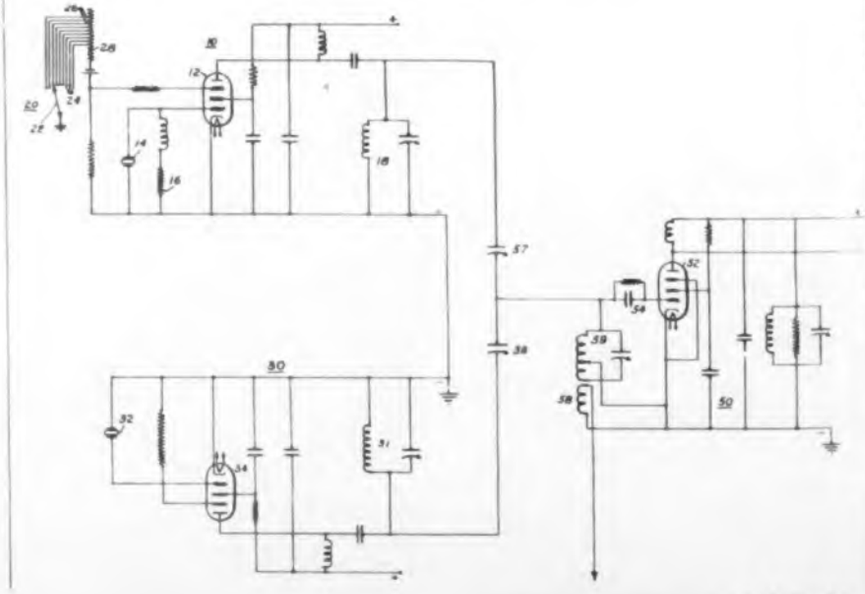
Voice Frequency Signal Control

The device includes rectifying high and low voltages separately and applying them to the control grid of a vacuum tube in opposing relation. With no input the tube has high plate current. A. C. Dickieson, Bell Telephone Labs., (F) Oct. 31, 1941, (I) May 18, 1943, No. 2,319,306.

METER CIRCUITS

Telemeter System

The apparatus is designed to transmit a meter reading to a distant recorder showing Arabic numerals. The meter reading may refer to consumption of electricity, gas or water or to some other magnitude to be relayed to a central station. The amplitude of oscillator 12 is modulated according to the position of meter pointer 22 to be transmitted, while oscillator circuit 30 provides a constant-amplitude wave of a slightly different frequency. Consequently, oscillator 50 will tend to oscillate at a frequency intermediate those of oscillators 10 and 30 according to their relative amplitudes; its frequency will therefore be a function of the position of pointer 22. Coil 58 of oscillator 50 is connected to the output of ten fixed frequency oscillators which serve to exert a pulling effect to bring it to any one of ten definite frequencies, so that its frequency varies in 10 steps, corresponding to the ten digits, and not continuously. The output of oscillator 50 is fed to ten buffer stages, the output circuits of which are connected to ten power stages through selective filters passing the ten frequencies of the ten oscillators, respectively. The power stages control ten relays, which in turn operate to selectively close ten reading or recording circuits corresponding to the ten digits. R. Muniz and J. Haddad, International Business Machines Corporation, (F) Oct. 15, 1942, (I) Jan. 11, 1944, No. 2,338,866.



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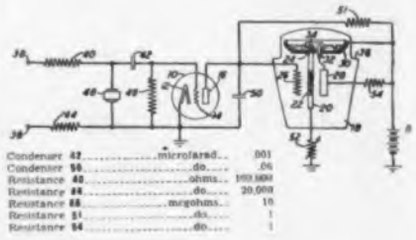
To calibrate an oscillator at two or more widely spaced definite frequencies, a quartz crystal 48 is used which is antiresonant at these frequencies. The frequency dial indication of a variable frequency oscillator may be checked for the antiresonant frequencies of the crystal by applying its output to terminals 38. The crystal impedance for its anti-resonant frequencies is very high, and the



Condenser 42	microfarad	.001
Condenser 58	do	.05
Resistance 40	ohms	100,000
Resistance 44	do	20,000
Resistance 46	megohms	10
Resistance 51	do	1
Resistance 54	do	1

negative bias on grid 14 will therefore increase considerably as the frequency of the input wave approaches any of these values. This will result in a visual indication on target 30 of indicating tube 18. A circuit built operates at 150 kc and 2,500 kc. K. D. Smith, Bell Telephone Laboratories, (F) July 11, 1940, (I) Jan 11, 1944, No. 2,339,198.

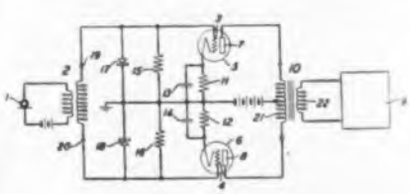
Q-Meter

A circuit is described which permits to measure directly the Q of coils, condensers and reactive circuits. Two readings are required. W. D. Loughlin, Boonton Radio Corporation, (F) Aug. 15, 1941, (I) Dec. 28, 1943, No. 2,337,759.

MISCELLANEOUS

Push-Pull Amplifier

To increase the gain of conventional push-pull amplifiers, large resistances 15, 16 and rectifiers 17, 18 are inserted in the cathode-grid circuits. During the half cycle of the signal current in which the terminal 19 of the transformer is positive with respect to the terminal 20, substantially the full signal voltage is applied across resistor 16, while during the next half cycle substantially the full signal voltage is applied across resistor 15. Approximately twice the change in grid voltage than with the conventional



push-pull connection is obtained. In the particular circuit shown the grids are alternately driven more negative with respect to the associated cathodes so that the initial grid bias, if any, will ordinarily be very small. However, the rectifiers may be poled in the opposite direction so that the grids will be made more positive during the active period of the tube. H. C. Duft, Western Electric Company, (F) May 13, 1942, (I) Jan 18, 1944, No. 2,339,466.

Variable Filter

With the filter circuit shown, it is possible to independently adjust the width of the transmitted frequency band and its position in the frequency spectrum. The sources SC may supply any band of frequencies but only a selected band will

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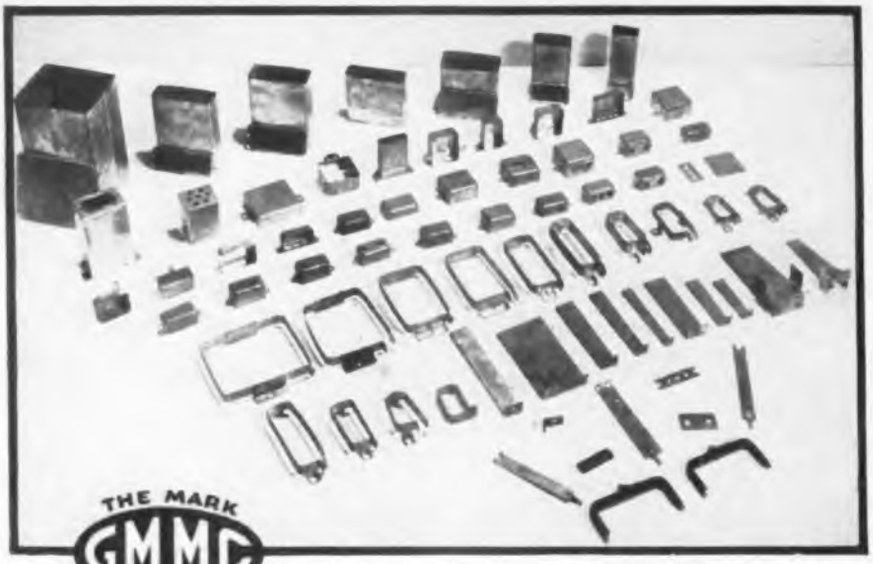

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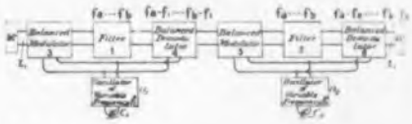
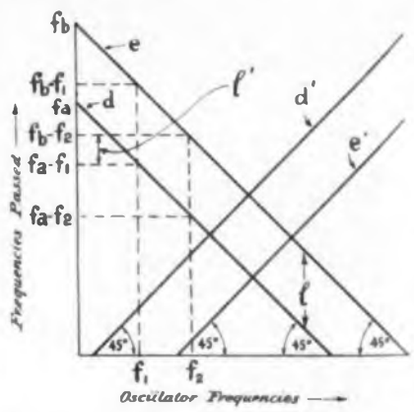
be transmitted to load circuit LC. In the example illustrated, band pass filters 1, 2 have equal band width f_a ---- f_b. The circuit between modulator 3 and demodulator 4 may be considered as a filter having a pass band f_a-f_1 ---- f_b-f_1, its width being equal to the width 1 of filter 1 and its position in the frequency spectrum being determined by the frequency f_1 of oscillator O_1. The circuit between modulator 5 and demodulator 6 may be considered as a filter having a pass band

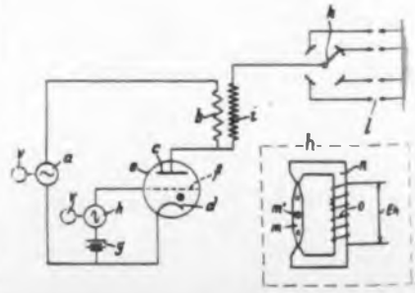


f_a-f_2 ---- f_b-f_2. The two filters being connected in series, only the overlapping frequencies f_b-f_2 ---- f_a-f_1 will be transmitted. Lines e, d refer to filters passing bands in the range of the upper side bands resulting from modulation, lines e', d' to lower side band ranges. As the oscillator frequencies f_1, f_2 are varied without altering the difference between them, a frequency band of constant width 1' but of varying position in the frequency spectrum will be transmitted. However, if the spacing between the oscillator frequencies is increased or decreased, the transmitted frequency band will be narrowed or widened, respectively. The widening of the band is limited by the width of the narrowest filter; the filters used may have different pass bands. A mechanical coupling for condensers C_1 and C_2, controlling the oscillator frequencies f_1 and f_2, is shown, making it possible separately to adjust the frequency difference between the two oscillators to chose the width of the pass band, and then to simultaneously change the oscillator frequencies by equal amounts to select the desired position in the frequency spectrum. G. W. Gilman, Bell Telephone Laboratories, (F) March 23, 1942, (I) Jan. 18, 1944, No. 2,339,633.



Igniter

Gas discharge tube e acts as a switch for the ignition of an internal combustion engine by controlling the current through primary b of an ignition transformer b, i, which in turn induces a voltage in the secondary i connected to



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In CML 1200, the accurately-timed radio frequency pulses break down the neon tube. As the breakdown occurs, a condenser also discharges through the tube. While the illumination obtained from a single R.F. pulse is negligible at low frequencies, the peak power obtained from the condenser is considerable. Means are provided to prevent the condenser from discharging until the gas is broken down by the radio frequency pulse. Thus accurate timing is secured from the pulse generator and adequate illumination from the condenser discharge. Both combine to generate uniform illumination throughout the frequency range.

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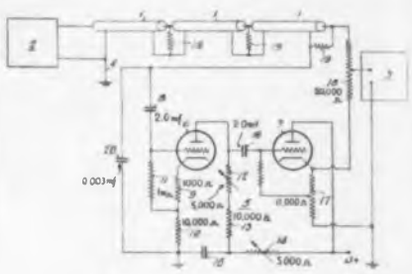
spark plugs 1 through a distributor k. An alternating current generator h provides the controlling grid voltage impulses Eh having a very steep wave front and a frequency corresponding to the ignition frequency. The generator h consists of a permanent magnet m fixedly mounted on a shaft m' which rotates in synchronism with the crank shaft of the internal combustion engine. F. Dausinger, Alien Property Custodian, (F) March 5, 1940, (I) Jan. 11, 1944, No. 2,338,906.

Compensating Circuit

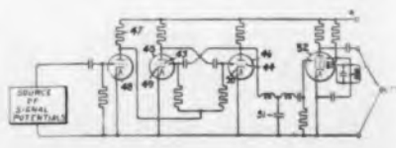
Twenty-five and 60 cycle voltages picked up by coaxial cable 1 extending between transmitter 2 and receiver 3 are to be eliminated. The disturbing voltage is separated from the signal, without providing an opportunity for cross modulation to take place, and applied to balancing circuit 5. Tube 6 has little gain and acts as a phase inverter of exactly 180 deg.; while the output of tube 7 taken off the cathode resistor 17 will be in phase with its input. By taking the



signal from the center point of resistor 18, the disturbing voltage to ground at the receiver end will be zero at all times, provided suitable amplification or reduction in compensating circuit 15. Another embodiment with only one tube in circuit 15 is also shown and described. Satisfactory operation of the circuit is reported for disturbing voltages of 10-20 times the signal voltage. F. J. Bingley, Philco Radio and Television Corporation. (F) Feb. 3, 1942, (I) Jan. 4, 1944, No. 2,338,399.

Multivibrator Circuits

It is proposed to apply positive bias to the multivibrator and to provide negative feedback. For positive grid bias, the exponential condenser discharge from the definite, initial, negative, blocking potential has a much steeper slope at the cut-off potential, because the difference between this initial negative voltage and the final positive grid bias is considerable greater than for unbiased grids. This steep characteristic makes the system less sensitive to spurious undesired voltages at the multivibrator grids. Further, the pulse width varies less with frequency for a positive biased multivibrator than for an unbiased one. It is stated that the oscillation frequency is a linear function of the positive bias over a wide range of frequencies and the device may therefore be used as frequency modulator. Low pass filter 51 is inserted to filter out the harmonics in the frequency modulator shown in the figure; it may be varied through a range of approximately 75 per cent of the average carrier frequency. Other applications of



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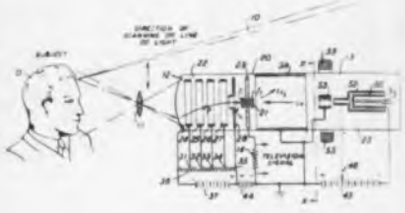
the positively biased multivibrator is described. E. H. B. Bartelink, General Electric Company, (F) June 25, 1940, (I) Jan. 4, 1944, No. 2,338,395.

Television System

The subject is scanned in a vertical direction (arrow) at frame frequency by a moving line of light, and the resulting image is focused onto a semitransparent photocathode 12 the curvature of which in conjunction with the following cylindrical electron lenses causes all electrons from a vertical arc to impinge at one particular element of the one-dimensional photosensitive mosaic 21 so that horizontal lines of the image are projected in succession. The individual horizontally arranged elements of the mosaic 21 are scanned at line frequency from cathode ray gun 50, 51, 52, 53 and the signal is taken off the condenser plate 29. Essentially, the conventional two-dimensional scanning is split into the moving line of light and the scanning of the one-dimensional photosensitive mosaic. The moving line of light may be produced by a cathode ray tube device. G. K. Teal, Bell Telephone Laboratories, Inc., (F) July 31, 1941, (I) Dec. 28, 1943, No. 2,337,578.

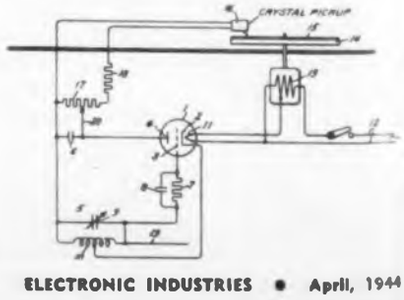


Antenna

An FM or television antenna is adapted to be used as cooling system for the house and to provide fire and lightning protection. It is made of a hollow rod and has small holes arranged therealong to act as a sprinkler system. The water supply is regulated by a valve according to the requirements; it improves reception, cools the roof and diminishes fire hazards. A lightning arrester is mounted on the antenna support. E. J. Cowan, RCA, (F) Nov. 1, 1941, (I) Dec. 28, 1943, No. 2,337,710.

Tube Oscillator

The tube oscillator, shown in connection with a phonograph, operates without plate voltage supply. It has been established by experiments that the current provided by initial velocity and contact potential of the electrons emitted from the cathode suffices to set up and maintain oscillations. An indirectly heated cathode is used so that all parts of its electron emitting surface are of the same potential. The modulated oscillations radiated by antenna 19 are of sufficient intensity to be intercepted by an ordinary broadcast receiver situated within a range of 50 ft. To increase the intensity of the oscillations produced, another electron tube may be connected into the plate circuit of tube 1. G. W. Fyler, General Electric Company, (F) Dec. 7, 1942, (I) Dec. 14, 1943, No. 2,336,855.



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1025-8	18	6	6
1025-9	18	15	9
1025-10	18	12	6
1025-11	18	15	12
1025-12	18	12	12
1025-13	18	18	12
1025-15	24	15	12
1025-16	24	15	15
1025-17	24	18	12
1025-18	24	18	15
1025-19	24	18	18
1025-20	24	12	9
1025-23	30	15	9
1025-14	30	15	12
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Bibliography, with Abstracts, on Electrical Contacts

E. I. Shobert, II, assisted by George Durst, S. G. Eskin and F. R. Hansel, published 1944 by the American Society for Testing Materials, 260 Broad St., Philadelphia 2, Pa. 160 pages, 6 by 9 in., cloth binding. Price $5.00.

A compilation of references to the literature on electrical contacts, with abstracts in English on most of the material cited. The subjects covered include the following: Contacts — General, Materials, Circuit Breaker Design & Testing, Relays, Stationary Contacts, Sliding Contacts, Miscellaneous Contact Applications, Contact Resistance & Temperature, Electric Arc as Applied to Contacts, Electric Arc in General, Spark Discharge, Glow Discharge, Low Voltage Arc, Contact Wear, Circuit & Circuit Parameters as Applied to Contact Operation. This compilation resulted from the work of a committee of the American Society for Testing Materials, B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, in developing standard methods of evaluating electrical contact materials and determining effect of variables upon their performance. It covers references from years 1835 to 1943.

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THE KEY to many a new industrial development is frequently the right application of AC to DC Power Conversion. At the heart of many of today's electrical marvels is a BL Metallic Rectifier. Equipment designs once believed impossible or impractical are now in common daily operation rendering efficient, dependable service.

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Write for Bulletin No. 91 giving details on B-L Metallic Rectifiers.

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THE BENWOOD LINZE COMPANY • ST. LOUIS 3, MO.

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Far in advance of today's production schedules and in anticipation of tomorrow's needs, EICOR engineers are preparing to meet the inevitable demand for rotary electrical equipment designed for new applications. During recent years their store of knowledge has been used to direct our activities and those of others in the manufacture of more and better motors and dynamotors for war service. The breadth of experience gained in this effort fits them, and our entire organization, for an important future in this field.

An exceptional range of designs and frame sizes facilitates the development of equipment to meet your exact specifications—from tiny direct current motors to dynamotors and generators for every conceivable output or purpose. Our facilities are equally adaptable to the engineering of a single experimental unit or to production runs.

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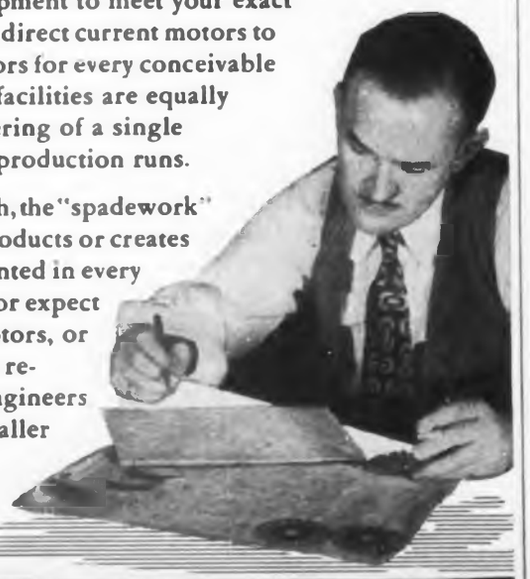

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A.S.T.M. Standards on Electrical Insulating Materials (With Related Information)

Prepared by A.S.T.M. Committee D-9, Published by the American Society for Testing Materials, Philadelphia 2, Pa., 1944. 515 Pages. Price $2.75

This publication gives, in their latest form, more than seventy-five A.S.T.M. standards specifications and test methods covering electrical insulating materials and related products. In addition to the fifty-six specifications developed by the Society's Committee D-9, there are eighteen other standards included to make the book complete pertaining to certain plastics, rubber, textiles, and paper products, etc. It contains new material giving requirements for phenolic molding compounds; laminated thermosetting materials; vulcanized fiber sheets, rods, and tubes, measuring dimensions of rigid rods; natural block mica and mica films suitable for use in fixed mica-dielectric capacitors; orange shellac and other lacs; low and medium-voltage pin-type lime glass insulators; and tensile properties of plastics.

Radio Receiver Design

By K. R. Sturley, Part No. 1. Published by John Wiley & Sons, Inc., New York, N. Y. Price $4.50. 1943. 435 pages.

This reference book is a treatment of the radio frequency amplification and detector systems for receivers of amplitude modulated waves. The author is English and the conventional English terms are used throughout. The general introduction contains a discussion of amplitude modulation, frequency and phase modulation and general characteristics of AM receivers.

Tubes are treated in Chapter 2. and the general relations for the input admittance due to interelectrode capacities and the transit time action are developed.

The general features of aerials and aerial coupling systems for receivers are given in Chapter 3 This section includes a treatment of noise reducing antennas and coupling systems. The use of conventional mesh network equations gives simplified results.

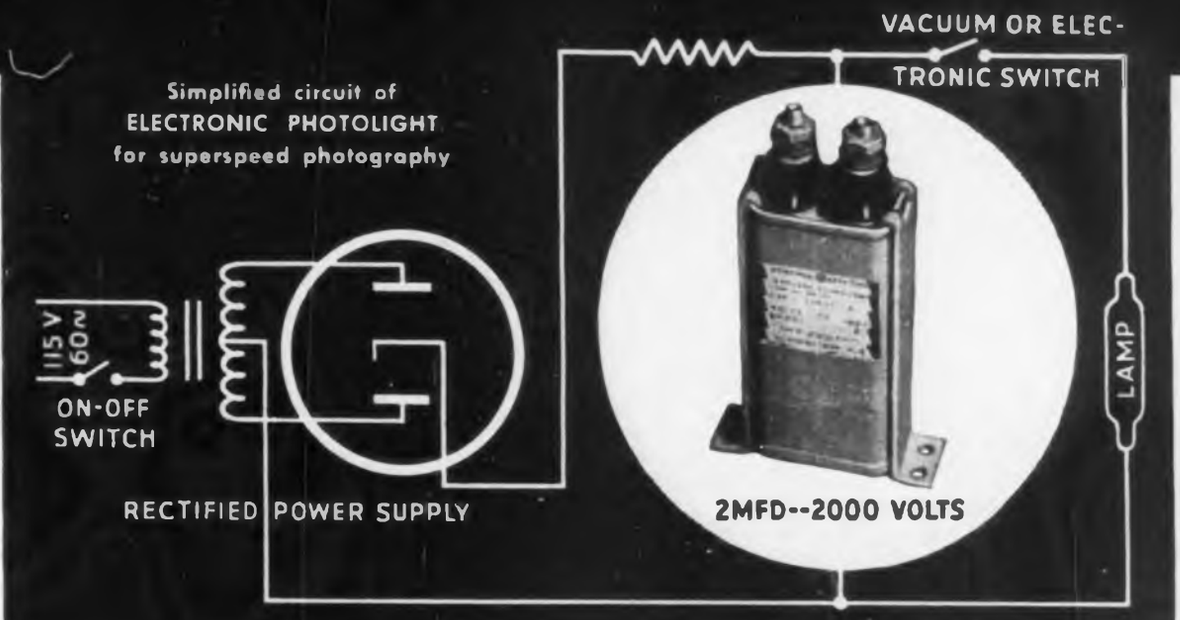
In Chapter 4, radio frequency amplifiers are treated both from the characteristics of the coupling networks, and from the effects of thermal and shot noise. Also included is a treatment of short and ultra short wave amplifiers. Frequency conversion and oscillators for receivers are treated in separate chapters. In oscillators considerable attention is given to choice of com-

(*Continued on page* 164)

New Uses* of Pyranol Capacitors

that may suggest short cuts on your circuits

Simplified circuit of
ELECTRONIC PHOTOLIGHT
for superspeed photography



This photolight is especially valuable in the photographic study of vibration, fluid flow, and ballistics. Here it "stops" running water in a strange, ice-like form.

The G-E photolight for very high-speed photography is primarily of interest in research work. It illuminates 20 square feet.

IN THREE SECONDS this small Pyranol capacitor accumulates enough energy to discharge 4,000,000 watts instantaneously, through a mercury lamp. This produces a four-microsecond flash which, at its peak, is one-fifth as bright as the sun's surface.

FEATURES THAT MAKE IT EASY FOR YOU TO DESIGN WITH PYRANOL CAPACITORS

COMPACTNESS—High capacitance per cubic inch, because of the unusual dielectric properties of Pyranol.†

SPACE-SAVING SHAPES—Many of the ratings are available in oval, cylindrical, or rectangular cases to make your design problems easier.

CONVENIENCE—They will work equally well mounted in any position.

DEPENDABILITY—Hermetically sealed for permanence and uniformity of characteristics.

They have long life because of the superior materials used, supervised manufacture, and individual testing. Write for our time-saving catalogs on a-c (GEA-2027) or d-c (GEA-2621) types. They cover our complete line. *General Electric Company, Schenectady, N. Y.*

†Pyranol is the G-E trade name for askarel, the synthetic, noninflammable liquid used in treating G-E capacitors.

**First in a series of ads that will outline new jobs being done with Pyranol capacitors*

GENERAL ELECTRIC

WASHINGTON

Latest Electronic News Developments Summarized by *Electronic Industries'* Washington Bureau

NO EARLY PROSPECTS FOR CIVILIAN PRODUCTION—Based on current information **which may be upset at any time by an unexpected turn in military events,** the WPB sees no early prospects for the production of radios (as well as a number of other heavy durable consumers' goods) because plant facilities as well as certain component parts and raw materials are required to make these items continue to be needed for war productions.

RESTRICTIONS ON "NEW" RADIO PRODUCERS—WPB Chairman Donald M. Nelson, in his letter to Senator Maloney of Connecticut, laid down a most significant principle for the electronic-radio industry, grown to such tremendous size for the war effort, that restrictions on "new" companies, which want to enter an industry for the first time after the war, will be needed until critical components and materials are in easy supply. So long as wartime controls are retained, materials and components, should not be allocated to these new firms until the already established concerns in the industry are in a position to resume civilian production of their former products.

CIVILIAN RADIO TUBES—The number of radio tubes for civilian use will continue to be inadequate for all needs because military requirements for combat electronic equipment are increasing. However, at least 18,000,000 "MR" tubes for civilians (for maintenance, repair or operating supplies) are anticipated for civilian production this year—and probably more because manufacturers are to be permitted "over-runs" above their quotas if military orders are completed and facilities and labor are available.

LESS THAN HALF OF NORMAL REPLACEMENTS—The 18,000,000 tubes constitute less than half of normal replacements—because of the backlog of demand for tubes, longer radio listening hours and use of old or repaired radios WPB estimates the tube replacement need in 1944 at more than 41,000,000. Frank H. McIntosh, Chief of the Foreign and Domestic Branch of the WPB Radio-Radar Division, as a result of his recent inspection at the tube plants found the production situation satisfactory and through his directive to manufacturers of trading among themselves the various types of tubes a more equitable distribution of tubes to civilians will be possible.

U. S. EQUIPMENT STANDS UP IN JUNGLES—Due to the genius of the American electronic-radio industry, the communications and radar apparatus in the Southwest Pacific theater of war received such thorough preparation and protection from moisture and fungus damage that it withstands the destructive climatic effects of the tropical jungles. Very little injury occurs in the Army and Navy radio and radar stations' equipment, Major General Ingles, Chief Signal Officer, reported to the War Department upon his return after a recent four-weeks inspection tour in the Pacific combat area.

LAST LINK ROUND GLOBE COMPLETED—The Army Airways Communications System has completed the final link of its radio network around the world so that American planes now can encircle the globe maintaining constant communications in flight with the AACS ground stations and with the AAF radio range beacons. The AACS utilizes more than 2500 transmitters and 5600 receivers at over 600 locations in every state of the United States and in 52 foreign countries and territories; it has divided the world into 23 operating regions. Latest development of AAF, which cannot be revealed in any detail, is blind landing system without special radio apparatus in the airplanes.

NOW ON PLATEAU—The Army Signal Corps in 1943 increased its purchases of communications-electronic equipment in monthly rate of output by 83 per cent as contrasted with 1942. This high rate of production has not only been maintained but even exceeded slightly in 1944. But the rate of production is slated to level off and remain on a plateau for remainder of year—at least so long as present war requirements keep up.

CONFERENCE ON SCHEDULES—A most important conference on scheduling programs was held with Signal Corps prime contractors in New York during the latter part of March by Major General William H Harrison, Chief of Signal Corps Procurement & Distribution Service. Incidentally, General Harrison and his force came through in 1943 to attain the goals set for them by the Army high command. The Signal Corps recorded the largest gain in output last year of any procurement branch of the Army Service Forces.

BIG AIRWAYS - RADIO PLANS READY—Civil Aeronautics Administration is planning postwar procurement program for radio range-radio communications stations and instrument landing systems so that equipment can be put into production immediately after military requirements start to slacken off; instrument landing systems projected at more than 100 airports; to convert entire airways radio stations to VHF frequency ranges; 500,000 private airplanes in next decade to be major radio market.

MISCELLANY—Congress chopped down FCC funds by over 25 per cent or total of over $2,000,000, mainly affecting its war agencies, Radio Intelligence and Foreign Broadcast Intelligence Services; for industry most injurious slash was cutting out of a few desired new radio engineers for allocations work. . . . Chicago's 51 electronic - radio - radar manufacturers engage in "guinea pig" test on establishing industry wage bracket to secure labor and cut down turnover.

National Press Building
Washington, D. C.

ROLAND C. DAVIES
Washington Editor

THERE'S A JOB FOR

Relays BY GUARDIAN

Induction heating costs less, is more dependable and easier by the electronic method. Safer, too, even with inexperienced hands, when protected from improper operation by quality relays such as the Guardian Series 90 Interlock Relay and the Series L-500 Overload Relay.

Series 90 Interlock Relay locks mechanically from an electrical impulse and unlatches or resets from another such impulse. Combinations up to DPDT available with 12½ amp. contacts rated at 110 v., 60 cycles, non-inductive load. Coil resistances up to 10,000 ohms. For AC or DC operation.

Series L-500 Overload Relay, manual reset, protects DC circuits against abnormal current surges where current conditions are constant. Contacts can take severe overloads undamaged, cannot be reset during overload. Rated for 1500 watts on 110 v., 60 cycle, non-inductive AC.

Series L-500—Overload Relay
Ask for Bulletin R-5

Series 90—Interlock Relay
Ask for Bulletin 21

Consult Guardian wherever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

GUARDIAN ELECTRIC

1622-D W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

"CALLING Battery F! Calling Battery F! Enemy in force on right flank. Range 3000!"

Accurate information on enemy formations and strength is vitally important for a successful attack.

American inventive genius has equipped our advance units with "walkie-talkie" sets, by which on-the-spot information can be flashed to the attacking forces, the artillery and air support.

These walkie-talkie sets and other two-way radio units are kept accurately on their own private wave-lengths, avoiding interception or jamming by the enemy, by means of quartz crystals which must be cut in a highly precise manner. Such precision is made possible by use of an X-Ray method of determining crystal plane alignment.

After the war, similar applications of x-ray techniques will point the way to many new and improved processes in the production of a wide variety of products. Savings in cost, improvement in quality, elimination of the "ignorance factor" from design considerations, will give every advantage to the industrial enterprise which is alert enough to utilize the remarkable possibilities of this tool of modern science.

THE X-RAY TUBE IS THE HEART OF THE X-RAY MACHINE...
The majority of leading makes of X-Ray apparatus are equipped with Machlett Tubes

MACHLETT
Laboratories Inc.
SPRINGDALE CONNECTICUT

LARGEST PRODUCERS OF X-RAY TUBES
X-RAY TUBE SPECIALISTS SINCE 1898

(Continued from page 160)

ponent parts and circuits for frequency stability over various ranges of temperature and voltage and also the desirable circuits for minimum parasitic oscillations.

The final chapter covers diode detectors, plate detectors and grid-leak detectors. The detector efficiency and distortion characteristics are developed mathematically and graphically. The appendix section covers the fundamentals of the Fourier series analysis of complex waves.

At the end of each chapter are a number of selected references to pertinent articles. The book is well written and presents a considerable amount of useful and practical information on the subject of receiver design. A second volume is planned to cover audio amplifiers, power supplies, measurements, etc.

NEW BULLETINS

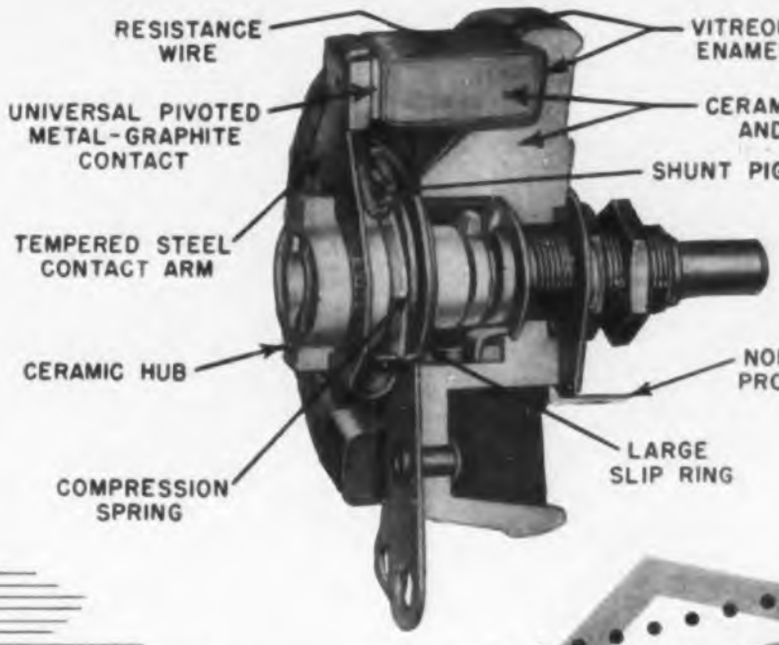
Radio Procedure Manual

A procedure manual for aircraft radiotelephone communication has just been published by Electronic Specialty Co., 3456 Glendale Blvd., Los Angeles 26, Calif. It is offered to all Civil Air Patrol members. The 16-page manual is a reproduction of the Civil Air Patrol training directive on the use of two-way radio equipment and was published in collaboration with the C.A.P. Distribution is by authority of the C.A.P. national headquarters to members of all Wings, Groups, Squadrons and Flights.

Inspection Handbook

"Quality Control" is the title of a new pocket size handbook on scientific inspection by Continental Machines, Inc., 1301 Washington Ave., South, Minneapolis 4, Minn. The handbook is unusual in its brief but concise explanation of the entire subject of precision measurement. The use of dozens of photographs, diagrams, charts and tables makes the explanation of scientific inspection interesting, and informative. The booklet is dedicated to Eli Whitney, the father of mass production, whose invention of interchangeability of parts has become highly developed through the use of precision measuring instruments to interpret fine dimensions. These measuring instruments are pictured, showing their use in everyday production, safeguarding that production from rejects by establishing uniform control throughout the whole production set-up. Gage blocks, a host of gage instruments and accessories are described, including presentation of the new

The Inside Story of OHMITE Rheostats



OHMITE Design Makes the Difference in Smooth, Close Control

Everywhere . . . on every battle front . . . and in the tools of Industry . . . you find Ohmite Rheostats doing critical control jobs.

Permanently smooth, close control is built-in . . . to withstand shock, vibration, heat and humidity. Construction is compact . . . all ceramic and metal. There is nothing to shrink, shift or deteriorate.

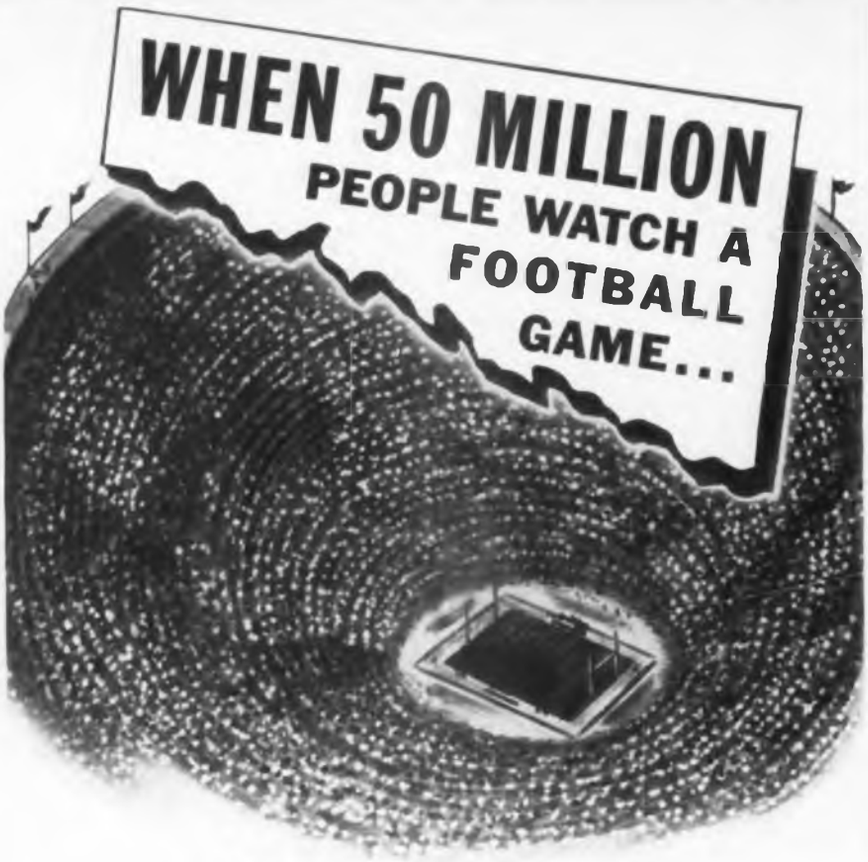
Illustrated in the cutaway above are many of the features which contribute to the consistent dependability of Ohmite Rheostats.

Widest range of sizes—ten models from 25 to 1000 watts, from $1\frac{9}{16}$" to 12" diameter—in straight or tapered winding, in single or tandem assemblies—to meet every control need in the most advanced electronic devices.

Write on company letterhead for complete, helpful 96-page guide in the selection and application of Rheostats, Resistors, Tap Switches, Chokes and Attenuators.

OHMITE MANUFACTURING COMPANY
4984 W. FLOURNOY STREET, CHICAGO 44, ILLINOIS

Be Right With OHMITE Rheostats • Resistors • Tap Switches



...the "Rose Bowl" **will be as large as the television hook-up that will telecast the game . . . on a beam of electrons.**

Invisible to these millions, but essential to television, will be transformers: regulators of electronic energy ... The intimate experience gained from war communication musts, will be applied by Stancor engineers to electronic controls of the future—an incalculable plus value... Refinement in transformers spells Stancor.

STANCOR *Transformers*

STANDARD TRANSFORMER CORPORATION
1500 NORTH HALSTED STREET - CHICAGO

Manufacturers of quality transformers, reactors, rectifiers, power packs and allied products for the electronic industries.

SEND FOR NEW COMPLETE CATALOG

mobile inspection unit which brings the inspection department right to the point of work.

Of interest are the many tables and data pertaining to gaging methods used in precision measurement. One section highlights twenty-four subjects vital to precision measuring and explains the use of many precision instruments such as the sine bar, vernier gage optical flats, etc. At the end of the book fifty-three key questions are given with their answers, serving both as a check and test of the knowledge gained by the reader in studying this handbook. Also offered is a group of films, charts and illustrated booklets as further training aids on scientific inspection which can be secured from Continental Machines, Inc.

Franklin Products

The Franklin line of sockets, switches, plugs, locking rings, terminal strips, metal and plastic fabrications, etc., is illustrated and described in the new catalog just released by this company.

Illustrations are in blueprint and photographic style and each socket, plug, switch, etc., is given individual detailed description.

Copies of this catalog may be obtained by writing A. W. Franklin Mfg. Corp., 177 Varick St., New York 14, N. Y.

Allied News

Allied Radio Corp., 833 West Jackson Blvd., Chicago 7, Ill., is now publishing the **"Allied Radio and Electronic News,"** a monthly bulletin of developments in the electronic field, distributed throughout the country to engineers, purchasing agents, department heads, etc., who are interested in the maintenance and development of electronic equipment. Engineers desiring to be placed on the mailing list for this bulletin should address requests on company letterheads.

Magnetic Chuck

New Doall electro-magnetic chucks, and the Selectron, a current recifying, demagnetizing and power varying unit, manufactured by Continental Machines, Inc., 1301 Washington Ave., S. Minneapolis 4, Minn., are described and pictured in a four-page bulletin. This bulletin shows how the Selectron, an electronic device, furnishes dc power, gives the operator control over the magnetic pull of the chuck and also demagnetizes the chuck. The Selectron has a capacity of 175 watts, operating on 220 or 440 volts to produce 220 volt dc and will operate any chuck drawing up

. . . in Resistance to Corrosion and Moisture

This is a standard test at Shure Brothers. The microphone is connected to the air pressure line and submerged. No bubbles—its "insides" are protected against rain and ocean spray. More than that, Shure engineers have successfully defeated corrosion of iron, steel, brass and aluminum microphone parts—and they were the first to moisture-proof, successfully, Rochelle Salt Crystal Microphones. You may well look to Shure engineers to provide you with better microphones and headphones.

SHURE BROTHERS, 225 West Huron Street, Chicago

Designers and Manufacturers of Microphones and Acoustic Devices

ARMY NAVY

SHURE
MICROPHONES

Just ahead, in the great adventure of science, lie many discoveries that will serve mankind.

Upon such discoveries, Sperti, Inc. has been built.

For Sperti is more than the manufacturer of *SUN LAMPS, IRRADIATION LAMPS, FLUORESCENT LIGHTING, MEAT TENDERIZERS* and the much-publicized *BIO-DYNE OINTMENT.*

It is more than the maker of *SPERTI'S ELECTRONIC DEVICES* and *NAVIGATION INSTRUMENTS.*

Beyond Sperti there are laboratories devoted to pure scientific research, staffed by scientists wholly devoted to exploring new fields of knowledge.

Many of their studies yield results which have immediate practical application.

Sperti, Inc. exists to make these practical discoveries available.

Even now, though almost wholly occupied with war work, Sperti may have an advancement applicable to your business.

And just ahead may lie other discoveries of vital importance to you.

It will pay you to consult Sperti now—as you plan your postwar products.

Sperti INCORPORATED

RESEARCH, DEVELOPMENT, MANUFACTURING • CINCINNATI, OHIO

to 175 watts. Descriptions of the Doall electro-magnetic chuck cover two sizes, 6x18 in. and 8x24 in.

Resins and Plastic

Description of the unique group of polyvinyl resins and plastics which it has recently developed and offered for distribution to industrial users under the trade name Geon is contained in an attractive four-page folder just issued by the Chemical Division of the B. F. Goodrich Co., Akron, Ohio.

Stock Record

A stock record in folder form has been issued by Manufacturers Screw Products, 216-222 W. Hubbard St., Chicago (10), Ill. It is a periodical record of "in-stock" aviation and commercial fasteners of every type and description, and keeps buyers abreast of the firm's stock condition. Millions of regular and special items are listed in the record, including screws, washers, rivets, studs, nuts, bolts, aluminum washers, drilled screws and similar items.

Control Bulletin

Centralab's bulletin 697 on Controls has been revised and the new version contains eight pages of informative data on Standard, Midget, Sub-Midget and Elf Radiohms as well as switch covers, shafts and bushings that apply to these controls. There are photographs of the parts, detailed engineering drawings, specifications and resistance curves that will be valuable to research men and purchasing departments. Manufacturer is Centralab, Division of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee, Wis.

Burner Equipment

A new 46-page catalog has been released by Haydu Bros., Plainfield, New Jersey, which describes and illustrates their glass-forming burner equipment. The equipment shown includes cross fires, sealing torches, bunsen burners (adjustable and heavy duty), blast burners, oxygen blow pipes, ribbon burners, manifolds, burner tips of all types, etc.

Symposium on Plastics

A report of the extensive symposium on plastics held in Philadelphia on February 22 and 23, 1944, can be found in the January, 1944, issue of the Bulletin of the American Society for Testing Materials. Short abstracts of the technical papers dealing with the testing methods and results of essential mechanical, electrical, and chemical properties of plastics are given.

California Quiz

FOR MARKETING EXECUTIVES

HIGHSPOTTING

The California Issue of

ELECTRONIC INDUSTRIES

TO BE PUBLISHED IN

June '44

FIRST IN A SERIES OF REGIONAL EDITORIAL SURVEYS

Q—*Why a California issue?*

A — Because of California's rapidly increasing importance as a center of radio production and war strategy.

Q—*What type of information will be published?*

A — In addition to a well-balanced issue covering all phases of electronics, the June issue will have feature articles on engineering and production facilities, written by California authors in California plants. Also a summary of West Coast manufacturing and a list of West Coast representatives handling radio-electronic parts, components and supplies.

Q—*Why is the California story important to Eastern manufacturers?*

A — West Coast plants are large buyers of radio materials, parts, accessories and instruments. Although engaged 100% in war work at present, California will be a large postwar producer of radio and electronic products. The West Coast has a greater per-capita use of radio equipment than any other section of the country and its population is increasing faster. San Francisco and Los Angeles will be key ports for the exportation of radio to the Far East.

Q—*Why should an Eastern manufacturer advertise in the California issue?*

A — To get better established in the California market. Eastern concerns should capitalize California's unusual interest in the June issue and advertise on the basis that California will be a permanent and substantial market. In future, few Eastern manufacturers can afford to overlook the West Coast.

Q—*Why should West Coast manufacturers advertise in the California issue?*

A — Because West Coast manufacturers have the same problems of selling and distribution as Eastern manufacturers. Their markets also are the same. Except for government business, their selling is largely intra-industry selling. They make items for other manufacturers and also for the final user. Western and Eastern manufacturers alike need the service of a magazine such as ELECTRONIC INDUSTRIES, whose paid circulation is almost exactly in proportion to the market and population.

Q—*What can East Coast and West Coast manufacturers accomplish by advertising in ELECTRONIC INDUSTRIES?*

A — They can reach the top-ranking engineers and executives of the entire industry, including a complete coverage of important factors in manufacturing and communications on the West Coast. They can get immediate business and lay the groundwork for postwar selling. They can save valuable time by reducing the traveling of executives and engineers. They can back up their sales agencies.

Q—*When will the June advertising forms be closed?*

A — May 10 for complete plates; May 5 for composition without proofs; May 1 if composition and proofs are required.

CALDWELL-CLEMENTS, INC.

Publishers of
ELECTRONIC INDUSTRIES
RADAR
RADIO RETAILING TODAY

Editorial and Executive Offices
480 Lexington Ave., New York 17, N. Y.
Telephone PLaza 3-1340

Chicago Office
201 N. Wells Street, Chicago 6, Ill.
Telephone RAndolph 9225

THE greatest single factor in the wide acceptance of Jefferson Electric Transformers, is the ability to insure "quality" while producing in great quantities.

If you need a few or a million, Jefferson Electric facilities, experience and manufacturing control insure like quality for all.

Reports from all over the world emphasize the value of Jefferson Electric Transformer reliability under all manner of conditions,—from the Arctic to the Equator —from the moisture-laden coastal regions to the arid desert areas.

With all factors—engineering, designing, research, manufacture of all components under one control, insurance of "quality" with quantity is secured. You can bring your particular requirements to "transformer headquarters" with full confidence that recommendations and suggestions will help you save time—and the transformers furnished whether in small or large quantities will be alike in quality. . . . JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Illinois. Canadian Factory: 60-64 Osler Ave., W. Toronto, Ont.

JEFFERSON ELECTRIC

TRANSFORMERS

OSCILLATORS

(*Continued from page* 105)

age to appear across the circuit L-C, and C charges. If, at this point, switch S were closed, the applied voltage would drop and C would discharge building up a magnetic field in L.

Meanwhile, the full dc voltage would build up across L_1. When S is reopened, L would discharge into C and the process repeats. All that is needed is to have switch S operate at the resonant frequency. Capacitor C_1 acts to block any steady flow of dc through inductance L but presents a very low impedance to the flow of the pulses of current feeding the resonant circuit. L_1 is a choke which serves to absorb the short current pulses and prevents them from affecting other elements in the circuit. A spark gap could be used as this switch at speeds below 200,000 cycles per second but for the higher frequencies, the only satisfactory element is the vacuum tube.

The vacuum tube can be thought of as a contactor capable of operating at very high speeds. The tubes used for this application have three elements, an anode (or plate), a cathode and a grid, all within an evacuated envelope.

Before the vacuum tube will operate to maintain oscillation in the circuit the proper grid voltage must be determined and a means found to create it. The voltages existent across the tube during oscillation will appear as in Fig. 4.

The plate-to-cathode voltage consists of two parts—the dc voltage (a) plus or minus the rf voltage (b). At point c, the voltage is at a maximum while at (d) it is at a minimum. The tube must conduct at that point during the cycle at which oscillation would be aided. If this occurred at point c,

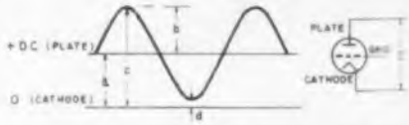


Fig. 4—Anode potential curve when oscillating

it would tend to reduce the rf voltage at that point and increase it during the other half of the cycle. Thus, the tube must be made to conduct at point d.

Also, since the vacuum tube always presents a certain resistance to the flow of current, the power loss within it will equal the summation of the products of the instantaneous voltage times the current. It is obvious that since the voltage is at a minimum at point d and increases at all other points, it would be very advantageous to limit the period of conduction to a small fraction of a cycle centered at that point.

(*Turn page*)

When something seems rotten in Denmark...

THERE is a strange quality in us all—even in fact-minded engineers. We tend to suspect ourselves first when we're face to face with failure. We forget that human beings have no corner on error.

Behind an apparent failure, for instance, may be the innocent face of a meter that failed to tell the truth. From there, calculations went hopeless awry and ended in a wad of paper held in an angry fist.

We do not suggest that you mistrust your tools. We do say—insist on *sustained accuracy** in your metering, measuring, and testing instruments. Use instruments that *through their lifetime* never waver from the truth.

***SUSTAINED ACCURACY** is not an easy quality to achieve. It must take into account all factors of use—must then employ the design, the alloys, the construction that infallibly protect an instrument against all threats to its reliable performance. Such instruments, obviously, must be built with performance—not price—in mind. We invite the inquiries of those who are interested in such standards.

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To do this, it is necessary that the grid be sufficiently negative to prevent the flow of current at all other points, thus the grid voltage must consist of a sine wave 180 deg. out of phase with the plate voltage, superimposed on a negative dc voltage as in Fig. 5. With a voltage of this type applied to the grid, the conduction period will be only slightly longer than "h" and the tube efficiency will be at a maximum.

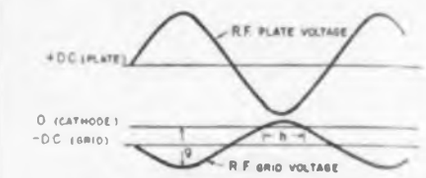


Fig. 5—Relation between anode and grid voltages in oscillator

The rf component of the grid voltage could logically be obtained directly from the resonant circuit while the dc component is applied from an external source. But since this requires adjustment of the dc potential whenever the magnitude of the rf component changes, a scheme for automatically providing the correct dc voltage is normally used.

Several methods are used to obtain the rf voltage from the resonant circuit for the grid—and this is the main point of difference in the oscillator circuits now being used by the various manufacturers of induction heating equipment.

This 180 deg. phasing between grid and plate voltages can be obtained in several ways. In the coupled grid circuit, Fig. 7, the voltage is developed across a coil inductively coupled to a portion of the resonant circuit. By proper connections this voltage can be phased nearly 180 deg., but due to the resistance inherent in any inductance, this phasing must be corrected in many cases by the addition of a phase-correcting capacitor.

In the Colpitts circuit used in G-E circuits (Fig. 8) the grid voltage is obtained by direct connection to the resonant circuit by splitting the capacitor into two series sections. If the plate-to-cathode voltage is impressed on one section (E_p in Fig. 6), the voltage across the other section E_g will

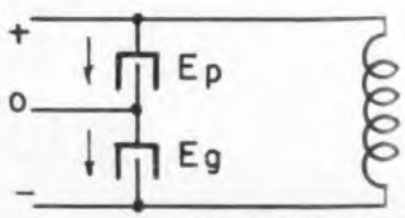
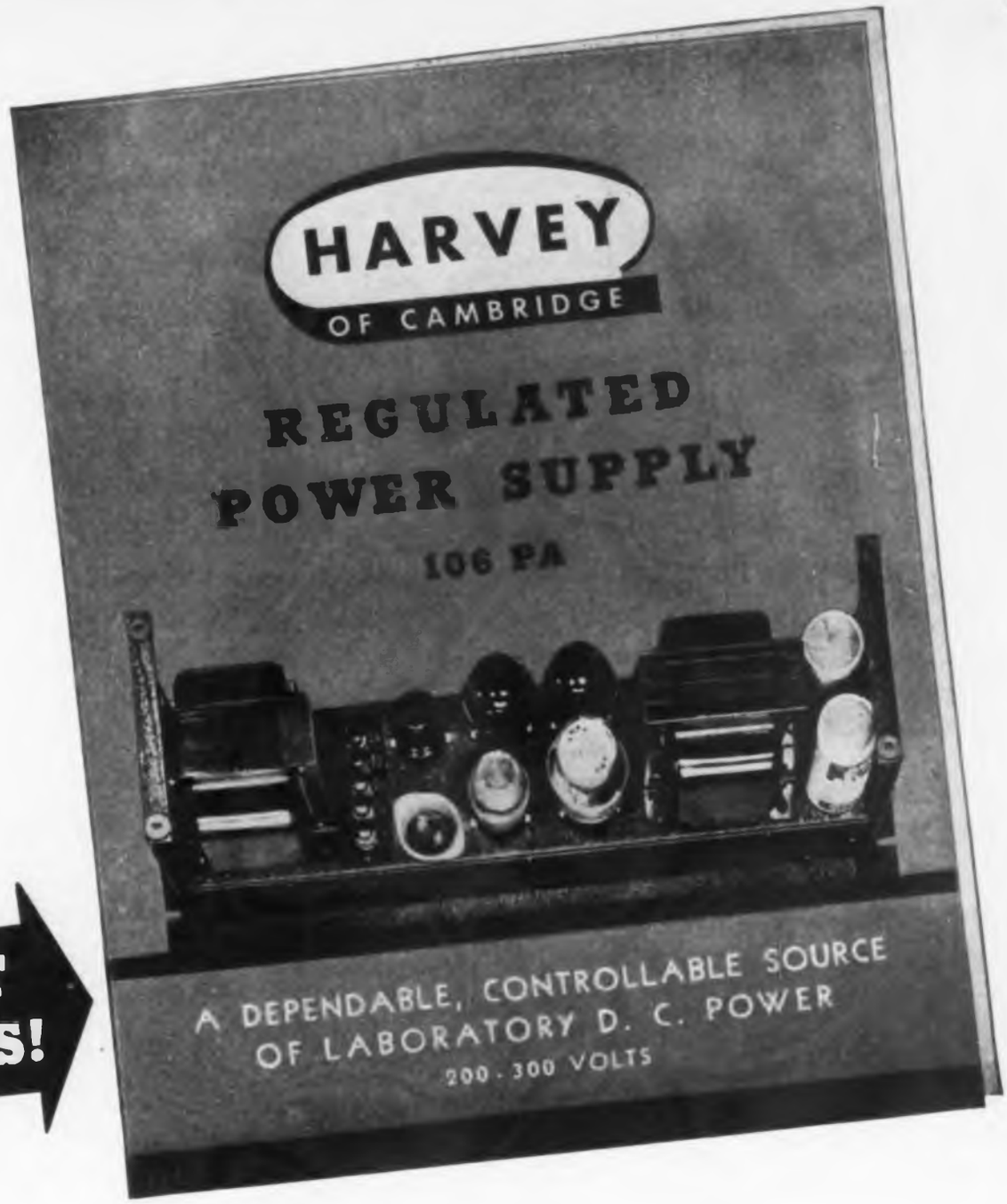


Fig. 6—Basic circuit of Colpitts oscillator



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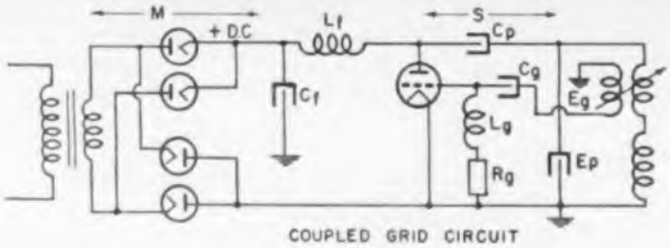

Fig. 7—Oscillator circuit with coupled grid coil for feedback purposes

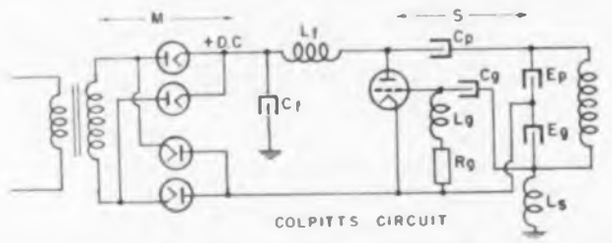

Fig. 8—Oscillator circuit with divided tank capacitor giving properly phased feedback voltages

always be of opposite polarity, thus giving a 180 deg. phase angle.

Section "M" (Fig. 7 and 8) represents schematically the mercury tube rectifier commonly used to convert the 60-cycle voltage output of the high-voltage transformer T to the dc utilized by the oscillator circuit S. The Colpitts circuit, (Fig. 8), has the advantage of greater stability, since the capacitance ratio which determines E_p/E_g is always fixed, thus providing a "stiffer" voltage source, as well as better efficiency because the phasing is more exact. However, the coupled grid circuit (Fig. 7) affords a ready means of adjusting the amplitude of the grid voltage which is in some cases advantageous.

It will be noted that since no effort is made to smooth out or filter the dc output of the rectifier, the voltage applied to the oscillator is actually a series of half sine waves. However, this in no way affects the previous analysis since for the duration of any one rf cycle the voltage could be assumed constant.

To conclude this theoretical discussion of the oscillator circuit, it is important that several points be understood thoroughly because of their importance in the application of this circuit to induction and dielectric heating. These are:

1. Voltage and current in the resonant circuit have no relation to power output, being solely a function of voltage, frequency, and circuit constants. This current does not flow through the tubes.

2. All direct current from the rectifier flows through the oscillator tubes. Since the direct current times the voltage equals the power output of the rectifier, this current is proportional to the power input to the oscillator circuit at any fixed voltage.

3. The serviceable life of all oscillator tubes is determined by the life of filaments; this in turn is determined by their operating temperature. With thoriated tungsten filaments, temperatures either too low or too high will seriously shorten their life. With pure tungsten filaments, the lower the temperature the longer the tube life. However, at reduced temperatures fewer electrons are emitted, thus limiting the permissable power output.

COUPLING METHODS

(*Continued from page 83*)

might have high efficiency and also be good at high frequencies. Consequently, a transformer was built having 15 turns of $^3/_8$-in. copper tubing for a primary. The overall dimensions were: diameter, $4^1/_2$ in.; length 8 in. The efficiency curve for this unit is shown in Curve I. With the exception of a drop in efficiency at frequencies less than 500 kc, it had excellent characteristics out as far as 7.5 mc.

The efficiency of coupling varies as the ratio $\frac{\delta_c}{\delta_w}$ where δ_c and δ_w are the electrical conductivities of the inductor coil and of the work, respectively. Therefore, the inductor coil should be made of copper or silver and should be kept as cold as possible. Even refrigeration of the coolant may be worthwhile in some instances. When heating materials of high electrical conductivity such as copper, aluminum, or brass, the coupling efficiencies will be relatively low. The curves of Fig. 6 show the efficiencies of a transformer and inductor loop when coupling to 1 in. rods of steel, copper and aluminum.* (*Turn page*)

*The efficiencies shown for copper and aluminum are unbelievably high. Certainly the method of measuring efficiency is not applicable to loads having high electrical conductivities since the current distributions must be quite different when measuring Q_l and Q

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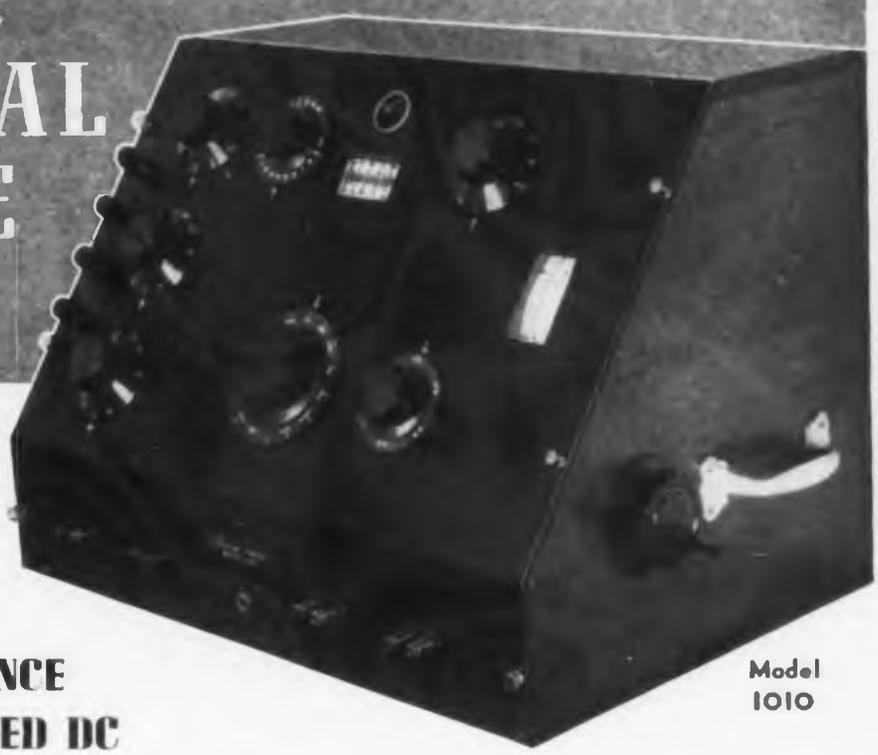

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To show the effect of increasing the number of inductor turns, some data were taken on ¾-in. rods of steel and copper using one inductor having a single turn and another having two turns. These data are plotted in the curves of Fig. 7. For the ¾-in. work a two turn coil more nearly matches the impedance of the transformer than does a one turn inductor.

Transformers approximately 10 in. in diameter by 15 in. in length and with suitable turn ratios of 1 to 10 or 20 have secondary impedances which match the impedance of a cylindrical piece of work two to three inches in diameter. If such a transformer is then used on a piece of work of less diameter the efficiency drops due principally to mis-matching. Therefore, one can expect the efficiency of the type described to decrease with the radius of work when less than three inches in diameter. The curves of Fig. 8 show directly how the efficiency

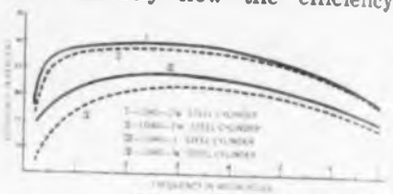

Fig. 8—Efficiency drops with small diameter loads

falls with decrease in radius. In all four curves the inductor was a single loop of 3/16-in. copper tubing which fitted the work with spacings of less than 1/32 in. As a matter of fact the spacing for the smaller diameters was less than for the larger which would tend to raise the efficiency values for the small sizes.

When an inductor surrounds the work the inductor current travels along its inner surface. Moreover, the path of the magnetic field on the outside of the inductor is practically unlimited. Therefore, the radial width of an external inductor has little effect on the efficiency. To illustrate this effect, data were taken on two inductors, both having the same inside diameter, (1 3/16 in.) but having widely differing widths. Both were made from ⅛-in. copper plate. No. 1 had a radial thickness of ⅛ in. No. 2 was a large irregular plate with an average width of more than 2 in. These two inductors are shown in Fig. 9. The effi-

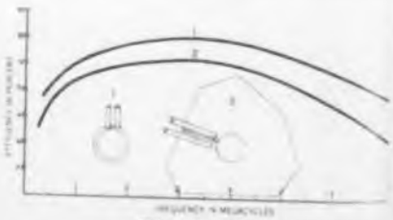

Fig. 9—Effect of conductor width on work coils

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ciency vs. frequency for each inductor is plotted in the curves. The work was 1⅛-in. steel rod in each case.

For the purpose of heating an inside surface, again the simplest type of applicator is merely a loop of copper tubing which fits inside the work with as small a spacing as possible between coil and work. All of the effects mentioned in connection with outside inductors hold good for inside inductors, with one exception: for inside inductors the radial width is very important.

To show how efficiency varies with "width" of inductor, several applicators were made having the same external diameters but having various inside diameters. The thickness of each, axially was ⅛ in. and the common outside diameter was 2.0 in. The inside diameters varied from 1.75 in. to .75 in. Each was connected to the 4½-in. hf transformer and the over-all efficiencies were measured at a number of different frequencies. In each case the work was a heavy-wall, steel pipe with an inside diameter of 2 1/16 in. The efficiency drops rapidly with an increase in radial width of inductor, as shown by Fig. 10.

It becomes very difficult physically, to build an inside inductor coil for bores less than one inch in diameter. If small tubing is used the difficulty is to get enough water through it for cooling purposes. Moreover, it is very hard to form a uniformly round coil from tubing with the close tolerances necessary in this case. To overcome these difficulties a special design of inside applicator was developed to work in bores of

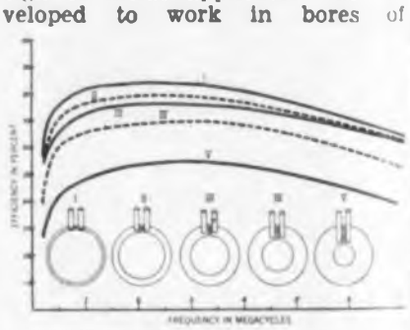

Fig. 10—Effect of radial width of coil turn

diameters between 1½ in. and ½ in. It is shown in Fig. 11.

The device is completely machine made so that close tolerances can be maintained. The "inductor coil" is a thin copper ring R mounted on the end of a bakelite block B. The ring is split and fed with current by the conductors C and C' which form two halves of a split conical rod. Cooling water enters the tube T, passes through the annular space between CC' and the bakelite walls, and is sprayed against the ring at a high velocity.

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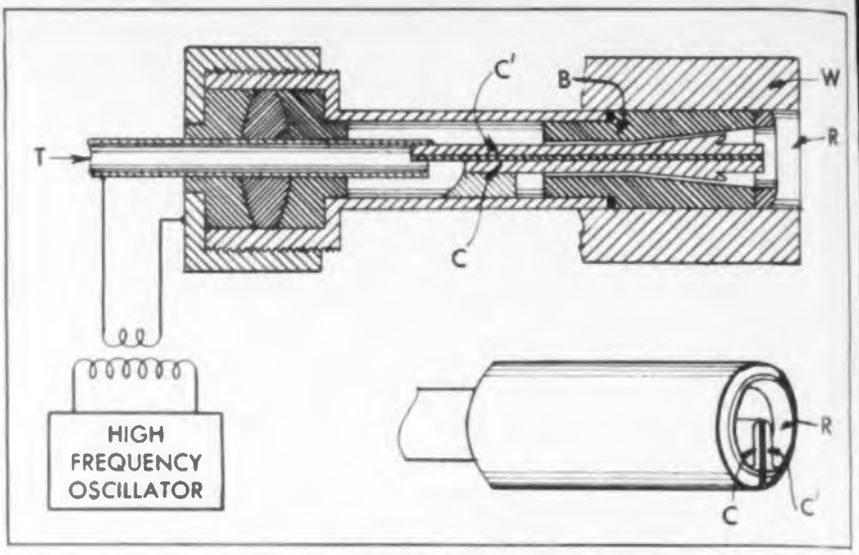

Fig. 11—Inside applicator for working in small bores

bore of the work W and acts as a guide for the inductor. The work is moved to the right as the heating progresses. By slightly varying the shape of the ring, the cooling water can either be thrown against the hot work or not, as desired.

An interesting type of applicator is the nose piece of the explosive rivet detonator. The appearance of the apparatus can be seen in the photograph, Fig. 12. The secondary of the transformer is a split cylinder type, as described, with the "nose" loop attached at one end. This nose piece is made from copper strap which is folded and bent into a flattened conical shape. A saw-cut down the top from the broad end to within ⅛ in. of the tip forces the current to flow in a single loop at the tip.

The device is most useful in forming an isolated concentration of electro-magnetic energy. The current frequency is generally less than 500 kc, which makes practicable the use of a powdered iron core at the tip. Such a core ⅛ to ¼ in. in diameter and ¼ in. long, increases the efficiency of the whole head assembly from about 20 to 40 per cent. Although a great number of different designs of nose pieces have been tried, no other type was found which had so high an efficiency. The relatively high effi-

Fig. 12—Applicator coil on rivet detonator

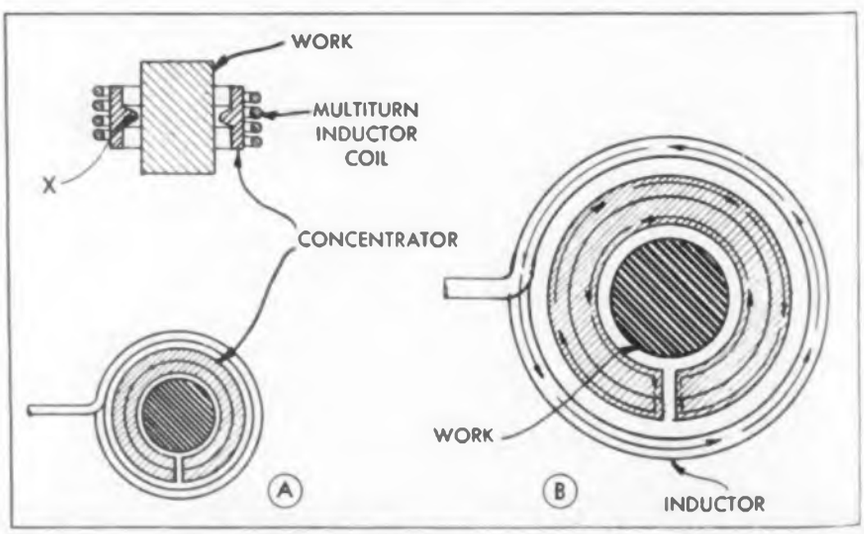

Fig. 13—Flux concentrators used to produce highly localized flux distributions

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ciency is thought to be due to the particular arrangement of the leads to the inductor loop.

The so called "current concentrator" is really a type of transformer, or rather a coupling link, which takes the place of a transformer secondary, and inductor coil. This device is used most frequently as a current transformer to couple the tank circuit inductance directly to the work. It is not nearly so convenient to use, however, as some of the designs of transformers described above. It can also be used as a further matching device between a multi-turn inductor coil and the work. Used in this fashion its function is to intercept the flux of the inductor coil and to concentrate it at a given plane.

The heating of the work in that plane is therefore greatly enhanced. A sketch of such a device is shown in Fig. 13. The magnetic flux of the inductor coil links the concentrator and develops an emf around its periphery. The resultant current follows this periphery because of the skin effect. And also because of the same effect the current concentrates axially, in the plane of minimum radius (shown at X in (a) of the figure). Thus, although the inductor coil may have several turns and a rather large impedance, to match that of the transformer, the resultant heating in the work is not spread over a large area but is confined to a narrow band.

In some instances at very high powers there may be a tendency to arc across the split in the concentrator. The remedy of course is to make the cut wider. However, this may leave a cool strip on the work opposite this cut. It is well in such a case to break the concentrator up into two or more sections so that the split between any two sections can be much narrower than if the concentrator is all in one part.

It is also possible, and often necessary, to water-cool the concentrator. This can be done quite easily even though it is in two or more sections.

Until recently, the "convenience factor" of rf heating is the characteristic that has been most exploited and little attention has been paid to the fact that the skin effect may be utilized for differential heating by conduction as well as by induction. In other words, there are many applications where differenitial heating is desirable but where it is convenient and more efficient to make electrical connection to the work. The idea is not new. It was pointed out as an effective means of differential heating by Edward Bennett in an article in **Electrical Engineering** of August 1932. For some reason, however, it has not been used extensively in industrial work.

(Turn page)

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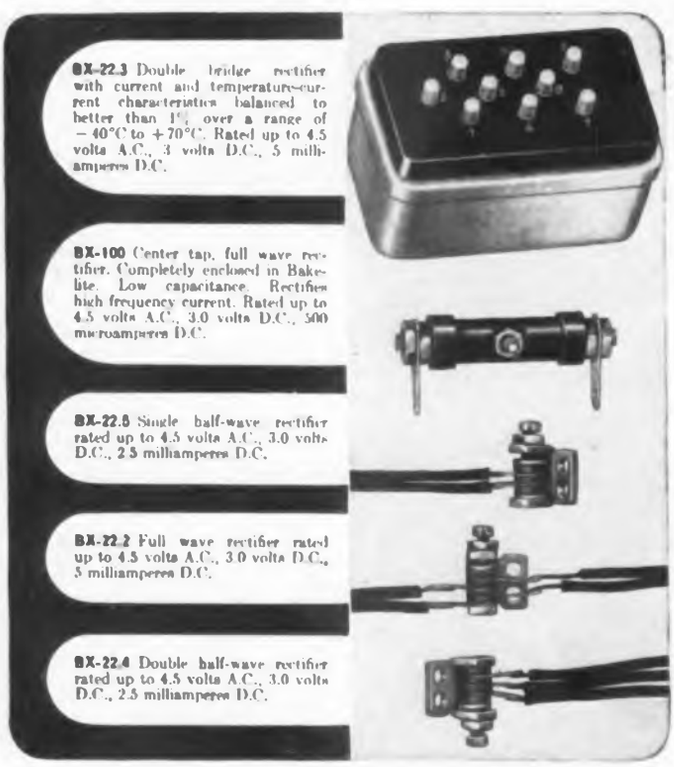

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A combination of conduction with induction is used in the co-axial type of applicator. By its use, small bores ½ in. to ⅛ in. in diameter may be hardened internally providing they are only a few inches in length. Such a device is shown in Fig. 14. E and B are heavy cop-

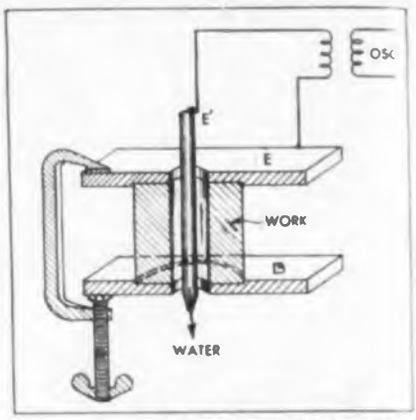

Fig. 14—Coaxial method of heating small bores

per block electrodes which are pressed tightly to the ends of the work. The electrode E', a water cooled copper tube, and E, are connected to a high frequency power source. Current flows along the outer surface of E' into B and thence back along the inner surface of the work and out at E. The length of work which it is possible to heat in this manner, is limited by the power of the oscillator, since such a method does not lend itself to progressive heating. When using the self-quenching technic the power requirements are 60 to 75 kw per sq. in. for heating times up to a half second.

A variation of the above method has been used to surface harden gears by the tooth-at-a-time procedure. The gear is firmly gripped between the heavy copper blocks B-B' as shown in Fig. 15. Current is led in through E, between a pair of adjacent teeth, to the block B, thence back along the faces of the teeth and bottom of the groove between them, to the other block B'

(Turn page)

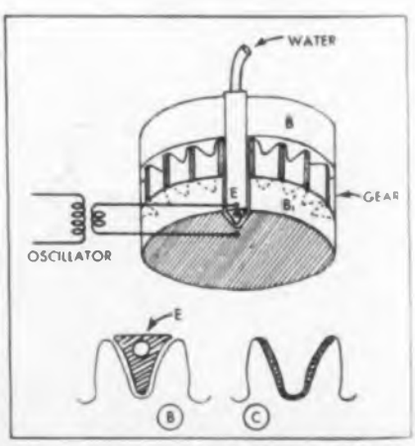

Fig. 15—Surface hardening gear teeth

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This procedure of heating opposite sides of adjacent teeth simultaneously, allows the heated surfaces to be backed with a maximum of cold metal for self-quenching.

Electrode E is water cooled and is shaped to conform roughly to the space between the teeth as shown at (b). It is necessary to have closer spacing at the roots of the teeth than near the tops, if the ideal heating pattern is to be produced, as at (C).

Several limiting factors must be taken into consideration in designing applicator coils for induction heating. One such factor is the relationship between size of the work and frequency. In order for a rod of non-magnetic material to absorb 99 per cent of the energy of the hf magnetic flux which threads it, the diameter of the rod should be at least five times the depth of current penetration.

According to this rule, the minimum diameter of steel rod which can be heated efficiently above 800 deg. C (where it is no longer magnetic) is 400 mils at a frequency of 100 kc.

At 1 mc the diameter is 140 mils; at 10 mc, 40 mils; and at 100 mc, 14 mils. For copper wires the minimum diameter at 100 kc is 40 mils; at 1 mc, 13 mils; at 10 mc, 4 mils and at 100 mc, 1.3 mils.

It should be remembered, however, that such figures do not tell the whole story. If an infinite power can be put into the inductor coil, then any size can be heated to any temperature. On the other hand there are many practical physical limitations such as the problem of cooling an inductor coil wound on a 1/16 in. radius. Moreover, the matter of persuading 100 mc energy to confine itself to such a coil is no mean feat. Again, the rate of heat radiation per unit volume of the work increases rapidly with decreasing size.

The net result is that it is exceedingly hard to heat wires or objects less than 1/16 in. in diameter and when it is possible, the efficiencies are ridiculously low. There is this exception however: when a magnetic material is to be heated to some temperature less than its Curie point, hysteresis effects make the heating relatively easy.

Work and frequency

Just as the size of the work determines the minimum practical frequency so also does the size of the work determine the maximum practical frequency. The limiting factor is the break-down voltage between inductor coil and work. For example, if a 3-in. shaft is to be heated and a spacing of about 1/16 in. is maintained between the work and a single turn inductor, the loaded inductance of the coil

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is on the order of .1 μh. Working at 1 mc and at a power level sufficient to case-harden the work by the self-quenching technique, the current in the inductor coil is in the order of 1000 amperes. Therefore, the voltage drop around the inductor loop is approximately 600 volts. When the iron gets hot this voltage is likely to cause arcing between coil and work. If the spacing is increased the coupling between work and coil is of course decreased and the equivalent inductance of the coil is increased. Thus nothing is gained by an increase in spacing. Therefore, at a frequency of 1 mc it is not possible to heat pieces much larger than 3 in. in diameter at power levels necessary for the self-quenching technic. This indicates that in order to heat larger pieces, lower frequencies are necessary. However, before definite relations between size of work, power and frequency can be worked out, more will have to be known about the laws governing the hf breakdown potentials between hot electrodes.

The shape factor enters the problem since in order to achieve good coupling a complete, low impedance path must be provided for the induced currents. For example, suppose a long steel bar of T cross section is to be hardened on only one face, (S of Fig. 16). One design of inductor is shown at I. Because of the close spacing between the inductor and S, the induced currents will be concentrated on this face, but coupling will be very loose.

Another scheme is illustrated in (b) of the figure. While the inductor will show better over-all coupling in this case, the fraction of the energy which is put into S is so small that the net efficiency is no greater than in the case of (a). A third method is illustrated in (C). There are several objections to this scheme. The return paths of the induced curents will be along the edges of S where they are highly concentrated. Thus, the edges will be much overheated. Moreover, there are two heated areas (one under each limb of the coil). As the work is heated progressively each point is heated, cooled, and heated a second time. Under such conditions self-quenching technics are almost impossible.

A fourth method and one which yields by far the best results is to

(*Turn page*)

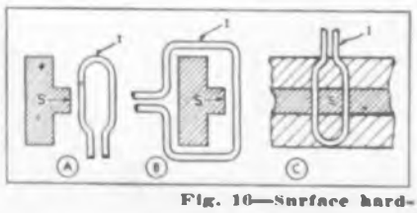

Fig. 16—Surface hardening selected areas.

Few Radio Batteries

The War Production Board has stated the possibility of an appreciable increase in dry-cell batteries for radio, flashlights and other battery-powered electrical equipment for civilian use is "remote" and that heavier military demands will virtually erase an increase over last year in civilian supplies. In fact, the production of some types of batteries used by civilians may be lower in this year than in 1943, the WPB added, but in 1943 the distribution of telephone batteries in rural areas was the same as in 1940.

Limitations Lifted on South American Exports

In a move to expedite the processing and approval of maintenance and repair programs of communications equipment for Latin American countries, the Foreign Economic Administration in mid-March removed "Import Recommendation" controls from certain specified radio equipment.

Previously, before the FEA Communications Division could process "MRO" programs submitted by American communications companies operating in Latin America, it had to await an Import Recommendation from an FEA official in the particular country destined to receive the equipment. In January, these controls had been removed from telephone and telegraph equipment, and as a result of the further decentralization procedure, almost all forms of communications apparatus which has been processed and approved by the FEA and the War Production Board, may be exported immediately.

Standard for Porcelain Insulators

A new standard for porcelain radio insulators, just approved by the American Standards Association, is now available to industry and the Armed Forces. This standard completes a series of American War Standards covering the broad field of ceramic insulation for communication and electronic purposes.

The standard on porcelain insulators extends the work on ceramic insulators. It follows the pattern of the preceding specifications covering insulators made of steatite, glass-bonded mica, and glass. Definite requirements for dimensional tolerances and finishes have been included in this standard as in the earlier ones. Included also is an appendix on design criteria recommended by leading manufacturers in each field. This appendix is intended to help design engineers not only in the radio manufacturing industry but also in the insulation industry itself.

All four insulator standards outline tests intended to determine the ability of the completed insulators to stand up in service under any of the conditions encountered by the various branches of our Armed Services, and supply data on the basic electrical characteristics of these components.

The Radio Division, Bureau of Ships, Navy Department and the Signal Corps of the United States Army have adopted these new standards for procurement purposes. It is anticipated that they will be used in the design of new equipment and, where practicable, in existing equipment, and for replacement purposes.

Approval of this standard brings to a conclusion the work of this committee on Insulation Material Specifications for the Military Services which has been functioning under the chairmanship of Dr. Alfred N. Goldsmith, representing the Institute of Radio Engineers.

The American War Standard for Porcelain Radio Insulators (C75.14-1944) may be obtained for 50 cents from the American Standards Association, 29 West 39th Street, New York 18, N. Y., and from the government agency concerned, free of charge, for procurement purposes only.

Hanovia to Altec-Lansing

Hanovia Chemical & Mfg. Co., manufacturers of high-pressure mercury vapor lamps for use in ultra-violet applications, has appointed Altec-Lansing Corp., Hollywood, Calif., exclusive western distributors. The Chicago and Detroit territories are also under exclusive direction of Altec-Lansing.

Resistance Strain Gage Capabilities

Supplementing the report on resistance strain gage capabilities given in our March 1944 issue, it has been noted by C. H. Gibbons (Baldwin Southwark) that the limit of the usefulness of these gages in measuring small displacements is greater than that reported and that linear displacements as low as 0.025 micron have been indicated with certain styles. With this sensitivity the process may be usefully applied to many more stress analysis problems.

Incidentally Fig. 4A on Page 368 of that issue should have shown one terminal of the voltage E connected to the upper terminal of oscillograph instead of the lower one shown there.

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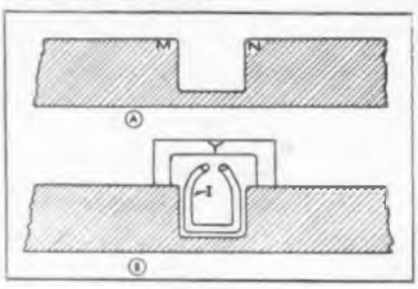
cover those parts which are not to be heated with copper and then to use an inductor similar to that in (b) but which closely fits the work. Such a procedure is of course not convenient or economical for most applications. If, however, a copper "return path" for the induced currents can be provided this method will be most satisfactory.

As a further example, a gear shifter rail is to be hardened on the inside surface of the notch between M and N of Fig. 17 (a). The best method for heating this piece is to clamp a copper yoke Y, over the top of the notch as shown at (b) and then to heat it progressively with an inside inductor coil I.

Very likely the steel will not harden clear up to the point of contact with the copper because of heat conduction. Therefore, such copper yokes should be kept back about 1/16 in. from the nearest point it is desired to harden.

Fig. 17—Here copper yoke provides return path

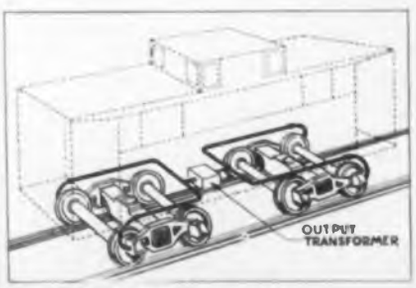


"PENNSY" R.R.

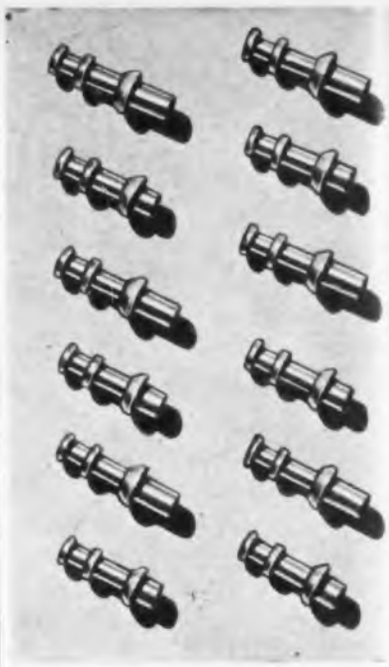
(*Continued from page 99*)

on the Belvidere branch. A second set is being installed at Trenton.

For the most satisfactory operation, it was found desirable to bond all joints of one rail and to install resistance shunts around all insulated joints. In practice, the average range of reliable communication between two trains using this system is about four miles. Neither safety nor efficiency would be served by increasing this range under most conditions of railroad operation. Moreover, since the block station can communicate with trains anywhere on the branch, messages may be relayed, where train-to-train contact must be established at distances of more than four miles.



Train communication system



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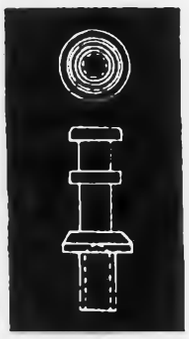

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FILTER NETWORKS

(Continued from page 89)

sults. In such case a few more reflections may be necessary before the energy finally finds its way to the load resistor. The important points to remember are that for maximum impedance the circuit capacities must be split up among the greatest number of sections and that the load resistor must be concentrated all at one place, preferably disassociated from the circuit capacity.

What configuration is chosen depends upon the associated equipment. If the filter is to be used as an interstage coupler between two tubes whose output and input impedances are pure capacities (or at least the output and input resistances are very high compared to the filter impedance), then any one of Fig. 10 may be chosen. By adding sections 12DB, more gain can be obtained from Fig. 10G than from Fig. 10A for any given band width and total circuit capacity. If by chance the plate resistance of the first tube is very low and the input resistance of the succeeding tube is high, then Fig. 10A, C, F, working backward will be satisfactory.

If the tube input resistance is low due to electron transit time or cathode lead effects so that the tube input resistance forms the load on the filter, or if the filter is to work between a transmitter tube and antenna, either 10A, C, F may be used. In the latter case the output is taken from the road resistor which is now replaced by a transmission line to the antenna.

The energy supplied by the source is dissipated in electromagnetic radiation by the radiation resistance of the antenna instead of dissipated in heat by the static resistance of the load. As previously explained, all the damping on the filter must be at one place which in this case is the antenna. Therefore the plate impedance of tubes driving the filter must be very large compared to the filter characteristic impedance. Consequently tetrode or pentode tubes are preferable to triodes in the output stage of such a transmitter.

Likewise, for receiver input circuits from antenna to first grid Fig. 10A, C, F working backward again are appropriate. It is desirable that input resistance of the first tube be very high compared to filter impedance. Otherwise considerable performance will be sacrificed. Llewellyn[4] has shown that an indefinite mismatch will give 3 db greater signal to noise ratio than the matched condition where the filter has equal resistive loads at each end. The unsymmetrical section of Fig. 7 can sometimes be used to advantage as an antenna coupler.

(Turn page)

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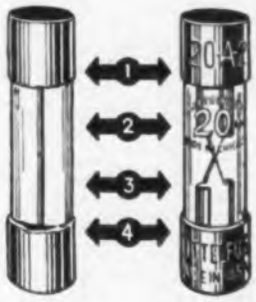

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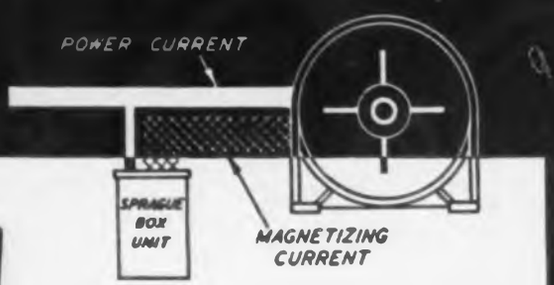

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The Use of Thévenin's Theorem In Circuit Analysis

Many engineers have a reasonable knowledge of Ohm's Law, a bowing acquaintance with complex algebra (j operators), and a faint recollection of transient analysis and circuit theorems. In keeping with the purpose of the series of little articles appearing in the Institute's monthly magazine, the CREI NEWS, we are publishing a short article on the use of Thévenin's theorem in circuit analysis. We think it will interest the engineer because it enables him to analyze complicated circuits in terms of simpler, more fundamental ones, and obtain answers with a minimum of mathematical analysis. The increased use of Thévenin's theorem is evident from a comparison of radio text books of a few years ago, and those being currently published.

We hope to continue the discussion of the use of circuit theorems in future issues of the CREI NEWS, and also to take up topics, such as active perameters, that are seldom more than mentioned in radio texts.

Your comments and suggestions will be very welcome. This implies that you are reading the articles as they appear in the CREI NEWS. If not, all you have to do is to write to us in order to be placed on our mailing list. *We shall be glad to send you the article on "Thévenin's Theorem" in the March issue of the CREI NEWS without cost, and without your incurring any obligation whatsoever.*

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The subject of "Thévenin's Theorem" is but one of many that are being constantly revised and added to CREI lessons by A. Preisman, Director of Engineering Texts, under the personal supervision of CREI President, E. H. Rietzke. CREI home study courses are of college calibre for the professional engineer and technician who recognizes CREI training as a proven program for personal advancement in the field of Radio-Electronics. Complete details of the home study courses sent on request. . . . *Ask for 36-page booklet.*

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A five stage amplifier using the configuration of Fig. 4 has been constructed and is shown in Figs. 11-A, B, C. Type 954 acorn tubes are used as amplifiers and a special R6048 diode is at the output. The midband frequency is about

Fig. 11A—Top view of wide band amplifier using 954 acorn tubes shown through side walls of filter sections

Fig. 11B—Side view of five stage amplifier. Each stage uses filter arrangement of Fig. 4 between tubes. Successive tubes are at alternate ends

Fig. 11C—Bottom view showing tubes and antenna input terminals at center

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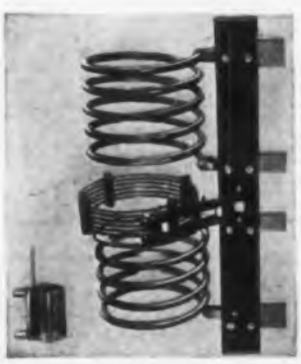
Dropped 35 feet to a cement sidewalk, this B & W Air Inductor was immediately put back in perfect operating condition without tools of any kind. Actually, the only damage was a bent "banana" plug, and a cracked support bar.

This indent feature illustrates the versatility of B & W "Air Wound" design. Every turn of the wire is indented on alternating sides of the coil. This means that the windings on both sides of the turn you want to tap are indented out of the way. No matter how small the wire, or how close it is wound, taps can easily be made *anywhere on the inductor.*



"Air Wound" construction is just as desirable for mammoth inductors as it is for small ones. Here you see a B & W No. 1591 Air Inductor, only 2" in diameter by 3" long, in a size comparison with a B & W high-power (10 KW.) coil.

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"Air Wound" Inductors—pioneered and perfected by B & W—hold many advantages for many applications:

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- *They can be protected for rough service with bumper rings —still at a minimum of weight.*
- *They offer greater design adaptability in such valuable features as indented turns which make it easy to tap any turn on a small coil.*
- *They have exceptionally low dielectric loss.*
- *They are wound to uniform pitch.*
- *They lend themselves readily to mechanical and electrical revisions in the circuit.*

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Tuning is accomplished by changing the inductive reactance of the filter lines. If the response curve is asymmetrically high on the low frequency side it may be straightened up and moved to a slightly higher frequency by decreasing the inductive reactance of the input line; or it may be straightened and moved to a slightly lower frequency by increasing the inductive reactance of the output line. If the response curve is asymetrically high on the high frequency side it may be corrected by operating on the lines in reverse fashion.

Slightly more gain and a bit flatter response may be had by increasing the load resistor a few percent over the value of midband impedance. If the load resistor is several times this value the characteristic double hump response of over coupled circuits will be had.

The effect of changing Z_s on the whole amplifier is shown in Fig. 12. Curve A shows the over-all gain of five stages when Z_s is large and 7,500 ohm loading resistors were used in parallel with input resistance of tubes from grid to ground. Removing these resistors gave curve B which is a very poor shape. By decreasing Z_s and thereby narrowing the band width the filter impedance was built up to more nearly that of the tube input resistance and curve C was produced. Curve D is the over-all response from the antenna with a single tuned first grid circuit adjusted for maximum gain at the center of the band and coupled rather tightly to the antenna to broaden its response.

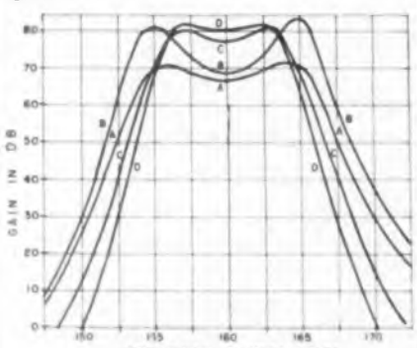

Fig. 12—Frequency response characteristics of amplifier of Fig. 11 showing effects of adjusting coupling impedance Z_s in Fig. 4. See text

Low inductive reactance by-pass condensers are used at the tube sockets and where power supply leads come into the line cavities. Special care is taken to see that no loops occur where the power leads enter, thereby coupling the flux inside to the space outside. Separate cover plates thoroughly bolted down to the frame prevent any other leaks of flux. By these meas-

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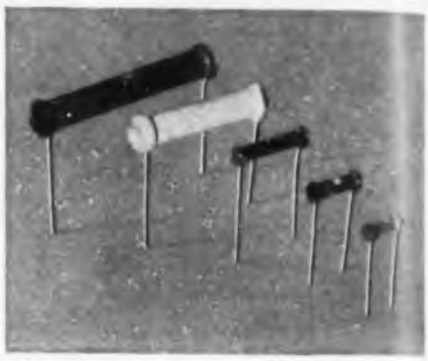

● Low ohmic values are made in body type "CX" only whereas type "A" body is offered in a wide range of resistance values.

Globar Brand Resistors are unusually rugged as your tests will prove. Those illustrated are standardized sizes and resistance values. In case you require resistors having special characteristics we can furnish them. Larger units or special sizes can be provided.

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TYPE "A" RESISTORS

PART NUMBER	WATT RATING	RESISTANCE RANGE	OVERALL LENGTH	OVERALL DIAMETER
997-A	1/5	150 Ohms to 4.7 Megohms	21/64	7/64
763-A	1/4	47 Ohms to 15 Megohms	5/8	7/32
759-A	1/2	33 Ohms to 15 Megohms	3/4	1/4
766-A	1	47 Ohms to 15 Megohms	1 1/8	1/4
792-A	3	22 Ohms to 150,000 Ohms	1 7/8	15/32
774-A	5	33 Ohms to 220,000 Ohms	2 5/8	15/32

TYPE "CX" RESISTORS

997-CX	1/4	1 to 150 Ohms	21/64	7/64
763-CX	1/2	1 to 47 Ohms	5/8	7/32
759-CX	1	1 to 33 Ohms	3/4	1/4
766-CX	2	1 to 47 Ohms	1 1/8	1/4
792-CX	4	1 to 22 Ohms	1 7/8	15/32
774-CX	6	1 to 33 Ohms	2 5/8	15/32

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ures all difficulty with feedback was overcome so that the dc output and feed wires could be brought into close proximity with the antenna leads and no perceptible reaction occur.

References

1. "Transmission Lines in Radio Filters," Mason and Sykes, Bell Technical Journal, July 1937, page 286
2. "Communication Networks," E. A. Guillemin, page 139
3. "Wide Band Amplifiers," H. A. Wheeler, Proc. IRE, July 1939, page 429
4. "Limits to Amplification," J. B. Johnson and F. B. Llewellyn, Bell Technical Journal, Jan. 1935, page 85

AUTOMATIC CALIBRATION

(*Continued from page* 93)

densers driven by the same main motordrive. A relay type sequence control G operates the adding-machine at the precise instant, by magnetic controls with solenoids operating in accordance with the operated thyratrons. This adding-machine is shown with its special controls at the center of the front rack, at H. The paper tape on which the calibration readings and the interpolation factors are recorded, is shown. The record on this tape is later transcribed (with nine additional intermediate interpolated readings) into the calibration books.

Each dial position record and the time taken by the adding-machine to compute the difference between it and the preceding reading (which represents the interpolation factor) requires two seconds each, so that the motor speed can be selected accordingly.

PROCESS CONTROL METHODS

(*Continued from page* 95)

balance as in Fig. 5. One layer of this strip must be magnetic so that its curvature is at once indicated by an experimentally calibrated ac instrument connected through amplifiers to the series opposing connected pickup coils.

Armature operated units are not the only magnetic pickup instruments used for vibration studies. A moving coil, inertia-operated unit consists of a light wire wound coil on a cylindrical tube supported by springs so as to permit movement in an axial direction. It is damped magnetically at critical mechanical frequency by eddy currents generated in the drum on

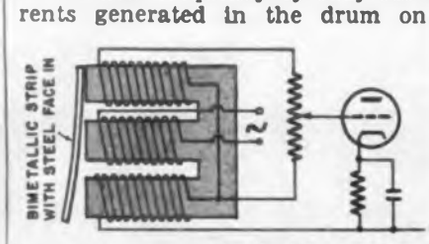

Fig. 5—Temperature-sensitive control unit

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which the coil is wound. The coil moves through a radial field from permanent magnets.

The inertia-type magnetic pickup unit delivers a voltage when subjected to vibration that is proportional to acceleration of motion, which in turn is proportional to the displacement multiplied by the square of the frequency.

This is not exactly the best output characteristic for many studies since high frequency components of the vibrational wave are unduly exaggerated. Ordinarily the whole vibration unit, as a whole, is attached to the device that is vibrating and moves in its entirety, except for a coil which lags behind the rest of the device on account of its own mass. The relative difference of position between the two parts produces a cutting of magnetic flux and hence a voltage.

Another type of vibration unit is the velocity type. Here, for example, the coil is moved back and forth thrcugh a magnetic field by a connecting bar, or prod, touching the machine being tested. The voltage generated depends upon the rate of change of the displacement, or in other words upon the velocity. This is equivalent to a reading indicating the product of displacement and frequency, so here again high frequency vibration components are over emphasized, although not to so great an extent.

In machine design work, it happens that each of these output characteristics is of value. Further it is possible to apply "integrating" networks to an acceleration type unit to produce either of the other forms of output.

In mechanics the force expended "or lost" in producing vibrations is equal to the mass times acceleration, so that an acceleration unit will give an indication of this force directly. In other tests either velocity or displacement may be necessary.

Referring to Fig. 1, the arrangements A, B, and C, might be considered displacement indicating units, item D is a velocity unit, unless the armature is spring mounted and moves back and forth by its own inertia as the whole magnetic structure is vibrated, in which case it gives acceleration values.

The so-called "integrating" network, as in Fig. 6 used in vibration tests for conversion of acceleration

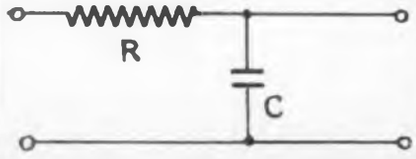

Fig. 6—Electrical integrating network

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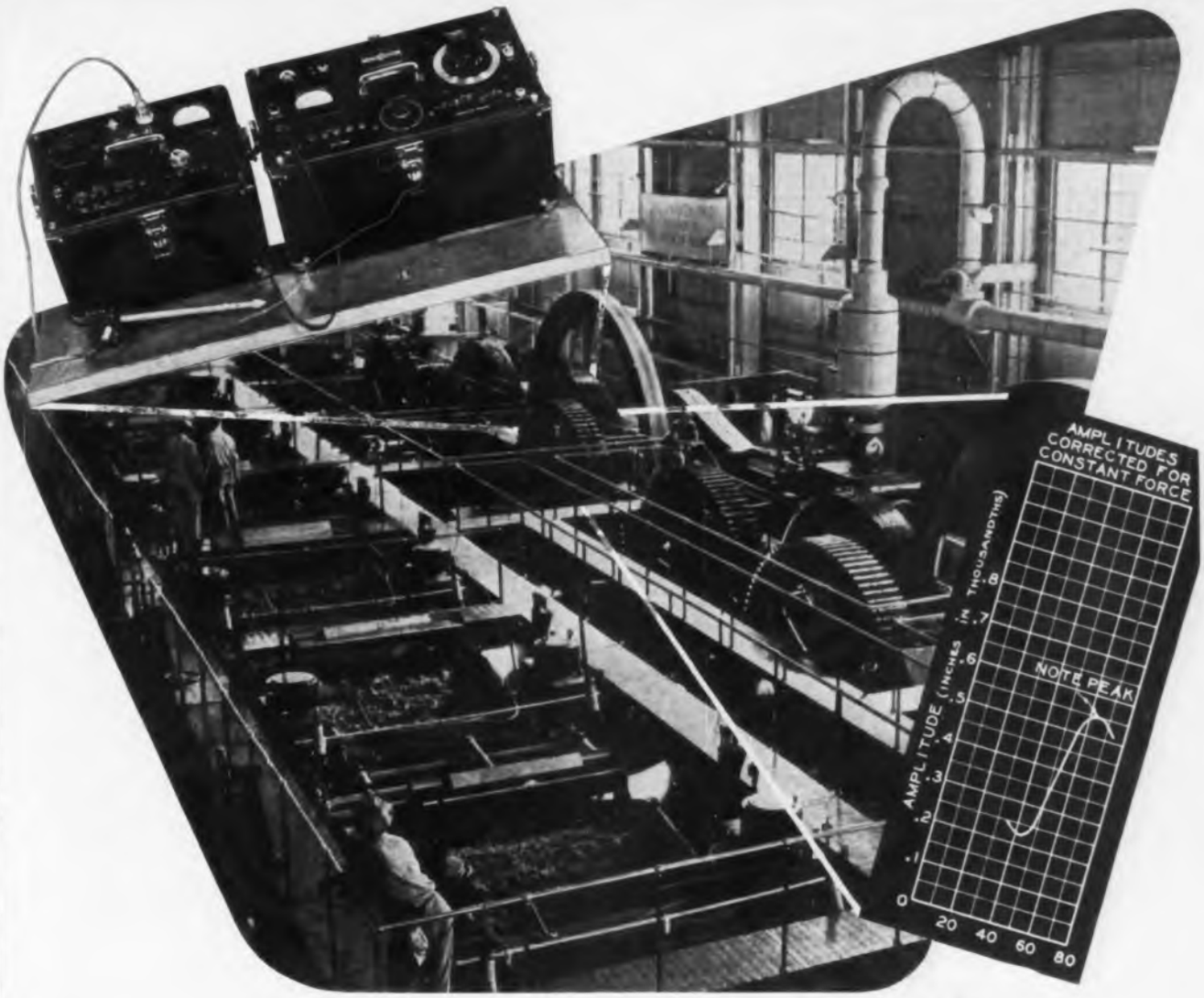

VIBRATION in this Heavy Engine Foundation

Located and Analyzed with General Radio Vibration Meters

VIBRATION in this sugar-cane grinding tandem in the Florida Everglades was sufficiently serious to cause uneven settling of the heavy concrete foundation. The magnitude of the vibration depended upon the speed of one of the three Corliss engines driving the tandem, increasing as the speed increased.

MEASUREMENTS with the General Radio Vibration Meter and Analyzer showed that the frequency of the main component of the vibration corresponded to the single-mesh frequency of the main pinion on the engine. A speed-vibration characteristic, taken over the complete range of operating speeds, showed a pronounced resonance peak at 68 rpm. near top speed. Calculations confirmed the fact that the concrete foundation was in resonance at the gear mesh frequency corresponding to this speed.

ELIMINATION of the vibration was simple, once its nature and source were completely known. The cause was found to be poor gear alignment, resulting in worn gear teeth.

Most vibration problems encountered in industry are simple — when you know the answer. General Radio noise and vibration-measuring instruments are designed to get that answer for you quickly and accurately. Their theory and operation are completely described in "THE NOISE PRIMER." Write for your copy today. **Ask for Bulletin No. 870.**

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to velocity or even to displacement (by using a double stage integrator) is only approximately accurate from a mathematical standpoint. It is theoretically impossible to have mathematically true integration with this circuit and have any output voltage left. Since R and E must both be extremely large, and at low frequencies especially, the unusually large time constant that must be provided, results in such a low output voltage, that carefully designed amplifiers are necessary.

SCR'S MEET TESTS

(*Continued from page* 104)

rendered more susceptible to enemy identification because of its distinguishing characteristics. However, the SCR-299 has rendered yeoman service and was the main means of radio communication between the American forces in North Africa, having covered ranges up to 2300 miles with satisfactory performance.

In the operation of the SCR-399 remote control is provided in the equipment so that the operating position can be separated from the station as far as a mile away. Like the SCR-299, the improved equipment may be operated while in motion. Camouflaging is more easily accomplished as the shelter and installed radio equipment may be removed and set up on the ground as a complete field radio station with all the communications facilities intact.

Separate generator

The detachable trailer which transports a gasoline-driven power generator can be separated from the shelter housing the radio equipment as much as 200 yards away through extension cables. The transmitter and its accessories, together with two standard Signal Corps receivers, operate the chests, spare parts chests and all other equipment necessary to make up a complete mobile radio station, are securely fastened in the shelter.

The radio components are placed on shock-proof mountings to absorb vibrations and throat or lip microphones may be used to permit voice modulations if gas masks must be worn. Two operators sit at the operating chests inside the shelter with all receiving and transmitting controls within easy reach. For the operators moderate temperatures are maintained through the use of an electric heater in cold weather and fans during hot spells.

The SCR-299 helped pave the way for Allied victories in the Mediterranean from El Alamein to Italy. In Africa alone it operated on five networks, including circuits from Oran to England, Gibraltar, Casablanca, Algiers and Accra.

G-E MYCALEX

The development of G-E mycalex, the superior insulator possessing low dielectric power losses at high temperature, is of particular interest to the radio, electronic, industrial control and heating industries.

G-E mycalex has superior electrical characteristics and good mechanical strength. It has a low power factor, high arc resistance, chemical and dimensional stability and a low coefficient of thermal expansion. It is impervious to water, oil and gas and is unaffected by sudden temperature changes. Metallic inserts can be readily molded into the parts.

General Electric is molding mycalex for rectifier seals, brush holder studs, tube bases, switch insulation, structural parts in radio transmitters, arc chutes, relay insulators, terminal insulators and as inserts in die castings and organic plastics. For further information write Section O-249, Plastics Divisions, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

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WIDE READING

(*Continued from page* 122)

Distance Measurements

C. D. Tuska (Journal of the Franklin Institute, January, 1944)

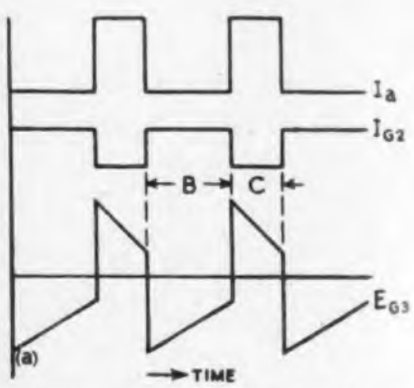
The historical development of the determination of distances by radio waves is traced through technical publications and U.S. patents. The different methods and apparatus are described and explained.

Single Tube Frequency Divider

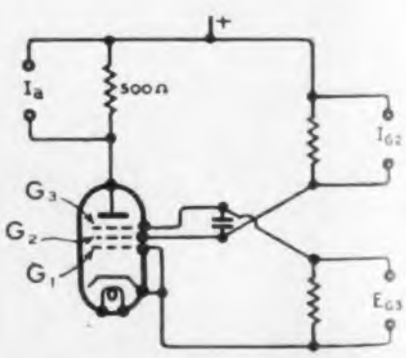
P. F. Cundy (Wireless World, London, November, 1943)

With control grid G_1 connected to the cathode, a constant electron current will be set up in the pentode; the potential at the suppressor grid G_3 will determine how this limited cathode current is divided between plate and screen grid G_2. It will be noted that within a certain range of suppressor grid voltage, the plate current increases and the screen grid current decreases, their sum being constant, when the suppressor grid voltage is made more positive; i.e. plate and screen grid have a normal or inverse characteristic respectively. A potential in phase with the screen grid voltage may therefore be derived from the suppressor grid, providing a source for positive feedback voltages that do not need any phase reversal.

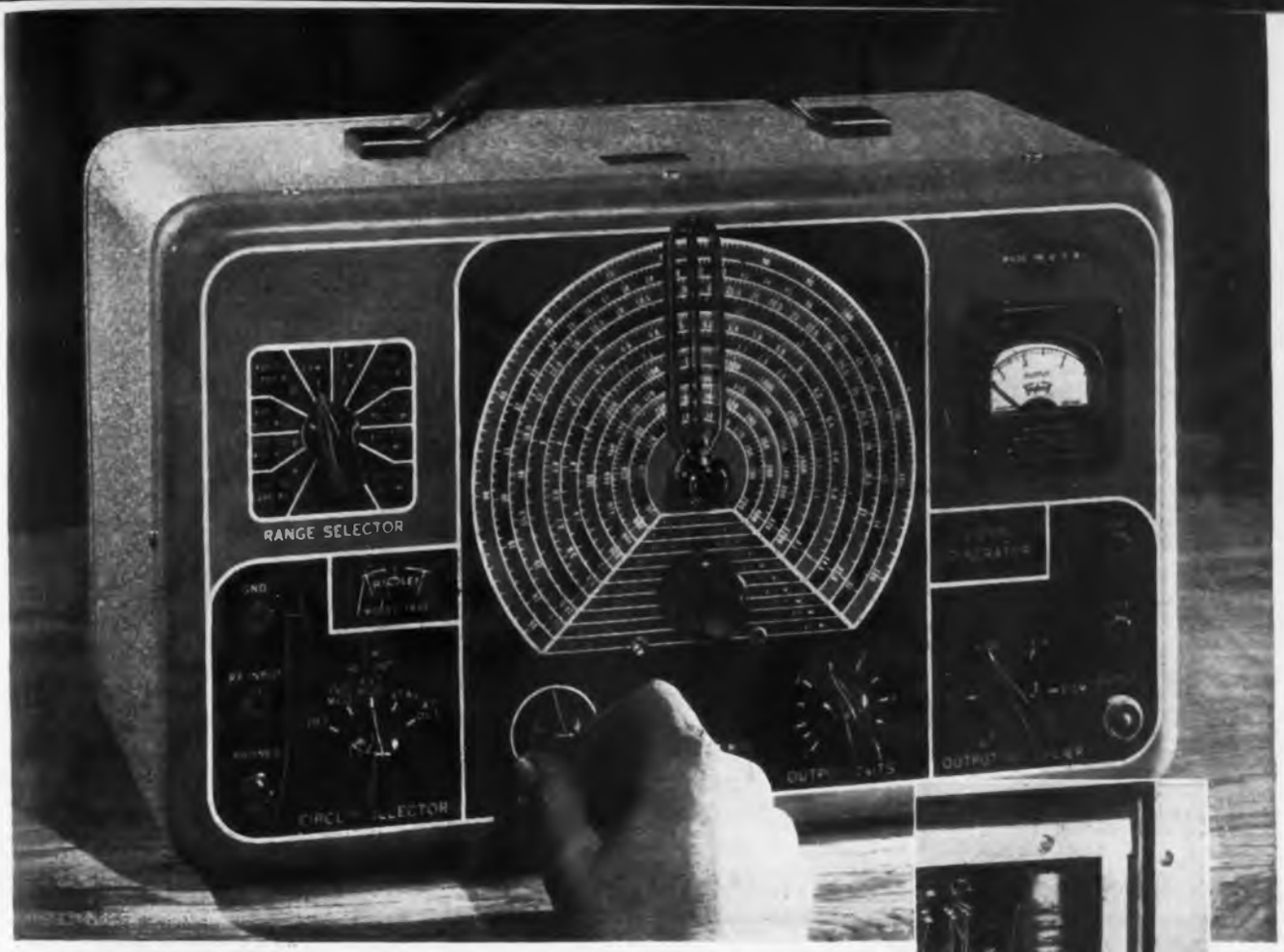
A tube was connected as indicated in the diagram, and the



Voltage-time, current-time diagrams



Single tube frequency divider



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INJECTION MOLDED Sinko PLASTICS

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waveforms shown were obtained with an oscillograph. Starting from a high negative value of E_{g_2}, for sometime all electrons will go to G_2 and none to the plate. As the charge on G_1 leaks away and it becomes more positive, plate current I_a sets in and I_{g_2} rapidly decreases, causing an increase in E_{g_2} and a further increase in E_{g_1}. For the resulting considerably positive value of E_{g_1} all electrons passing through G_2 are accelerated onwards and no further variation in I_a and I_{g_2} occurs. E_{g_1} is held positive by the condenser charge; this leaks away more rapidly than when the grid was negative because, in addition to the current flow through the grid leak, there is also an electron current to the grid. When this charge has fallen to a value causing some of the electrons that have passed through G_2 to be turned back, there will be an increase in I_{g_2}, a fall in E_{g_2}, and G_1 will be driven negative again; plate current will decrease during this period.

Synchronizing signals may be injected either at G_1 or at G_3; G_3 is preferred. Output can be taken from G_2 or G_3, but since G_3 is already in use for the synchronizing signal, G_2 is the only available electrode. The usual buffer stage is necessary to prevent variation in the output circuit constants from upsetting the oscillation frequency or waveform.

The analogy of this frequency divider to the multivibrator and the relationship to the oscillators corresponding to these two circuits is stressed. A three-tube crystal controlled frequency substandard has been constructed. The first tube is a 1000 kc/s-100 kc/s dual crystal oscillator, the second tube is a 5:1 divider which may be switched into the 100 kc/s circuit, and the last tube is a harmonic amplifier.

RADIO PRODUCTION

(*Continued from page* 101)

to require fluid, flexible production schedules and the establishment of new capacities through integrated conversion or expansion projects.

Emphasis on production

The emphasis must now be placed, however, on production. We must not pause to boast of our past miraculous accomplishments, but raise our sights and fully meet the 1944 Production Objectives.

Our Army needs radio and telephone equipment, highly specialized electronic equipment, wire and cable, batteries and electronic tubes. As the invasion of Europe and the real offensive in the Pacific take place, the Communications Production Team must be able to say "We have produced and deliv-

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Today, we have reached the limit of our physical frontiers. But new frontiers lie before us—new opportunities for exploration—in our research laboratories. Here in the multiple world of the electron tube are being born the scientific advances that will make our world immeasurably safer and happier.

Pioneering on this new frontier of research are RCA Laboratories in Princeton, New Jersey. Today RCA Laboratories are devoted to providing the fighting forces of the United Nations with the best radio and electronic equipment available. Tomorrow, this same skill will continue to serve America in creating new and finer peacetime products.

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EASTERN AMPLIFIER CORP.

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ered in time, sufficient communications materiel to meet the needs of our fighting forces on land and sea and in the air."

In retrospect, the Signal Corps Industry Team can be proud of the last six months. We now produce communication equipment and supplies for the Army at a monthly rate approximately two times as great as during the last six months of 1942 and over twenty times that of 1941. Comparing the production of the vastly more complicated and critical military designs to the commercial items of peace years, American "know-how", resourcefulness and mass production methods have literally resulted in miracles. Yet even greater results must be obtained to meet the 1944 requirements. Nothing must be allowed to interfere with achieving this new objective.

In the interest of permanent national economy, it behooves both the Government and industry to establish detailed plans for the colossal task of reconversion to normal production when peace may again come to the world. Basic and concrete actions in this regard are being and will continue to be taken to provide prompt and proper solutions. Industrial mobilization and timely production must, however, remain the supreme job until such capacity is not required for our current or contemplated military actions. No thinking or planning for reconversion can be tolerated if such interferes in the least with our supreme effort of producing and delivering enough communications materiel of the types and quality needed at the times and places required by our gallant fighting forces.

No person or group of persons can tell the future, with or without the rumored Washington Crystal Ball. It is pointed out, however, that communication equipment production will not be affected in the manner and to the extent to be expected of other munitions having no peacetime employment. When Allied success is attained in Europe, we will still require great quantities of communications equipment for administration and rehabilitation activities. We must still supply vast quantities of such materiel to the Pacific and Far East Theaters. After the war, we will need worldwide communications systems and a great deal more domestically.

The Signal Corps has depended on its Team-mate, "Industry." This confidence has not been misplaced. The 1944 production objectives can and will be obtained through the untiring cooperation of all Government agencies, and the industrial personnel of Plant Managements, Engineering, Production, Inspection and the associated suppliers. Our united watch-word is, therefore, "Production."

Electronic Parts: ENGINEERING AND PRODUCTION

The gadget above is a junction box for a co-axial gas-filled transmission line. It is one of a series of coupling units, end seals and other fittings for high-frequency transmission—designed and built by Lapp.

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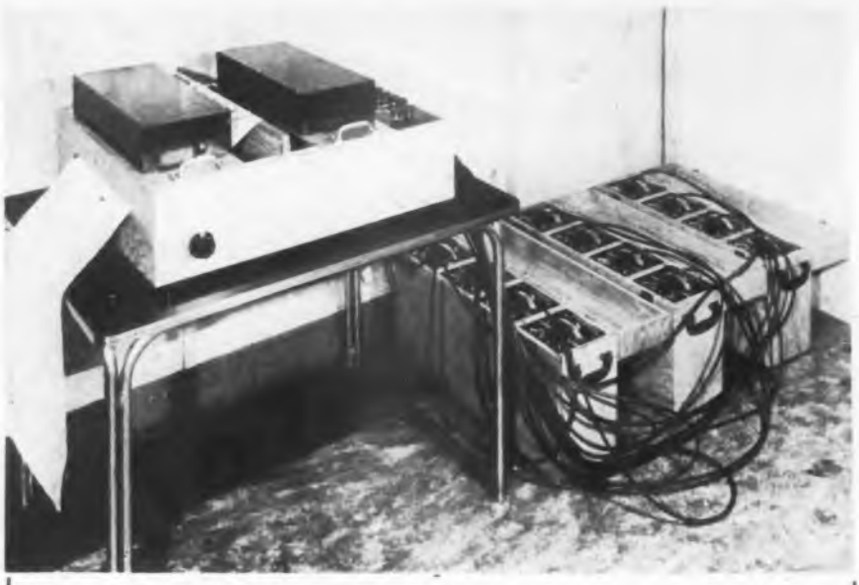
For quick and efficient assistance on a war production subcontract—or for the competitive advantage Lapp-designed and Lapp-built parts will give to you in the postwar battle—an inquiry to Lapp now may pay you dividends. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp



Illustrated above is a thirteen channel instantaneous direct recording oscillograph built to solve a specific recording problem.

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ELECTRONIC INDUSTRIES
480 Lexington Avenue New York 17, N. Y.

SCORING STAGE DESIGN

(*Continued from page* 117)

pose since it is able to vibrate over a wide range of musical pitch, unlike a panel of plaster or fiber board. The energy employed to set the sheet of wood into vibration is partly re-radiated in a manner which need not follow the regular law of equal angle of incidence and reflection. A vibrating surface of this type, because of its size and shape, may therefore emit plain or cylindrical waves even though excited by spherical ones.

3. Provision of a wall or ceiling section which is more absorptive for the low than for the high frequencies. The fact that work is done on the panel in moving it and that sound is radiated from the back as well as from the front describes the splay as a relatively efficient low frequency absorbent. A search through a list of available commercial acoustical materials will readily indicate that practically all of them show higher absorptivities for the mid-range than for the low frequencies. Where it is important therefore to reduce the low frequency reverberation in a room to a minimum, the use of vibrating membranes represents practically the only satisfactory solution.

4. Reduction of interference effect between direct and reflected sound. This effect may be directly ascribed to the longer wave front of the reflected sound from a convex splay, since the energy of a propagating wave front varies inversely with the square of its length.

5. Production of a relatively smooth sound decay curve. This condition can only be attributed to greater diffusion of sound in the room occasioned by surface sources, extended wave fronts and irregular wall contours in general.

6. Erection of reflective surfaces which minimize echo. Next to nonparallel walls, the most economical solution for avoiding echoes in a room consists in the provision of an irregular wall contour, as long as this wall is meant to be kept reflective. Parallel walls can of course be treated acoustically to eliminate echo effects between the surfaces, an expedient which does not readily lend itself to the construction of bandshells which should contain sufficient localized reverberation to allow the musicians to play with appropriate intensity.

In the construction of the bandshell for the second Columbia scoring stage, the effect of the resonant frequencies of the wood splays was carefully considered, and was not held at all detrimental. Splays of this type have many resonant frequencies. These frequencies are not harmonically related, and their amplitude distribution is made up of various modes of vibration. Moreover, modes are not sharply

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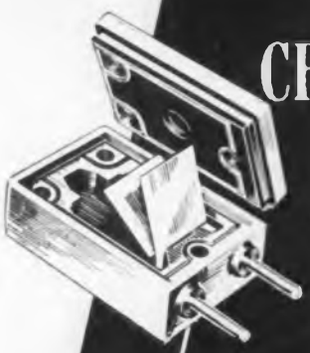

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defined owing to the presence of more than one mode. The only pronounced resonance to which a splay of this type is subject is that produced by the air chamber in back of it. Care was therefore taken to place the curved wood splay against an absorbent wall surface to avoid a so-called "hangover" effect or prolonged reverberation in the space between wall and splay.

As time went on, it developed that in the recording of a vocalist accompanied by a large orchestra, this second stage proved too small to provide sufficient acoustic separation between the vocalist's and the orchestra's microphone. As a result thereof, it was decided during the latter part of 1938 to build within the scoring stage a separate all-enclosed vocalist's room similar to that in a broadcasting station.

Separate vocalist's room

The dimensions of this room were approximately 15 ft. x 18 ft. x 20 ft. It was so constructed that no two opposite walls were parallel to each other, including the ceiling and the floor. In this way echoes and standing waves were eliminated, the reverberation of the room having been adjusted to about .45 seconds as against the reverberation time of the scoring stage itself of .95 seconds. This vocalist's room was set up adjoining the orchestra shell, and monitoring for the vocalist was secured through an adjustable window in the wall between this room and the bandshell.

By the use of un-directional microphones facing away from this monitor window, the vocalist's voice could be recorded with an orchestra level at the ears of the vocalist of about 15 db below the level on the scoring stage, while the orchestra level picked up at the vocalist's microphone was 10 db lower still, or about 25 db below the recorded orchestra level on the scoring stage.

This innovation provided some very interesting features insofar as it permitted the recording of a singer and the orchestra on independent channels with practically complete acoustic separation to the point where either the vocalist's voice or the orchestration could later be replaced by another, if necessary. This development led to the evolution of a multi-channel scoring setup by means of which three sound tracks can be recorded simultaneously by one mixer in the following manner: As shown on the schematic of Fig. 2, the microphones in the vocalist's room are brought into a mixer panel from where the output goes directly into the vocalist's recording channel to be properly equalized and amplified before delivery to the film record-

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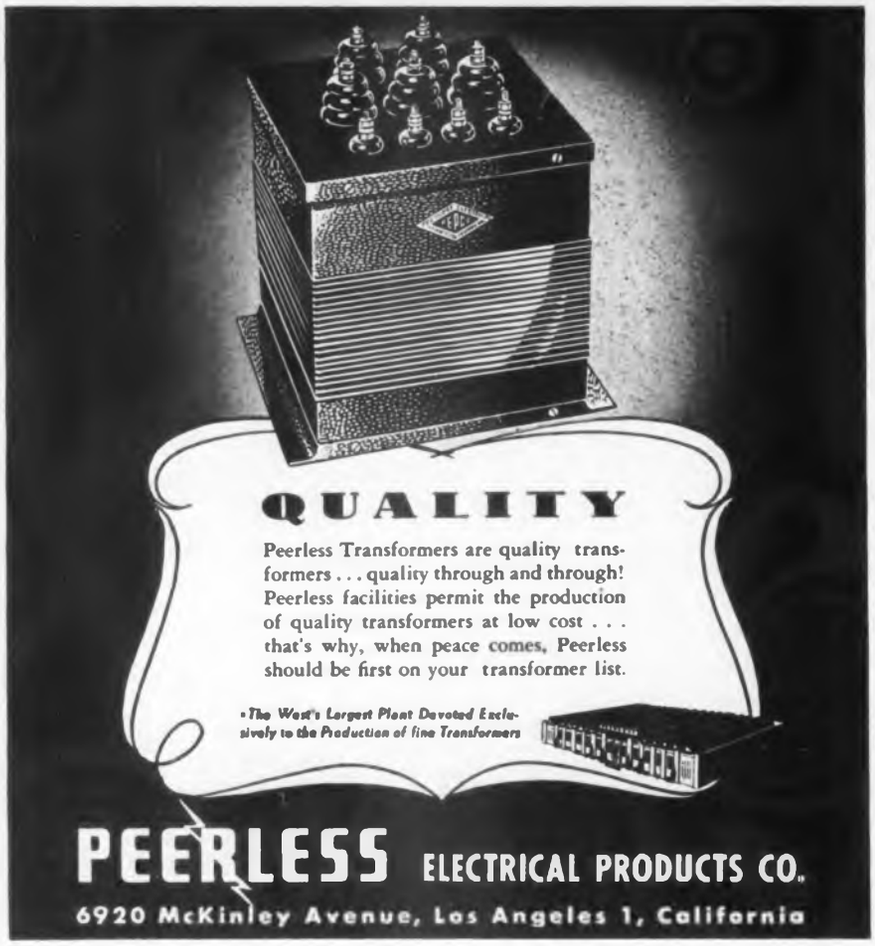

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ing machine. Similarly, the various orchestra microphones are fed into an adjacent mixer panel, the corresponding outputs of which are similarly routed to the music channel for proper equalization and amplification before delivery to the recording machine.

Two volume indicators bridged at the bridging bus of the vocalist and orchestra are carried back to the mixing panel for indication of recorded signal strength in each channel. A bridging amplifier from the music channel feeds back the output at the music bus to the mixer where the gain of this bridging amplifier is neutralized and where its output can be reduced by a subdial installed alongside the inclusive volume dial of the music mixer panel.

The output of this special dial is delivered to the amplifier room where it is combined with the output of a bridging amplifier from the vocal channel. This combined output feeds a third bridging bus adjusted to a level of 2 db lower than the buses of the vocal and the orchestral channels. The third bridging bus supplies monitoring level for the mixer, feeds the bridging amplifier of a third recording machine in which the combination of vocalist's and orchestra's output is recorded, and also provides signal level for an acetate playback machine.

Music level reduced

Examination of this arrangement shows that the mixer may reduce the music level to the barest accompaniment requirements for the vocalist's voice, while simultaneously he can provide a level in the orchestra channel which is satisfactory for re-recording purposes later. This scheme, in addition to providing separate sound tracks for the vocalist and the band, also secures a sound track containing a combination of the two which is approved by the musical director but does not bind the Music Department to retain the balance obtained during the scoring session as it permits the re-interpretation of the musical rendition at a later date during re-recording. This is quite important because at the time of pre-scoring it is frequently very difficult to know how a musical sequence will be handled later since it is almost impossible to anticipate the requirements for pictorial perspective.

It is also evident that one mixer actually serves the purpose of three, resulting in economy of production. Furthermore, the vocalist's booth saves considerable scoring time by providing fixed conditions under which the vocalist is recorded. In addition to the above, by the ability of establishing the de-

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sired reverberation time in the vocalist's booth, it is possible to preserve the speaking characteristic of the vocalist's voice and not to cause an undesirable difference between his recorded speech on the production stage and his singing voice on the scoring stage.

METALLURGICAL RESEARCH

(*Continued from page* 114)

temperature schedules or programs. With the controllers using milliammeters to activate the controller circuits, the arm carrying the oscillator coils is coupled to a shaft activated by a motor-driven cam. The cam can be cut to produce any desired motion of the arm in the milliammeter; thus the controller will operate to maintain the furnace temperature at a value determined by the cut of the cam.

In the potentiometer-type controller a similar cam arrangement is used to rotate the slide on the potentiometer slide wire, the voltage being varied to correspond to the desired temperature. With the resistance-type controller, one arm of the bridge circuit is varied so that balance will occur at the desired temperature.

In the apparatus illustrated in Fig. 2, the unit shown on the lower left side of the picture is a temperature controller of the type illustrated in Fig. 4. The unit above it contains the program controls. In this apparatus, a motor-driven auto-transformer and the temperature controller and program controller are used to maintain a temperature rise in a small furnace of 5 deg. or 10 deg. C. per minute throughout a temperature range of 100 to 1000 deg. C.

Displacement measurements

In metallurgical work, the measurement of changes in length and displacements frequently is more important than the exact measurement of absolute lengths. Examples of this are dilatometer measurements, stress-strain curves, modulus measurements, vibration measurements, and damping-capacity measurements. Mechanical gages are available for making these measurements and are sufficiently accurate where large changes or amplitudes are involved, but for small changes electronic methods are very useful.

Changes in length have been measured by a special circuit[2] for converting the capacity changes into corresponding electrical currents suitable for measurement and recording. The basic circuit of this converter is shown in Fig. 6. It consists of two oscillators, A and B, very well isolated and shielded from each other, and a coupling

circuit by means of which energy can be transferred from one oscillator to another. The oscillators are of the ordinary tickler feedback type and operate at a frequency of approximately 1,000 kilocycles. The coupling circuit consists of two coils L_1 and L_2 closely coupled to the oscillator tuning coils, a rectifier tube V_1 and a direct-current milliammeter M_1. The rectified direct current is indicated on M_1, and the stray capacity in V_1 and M_1 (C_1) serves as a path for the high-frequency current.

These oscillators operate very much like two alternating-current generators in parallel. If both are timed to exactly the same frequency and the couplings between the oscillators and the coupling circuit are equal, no current will flow in M_1. If the normal frequency of either oscillator is changed slightly by changing its tuning capacity, energy will be transferred from one oscillator to the other to keep them synchronized, and current will flow through M_1. Thus over a considerable range of capacity above and below the value corresponding to identical normal frequencies for the two oscillators, they will continue to oscillate at the same frequency and the current in M_1 will vary approximately in proportion to the deviation of the capacity from its normal value.

Current-capacity method

The actual variation of current with tuning capacity is shown in Fig. 7. The current rises rapidly on each side of a minimum value, and for values of capacity below or above the limits shown the oscillators will not remain synchronized and the current will drop suddenly. The minimum current is not zero, as it theoretically could be because the oscillator circuits and their coupling to the synchronizing circuit are not identical and some unbalance is always present.

It can be seen that the portion of the curve on the high-capacity side of the minimum current point is essentially a straight line for a wide range in current and capacity values. By operating in this range, we can obtain a current that is proportional to capacity. In studying any phenomenon that can be reduced to a capacity change, it is only necessary to connect this changing capacity in parallel with one of the oscillator tuning condensers, and the current in M_1 will change in proportion to the changes in capacity. If a changing voltage is desired rather than a current, a series resistor can be placed in the synchronizing circuit without changing operation of the converter, if the resistance is not too high.

With units like this, current ranges from 5 to 50 milliammeters can be obtained with a sensitivity of 2 milliamperes per micromicrofarad with the normal synchronizing circuit and 1.5 milliamperes per micromicrofarad with a 1000-ohm resistor in the synchronizing circuit. This unit has several important advantages:

1. The shape of the current-capacity curves and the sensitivity can be readily controlled.
2. It is simple to operate.
3. It will respond to changes in capacity having frequencies from zero to several hundred kilocycles per second.
4. It has low background voltage, the internal noise being approximately 0.003 volt across 1000 ohms.
5. It is free from interference by local magnetic and electrostatic fields as long as their frequencies differ appreciably from the resonant frequency of the oscillator circuits.

Instruments using the converter circuit described above have been made for both direct-current and alternating-current operation and used for dilatometric and strain measurements, but the advantages of the electronic circuit are most pronounced where vibration, modu-

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The Center Scope enables the operator to easily and quickly locate edges to a spindle axis, set-up faster and compensate for run-out. It saves vital hours in checking, inspecting and measuring when mechanical methods and tools are impossible to use. Its 45 x magnification allows operator to see ".001" and requires no technical knowledge or training to operate.

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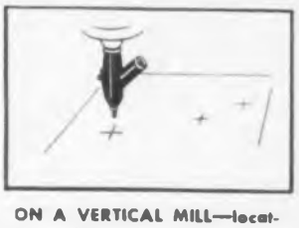
You can get complete information from the Center Scope Instrument Company, 351 S. LaBrea Ave., Los Angeles, Calif., or Kearney & Trecker Products Corporation, Milwaukee, Wis.



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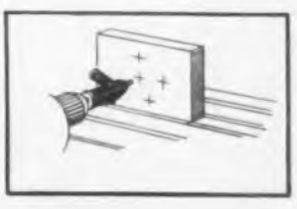

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Constant inspection controls over materials, parts and sub-assemblies guarantee perfect operation from each finished product.

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RADIART VIBRATORS and VIPOWERS justify these rigid production standards by their exceptional performances under severest battle conditions.

Radiart Corporation

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How to Keep Electronic Equipment Operating at Peak Efficiency . . .

Rx Keep Tubes Cool with Pilot Blowers

RADIO and Electronic equipment operates most efficiently when excess tube heat is reduced. This is where PILOT BLOWERS enter picture. Compact, efficient, quiet—these Blowers keep tube-generated heat on the move. Available in five standard sizes with output ranging from 49 to 106 C.F.M. With custom-built F.H.P. Motors—15 to 120 C.F.M. Write for detailed information.

F. A. SMITH MFG. CO., 901 Davis St., Rochester 5, N.Y.

Pilot BLOWERS

MADE BY THE MAKERS OF THE FAMOUS PILOT FRACTIONAL H P MOTORS

lus, and damping-capacity measurements are involved.

Damping capacity or the rate at which vibrational energy in a body is converted into heat is a characteristic of the material. It can be expressed quantitatively in a number of ways, but the term "specific damping capacity"[3] is the only one we will discuss here. This term is defined as the ratio of the energy lost in a body as heat, when it is subjected to a cycle of stress, to the potential energy stored in the body at maximum stress, and it is usually expressed in percentage. On this basis, lead will have a "specific damping capacity" of 10 to 20 per cent, while steel and brass have values of approximately 0.01 per cent.

One type of apparatus used for making damping-capacity measurements at high stresses (greater than 100 p.s.i.) is shown in Fig. 8. In this apparatus, a specimen with square ends and a round center portion is clamped at its lower end in a metal frame securely fastened to a large cement block. The frame and specimen can be seen to the right in Fig. 8. A metal bar also visible is clamped to the upper end of the bar. The bar is twisted enough to stress the specimen to any desired value by two electromagnets and released suddenly. The motion of the bar is recorded, and the rate of decay of the oscillations is determined. From these data the damping capacity can be calculated.

The motion of the bar and specimen is recorded by means of the converter circuit described. Two triangular electrodes are mounted from the rigid frame by insulators and adjusted so that they are close to the top of the bar. Any motion of the bar changes the capacity between the bar and the electrodes, and this capacity change is converted into a current in the converter and recorded on an oscillograph. An alternating-current-operated converter is seen in the upper center of Fig. 8, and the recording oscillograph is in the lower center of the picture. A cathode-ray oscillograph shown in the left of the picture is sometimes used for recording and measuring the motion.

A type of instrument used for measuring damping capacities at low stresses (below 100 p.s.i.) is shown in Fig. 9. In this case, the specimen is bent flexually by the electrostatic force between itself and the driver electrode. The pick-up electrode and the specimen are connected to the converter and hanging current or potential produced by the motion of the specimen is measured on a cathode-ray oscillograph. Sometimes it is necessary to amplify this output as much as 50,000 times before it can be readily measured.

(Turn page)

Suppose you said—
"Let there be No Red Cross!"

SUPPOSE you turned your face away . . . suppose you said, "I have done enough." . . .

Suppose there were no blood centers . . . no plasma for the wounded . . . suppose there were no Red Cross rest homes . . . no bed for your boy when he is furloughed from the front. . . .

No "coffee and" at the end of a long march, no cigarettes, no magazines, no books in the hospitals behind the lines. . . .

Suppose our men in enemy hands received no weekly food packages . . . suppose they were left to scrape along, living on alien bread. . . .

Suppose there were no Red Cross to march beside our men in every land . . . no helping hand to do a mother's work. . . .

Then could you sleep at night?

You, with a son in the service?

• • •

When you say, "Thank God for the Red Cross!" remember this . . . It is *your* Red Cross . . . *your* bandage and *your* blood.

Yes, and your money, too!

Of course, you have given before, generously and from your heart. Of course, you will give again . . . you who have always given for others.

But this year, when the need is greater than ever before . . . When it is *your own sons* we serve . . . This year, when you figure how much to give, think first, "Suppose there were no Red Cross?"

Then dig deep and be glad. For wherever he is

The RED CROSS is at his side
and the Red Cross is YOU!

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The advantage of the oscillator-converter circuit is well shown in this application. The potential between the driver electrode and the specimen may be 300 to 400 volts, but the pickup circuit connected to the pickup electrode is so insensitive to external fields that no interference is obtained, even when the output of the converter circuit is amplified as much as 50,000 times.

In making these low-stress damping measurements, the specimen is usually driven at its resonant frequency, making it possible to determine the modulus of elasticity. The formula for calculating the resonant frequencies of bars of regular section is well-known, so it is only necessary to know the density, dimensions, and resonant frequency of the specimen in order to calculate the modulus of elasticity.

The use of such electrostatic pickups and the converter circuit in many other problems involving vibration measurements can be readily visualized but no further discussion of these uses will be given here.

---

[1]Published by permission of the Director, Bureau of Mines, U. S. Department of the Interior.

[2]Potter, E. V., "An Electrical Transducer Circuit for Use with Capacity Pick-Up Devices": Bureau of Mines R. I. 3685, 1943, 7 pp.; Rev. Sci. Inst., Vol. 14, No. 5, May 1943, p. 130.

[3]Dean, R. S., Anderson, C. T., and Potter, E. V., "Alloys of Mn and Cu, Vibration Damping Capacity," A. S. M., June 1941, pp. 1-14.

Hardwick Joins IRC

International Resistance Co., Philadelphia, has added A. H. Hardwick to its executive sales staff. Mr. Hardwick is well known throughout the radio and electronic fields, having been directly associated in the resistor industry for the past 16 years with Hardwick, Hindle, Inc., Newark, N. J., whose presidency he relinquishes to assume his new duties.

Army-Navy E Awards

Automatic Electric Company, 1033 W. Van Buren St., Chicago, Ill. (fourth time).

Admiral Corp., 3800 W. Cortland St., Chicago 47, Ill.

Henry L. Crowley & Co., Inc., 1 Central Ave., West Orange, N. J.

Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.

Sylvania Electric Products, Inc. (3 plants), the Loring Avenue, the Boston St., Salem, Mass., and Danvers, Mass., plants.

Tung-Sol Lamp Works, Inc., 95 8th Ave., Newark, N. J.

United Electronics Co., 42 Spring St., Newark, N. J. (star added).

DRAFTSMEN

with 3 to 5 years' experience

Offered excellent opportunity with one of America's foremost electronic laboratories. Some electronic experience required. Essential workers need release.

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Free transportation from Little Neck station, Northern Boulevard & Jericho Turnpike.

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GLASS "V" BEARINGS
made to your specifications

ARMY E NAVY

We welcome your inquiries

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RICHARD H. BIRD

Manufacturer of Jewel Bearings for thirty years

23 MOODY STREET
WALTHAM, MASS.

Dr. Burnstan Heads Lawrance Aeronautical

Lawrance Aeronautical Corporation, Linden, N. J., manufacturer of auxiliary electric power supply for aircraft and surface craft (formerly Lawrance Engineering and Research Corp.) announces as its new president Dr. Rowland Burnstan who joined Lawrance Aeronautical in 1943 as executive vice president and general manager. He started in the exporting business with Lee and Villela (South America) but in 1927 he was appointed research economist with the New York State Commission for Revision of the Tax Law. In 1930 he went to the University of Heidelberg as a lecturer on economics. A year later he returned to become economist with the U. S. Department of Commerce. In 1931 he went with Armour & Company as director of marketing research, and later served as business manager of the Chicago Times and as professor of economics of Carleton College, Northfield, Minn. From 1941 to 1943, Dr. Burnstan was Director of Aeronautical Division, Minneapolis - Honeywell Regulator Company. In 1942, he served with the 8th U. S. Air Force and the R.A.F., as technical consultant on the automatic pilot.

Charles L. Lawrance, organizer and president of the company since 1930, has become Chairman of the Board.

Universal Re-christined

Universal Microphone Co. is the new name of Universal Microphone Co. Ltd., Inglewood, Calif. The president and vice-president of the corporation, James L. Fouch and Cecil L. Sly, who were also principal stockholders, have organized a partnership and taken over the assets and liabilities of the (1928) Universal Microphone Co. Ltd. Durwood D. Allen is secretary.

Whitmore to Kold-Hold

H. W. Whitmore has been appointed chief engineer of the Kold-Hold Mfg. Co. of Lansing, Mich., according to a recent announcement by James R. Tranter, president. He succeeds R. H. Swart.

Mr. Whitmore comes to Kold-Hold from the Automatic Products Co. of Milwaukee, where he was for two years. Prior to that time he was associated for ten years with General Refrigeration Division of Yates American Machine Co., Beloit, Wis.

Kold-Hold Mfg. Co. makes sub-zero and dual temperature processing and testing equipment as well as cold plates and lowsides for transportation of perishables.

Bendix Promotes Hilliard

W. P. Hilliard has been appointed general manager of the Radio Division of the Bendix Aviation Corp. with plants at Baltimore and Red Bank, N. J. He succeeds Hugh Benet who is assuming a special assignment.

Hytron Adds Plant

Hytron Corp., Salem, Mass., has increased its output more than five times since June, 1942, and has recently acquired a feeder plant at Beverly, Mass.

The new plant will employ several hundred persons, concentrating upon the production of electronic tube "mounts" (completed assemblies of internal parts). This plant will serve as a "feeder" for the Salem factory.

"E" Award to Erco

Erco Laboratories, Hempstead, N. Y., was awarded the Army-Navy E, first of March, marking the first time the U. S. Coast Guard has so honored any manufacturer. The company manufactures a variety of communications and other equipment for the Coast Guard and the Army.

PULSE GENERATOR

If you work with pulses in any form, could you use a pulse generator? A wartime development is now available on a priority or directive orders.

SPECIFICATIONS:

Pulse Characteristics. D.C. pulses, positive or negative, suitable for many direct engineering measurements and observations, and for pulse modulating an R.F. signal generator.

Pulse Duration. Continuously adjustable (direct dial calibration) from 0.4 to 14.0 micro-seconds.

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Repetition Rate. Two rates, 500 and 5000 per second, on an internal oscillator, 50 to 20,000 per second with external audio oscillator.

Pulse Form. The leading and trailing edges of the pulse each consume about 0.15 micro-seconds.

Output Impedance. 100 ohm termination on 3 foot cable.

Other Features. Sine sweep and expanded sweep voltages available for oscilloscopes. Synchronizing pulses for oscilloscopes with slave sweeps. Marker circuit for calibration check. For 115-125 volts 60 cycle supply.

Price. $800. complete, FOB Buffalo, N. Y.
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For Full Information, Write for Bulletin No. 700-A.

COLONIAL

COLONIAL RADIO CORPORATION
BUFFALO 7, N. Y.

How much gross business could you do?

One great characteristic of the successful American merchant is that he is never satisfied. Never satisfied with his sales figures . . . never satisfied with his merchandise. Always on the search for more desirable merchandise . . . and for greater sales.

THE greatest piece of merchandise on the market today is the War Bond. And American merchants have done a magnificent job in selling them! A national 5¢–10¢ chain store company sold $53,464,389 in War Bonds and Stamps in 1943. A New York Department store with a volume in excess of $10,000,000 sold War Bonds in 1943 equivalent to 40.6% of their total merchandise sales.

Your War Bond sales figures may not rank with these in *amount*. But there's no reason why you can't top these figures percentage-wise! It's just the old story of getting behind the merchandise—and selling harder! A shrewd merchandiser in Kentucky devoted his entire 1943 advertising lineage — 348,000 lines—exclusively to pushing the sale of War Bonds.

Mounting War Bond sales will bring this war to a victorious close just that much the sooner! But there's another side to the picture, too. Stable, *profitable* trade after the war demands a *stable* buying public. 'Flash-in-the-pan' buying harms *everybody*—the buyer, the merchant, *and our country!* But a solvent, thrifty, bond *holding*, buying public that fills its actual needs—*and keeps on filling them year in and year out in ever greater volume*—is the soundest possible foundation for successful commercial enterprise.

How much gross business COULD you do?—In War Bonds, we mean?

WAR BONDS TO HAVE AND TO HOLD!

How Many Bonds Are You Selling?

If your bond sales approach, or exceed, 250 pieces a month, and you are not already an Issuing Agent for United States War Bonds, we suggest that you discuss the matter with your Federal Reserve Bank. If your bond sales are running at a lower rate, your own bank can probably arrange to have you appointed a sub-issuing agent.

LET'S ALL BACK THE ATTACK... WITH WAR BONDS!

The Treasury Department acknowledges with appreciation the publication of this message by

ELECTRONIC INDUSTRIES

This is an official U. S. Treasury advertisement—prepared under auspices of Treasury Department and War Advertising Council

When days of Peace return, our increased facilities and manpower will not only continue in the production of better Radio and Automotive equipment, but will also turn to pioneering other developments to make the post-war period worth while fighting for—Patience—please.

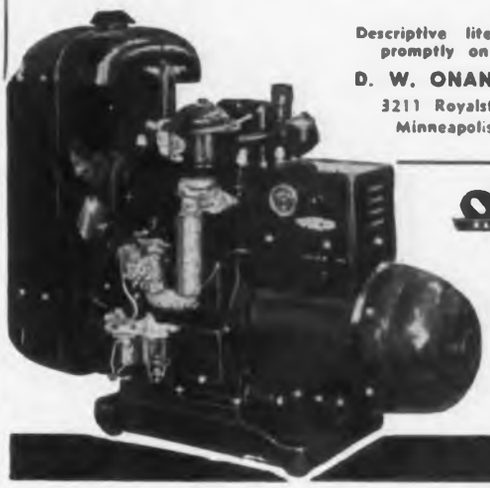
ANTENNAE and Associated Products

ELECTRICITY
For Any Job . . . Anywhere

★ For a dependable source of electricity for electronic and radio applications remote from commercial power, Onan Electric Plants are proven leaders in the field. More than half of the armed Forces' total requirements for Power Plants are built by Onan.

Gasoline-driven. . . . Single-unit, compact design. . . . . Suitable for mobile, stationary or emergency service.

Over 65 models, ranging in sizes from 350 to 35,000 watts. 50 to 800 cycles, 110 to 660 volts, A.C.—6 to 4000 volts, D.C. — Also dual A.C.-D.C. output types.



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Development and design work in transformer applications for radar, lighting, power, etc. Also junior engineers for drafting and layout. 100% war work. Excellent post-war potential in research laboratory or sales engineering department. If you are not utilizing maximum skill at present position apply by letter at once.

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SIGNAL *Offers*
A NEW SERIES OF
NEON PILOT LIGHTS
(INCORPORATING G E OR WESTINGHOUSE NEON LAMPS)

We manufacture a complete line of Pilot Light Assemblies for every possible use in Aircraft, Marine, Radio, Electronic and Electrical apparatus. Send sketch for prompt estimates and suggestions.

ASSEMBLIES COMPLETE WITH LAMPS:
We can supply any G.E. or Westinghouse Lamp together with the required Pilot Assembly, thus saving time in your production schedule . . . Write for samples.

Illustrated: (A) Neon Pilot Light with full-view plastic head. (B) Neon Pilot Light with dome lens. Lamps removable from front of panel.

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New INLAY PROCESS

Eliminates Name Plates on Front Panels

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1. **Inlaid baked enamel characters, protected by background finish; resistant to abrasions and salt spray; guaranteed to pass 50 hour salt spray test.**
2. **Front panel will match finish of cabinets.**
3. **Recommended and endorsed by scores of manufacturers of electronic, sound and communication equipment.**

PROMPT DELIVERIES *Send us the bare steel fabricated and within two weeks we will return it finished and marked to your complete satisfaction.*

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See our "Silk Screening" Announcement on Page 231

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Interphone Equipment and Component Parts

NOW IN PRODUCTION

CD-318-A	JK-48	PL-68
CD-307-A	PL-47	"A" Plug
CD-874	PL-54	BC-366
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JB-47	TD-3	

TRAV-LER KARENOLA

RADIO AND TELEVISION CORPORATION

1032 W. VAN BUREN ST., CHICAGO 7, ILL.

Philips Opposed Argentinian "Radar"

An attempt has been made Argentina by two individuals (Ju del Valle and Salvador Smilovitc to register "Radar" as a tradema for radio sets and radio tubes. I asmuch as this is a descripti word in common use, oppositi was filed by Philips Argentina S de Lamparas Electricas y Rad and it is expected that the reg tration will not be granted. Phil acted in the general interest of t whole radio industry, and was t only company to file such a pr test, it is to be noted.

Philips Argentina has also fil opposition in cases where attemp were made to trademark combin tion words including "radar."

Lip-Mike in Submarine Broadcast

CBS' traveling interview progra provided an innovation, March when Parks Johnson took "V Pop" to Groton, Conn.

Mr. Johnson used the Arm new lip microphone while int viewing submarine builders at t Elco plant in Groton. He and interviewees over-rode the ro and din of the shipyard throu use of the lip microphone wh fits on the user's lips like a mo tache and has won the servi man's sobriquet: "Little Shick gruber," because of its effect up the wearer's appearance.

In war, the lip-microphone ready has been used in tanks, an artillery fire and near any no centers of operation. It fits und a gas mask and weighs less th 2 ounces.

Electronic Heating Standards

Electronics Section of Natio Electrical Manufacturers Assoc tion has adopted some standa for electronic equipment used induction and dielectric heati The following output ratings equipment are to be preferred: kw, 1 kw, 2 kw, 5 kw, 10 kw, 20 kw kw, 100 kw, 200 kw. Tubes and oth component parts are to be u within the manufacturers' rating is recommended that equipment arranged to minimize radio int ference; that equipment be bu to include protection for the op ating personnel, as well as a quate protection in the form fuses, circuit breakers, etc. Ind tive heating, it is set forth, "is heating of a nominally conduct material due to its own I^2R loss dielectric heating is the heating a nominally insulating material d to its own dielectric losses."

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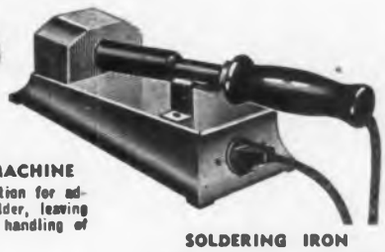
SOLDERING IRONS

are widely used in industrial plants throughout the country. They are designed to withstand the strain of continuous service required of factory tools



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designed for treadle operation for advancement of iron and solder, leaving operator's hands free for handling of product.

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prevent overheating of soldering irons between soldering operations. Irons do not deteriorate when being used. The idle period causes oxidation and shortens life.

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ruggedly constructed pots of various sizes designed for continuous operation and so constructed that they are easily and quickly serviced, should elments have to be replaced.

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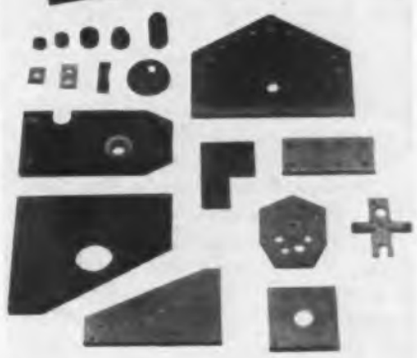
SKILL that saves you **TIME • MONEY WORRY!**



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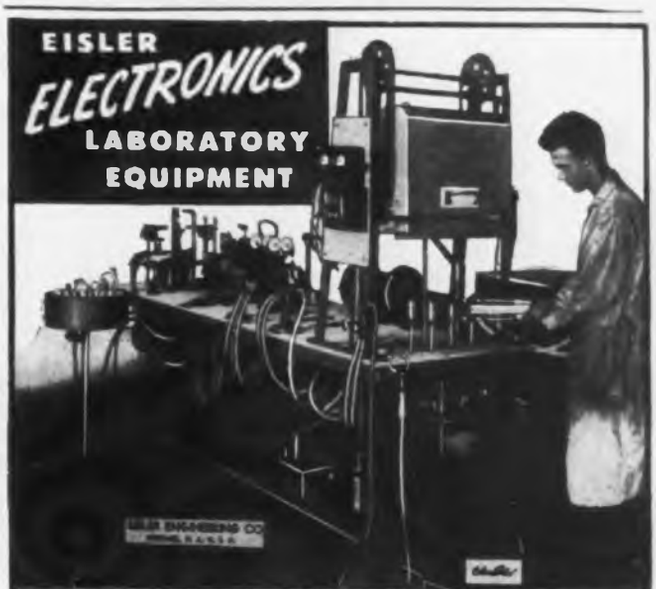
LABORATORY EQUIPMENT



This electronic tube making unit fills the needs of schools, colleges, experimental and research laboratories for a compact machine complete in itself and capable of performing all operations required in the construction of incandescent lamps, radio tubes, electronic tubes and similar devices.

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Send for samples and price list. Give priority, whether under MRO or numbered war contract and whether for assembly or maintenance.

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SIMPLE AS A B C

READY TO USE

PEEL OFF STRIP

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E-Z Code LABELS
QUICK-EASY TO APPLY AND READ

Electrodes for Crystals

BUTTON TYPE. FLAT OR STEPPED TYPE

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SQUARE, OBLONG AND ROUND

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CLOSEST TOLERANCES

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EXCELLENT FINISH

MINIMUM LAPPING
GREAT SAVINGS IN MAN HOURS AND COSTS

PROMPT DELIVERIES

Send for full information

Gemex Company
UNION, NEW JERSEY

Availability of Beryllium-Copper

A memorandum from Major R. A. Walker, office of the Chief Signal Officer, Signal Corps, indicates beryllium has become freer during the past year. The supply of beryllium-copper is now adequate for all essential Signal Corps requirements. This does not mean that beryllium-copper sheet and rod may not at times be difficult to obtain in thin sections because of fabrication delays. It should be used in all applications, in manufacturing communications equipment, where its particular properties make it the best material for the use.

Where nickel-silver or bronze have been used in lieu of beryllium-copper to the detriment of the optimum performance of the equipment, reversion to beryllium-copper should be considered by the manufacturer. It should not be used where the performance of less scarce material would be entirely satisfactory.

It is requested that each new or increased use of beryllium-copper, including reversions, be reported to the Resources Branch, Production Division, Office of the Chief Signal Officer, Washington 25, D. C. in order that the necessary coordination and evaluation may be effected.

N. A. Philips Executives

Left, Pieter van den Berg, vice-president and general manager, and right O. M. E. Loupart, executive vice-president, before a symbolic mural in Philips Company's new showroom, 100 East 42nd St., New York 17, N. Y.

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Variable Condenser Engineers

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Mechanical Design
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If you are experienced in one or more of the above, and are not now using your highest skill in war work, we are interested in hearing from you. Give full details of your experience and qualifications. These are permanent positions and salary will be commensurate with ability.

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Limit Reconversion to Prevent Unfairness

Because of the mushroom growth of the electronic-radio industry to meet the tremendous war production requirements of the past two years, many authoritative sources in Washington feel that the industry will have to be realigned sharply in the postwar period. This is felt to be particularly true in the case of manufacturing companies which were enrolled from other fields of industry to make standardized components and parts and in many such cases it is felt that these companies will voluntarily return to their former sphere of production or be forced back into it.

Another view was given recently by one of the top executives of a leading electronic manufacturing company who felt that integrations and mergers of concerns in the electronic field along vertical lines will have to result after the war and that programs of smaller companies joining together for common purchasing of raw materials and a combined distributing organization should be evolved.

To prevent companies which are released from war production ahead of their competitors from re-entering civilian lines with an advantage, the War Production Board is now studying a program under which such companies as are allowed to return to civilian production will be limited in output to the amount of goods they sold in 1939 or 1940. This limitation would be brought about through the allocation of raw materials and metals to these reconverted companies.

Carrier-Frequency Pioneer

J. S. Jammer has been appointed general commercial director of Federal Telephone & Radio Corp., IT&T manufacturing affiliate. Mr. Jammer created by hand the first telephone carrier system at the research laboratories of Western Electric in 1918

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.001	.0008	.0005	.00025
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in regular mica foil capacitors, 5 & 10% Tolerance, manufactured in accordance with American War Standards to meet Army and Navy Specifications.

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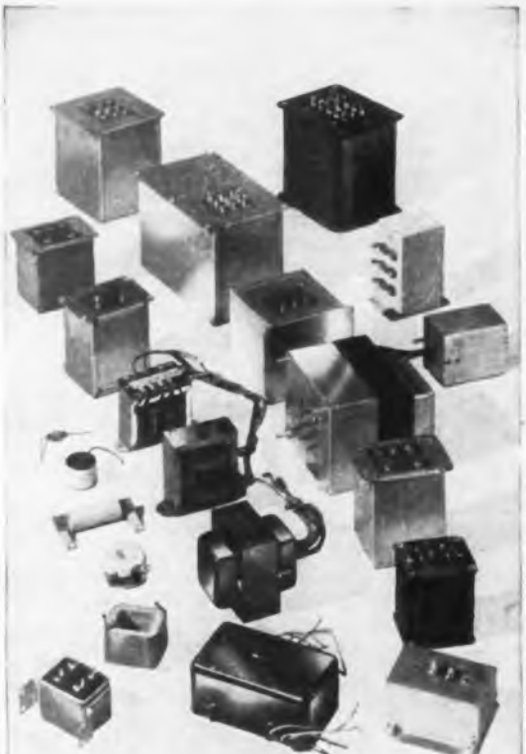

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"TNT—Television Now and Tomorrow"

Under the above title, Allen DuMont, president of DuMo Laboratories and recently elect president of the new Televisi Broadcasters Association, w scheduled to address the March Radio-in-Wartime luncheon of t American Marketing Association the Murray Hill Hotel, Park Ave. 41st St., New York.

With him on the program w scheduled Miller McClintock, pre dent of the Mutual Broadcasti System.

Baltin Joins TBA

Board of Directors of Televisi Broadcasters Association has a pointed Will Baltin its secretar treasurer. He has been progra manager of the DuMont Telev sion Station, W2XWV, New Yor since 1940 and has resigned th post to accept his new duties. H will devote himself to handli the business affairs of the associ tion and will coordinate the activ ties of member television cor panies for the advancement television during wartime and the postwar period.

New Signal Corps Assignments

The designation of Lieutena Colonel Sterling C. Bush, Chief the Equipment Branch of t Procurement & Distribution Servi as the Signal Corps represent tive on the Procurement Assig ment Board of the Army Servi Forces was among several rece important assignments of Sign Corps officers.

Lt. Col. Bush, who was a servi representative of the Southe California Telephone Co. before r turning to active duty as a Reser Officer July 10, 1941, succeeds l Col. Albert E. Brundage, form Chief of the Program Contr Branch, on the ASF Board whi will have an important function the scheduling programming of t Army during the remainder of t war.

Other new assignments ha been: Lt. Col. Joseph Piner, form commanding officer of the Sacr mento, Calif., Signal Depot to t Distribution Division of the Office the Chief Signal Officer under C George I. Back; Lt. Col. George Kahler, chief of the Internation Branch, Office of the Chief Sign Officer, and Capt. Russell C. Co of the Production Control Branc designated Signal Corps membe of the Radio Allocation Su committee of the War Departmen Joint Aircraft Committee wi

Capt. Theodore Helan, International Branch as alternate; and Col. Victor A. Conrad, former Wire Officer of the Allied Force Headquarters in North Africa, has returned to the United States and been assigned to the Signal Corps Ground Signal Agency at Bradley Beach, N. J.

Fisher President of FCC Bar Association

Ben S. Fisher, a leading Washington radio lawyer, is the new president of the Federal Communications Bar Association. Carl I. Wheat, who represents leading Independent telephone interests and formerly was FCC Telephone Rate Counsel and also California Railroad Commission General Counsel, is second vice-president. Both are formerly from the Pacific Coast.

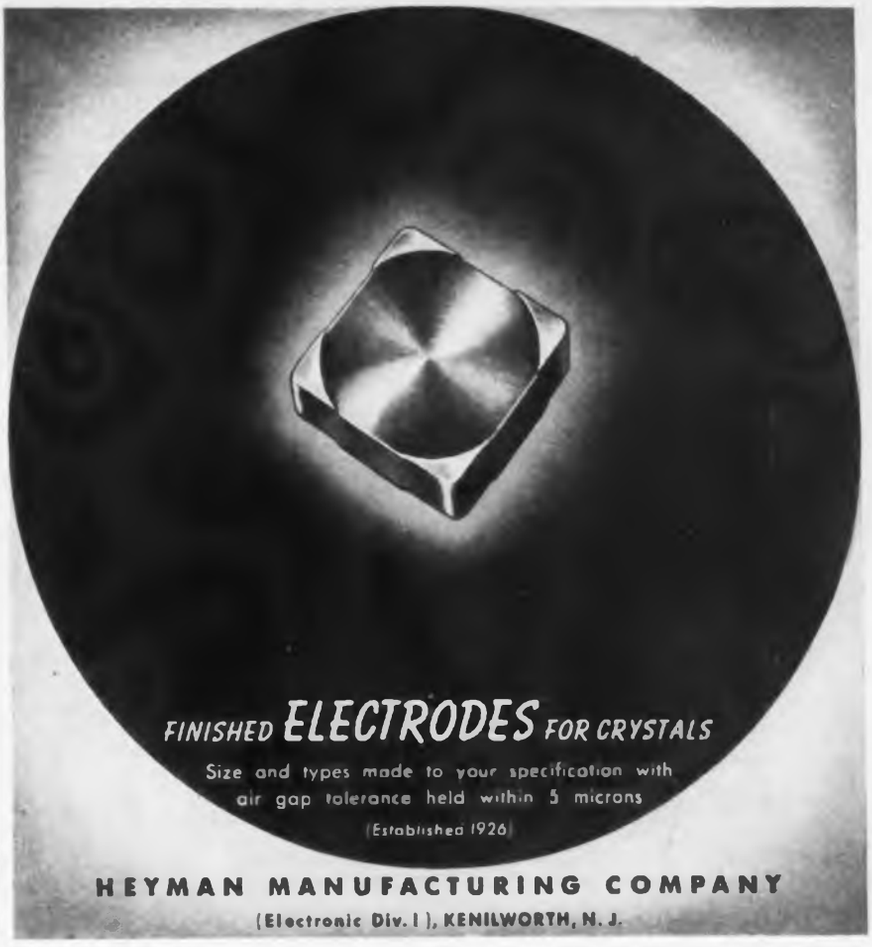
Other officers are: Eliot C. Lovett, first vice-president, and W. Theodore Pierson, secretary, and new Executive Committee members, retiring president Horace Lohnes and Lester Cohen—all lawyers mainly in the broadcasting field. Kenneth L. Yourd was reelected treasurer and holdover Executive Committee members are former FCC Chairman E. O. Sykes, Press Wireless Counsel Reed T. Rollo, former president Herbert Bingham, and Ralph Van Orsdel — vice-president and general counsel of the Chesapeake & Potomac Telephone Co.

CAA Converting to VHF for Navigation

Despite the obstacles of military production needs, the Civil Aeronautics Administration has been endeavoring to convert its radio navigation system to the "very high frequency" bands and requested Congress to allot $3,000,000 for this project during the next (1945) fiscal year. The plans for the construction of 97 radio range stations, in addition to the 170 vhf stations already authorized, were described to the House Appropriations Committee by CAA Administrator Charles I. Stanton in the executive hearings on the Commerce Department funds for next year, whose testimony was made public when the House passed and sent the bill to the Senate.

97 stations planned

Mr. Stanton pointed out that the CAA had wished both to complete the 170 radio range stations already commenced but was seeking to build 97 more stations. Because of the military radio requirements, the original request for $5,866,000 for the installation of the 97 additional stations was shaved down by the



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or men with equivalent industrial experience, for the development and design of pocket size radio and audio frequency equipment. We are especially interested in qualified engineers looking to the postwar period who, at present, are not being used in their highest skill or capacity. The Company is well established in the electronic field, located in the suburbs of a large metropolitan city in New England.

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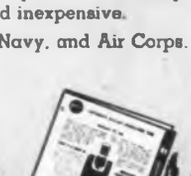

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Budget Bureau to $3,000,000. Th latter fund is to be used for t completion of the 170 already-a thorized stations. The unit pri per installation would be $44,000 station, including $30,000 per tran mitter and a standby transmitte with the additional amounts bei for the antenna, standby gener tors, remote control equipme building construction and install tion costs.

IRAC Making Own Re-Allocation Study

Although no progress in actu and tangible radio frequency all cations can be made until t "lid" is lifted on the secret milita radio developments, the Indepar ment Radio Advisory Committee the Federal government, whi recommends frequency requir ments of the armed services a government agencies to the Pre dent, is canvassing various un and individuals in the electron radio industry for their postw spectrum space needs.

Under the leadership of IRA Chairman, Commissioner T. A. Craven, this governmental agen has been engaged in continuo engineering studies on allocatio of a preliminary nature so as gain a full picture of the nee of the civilian radio-electron services-to-come, including tele sion, FM, aviation, etc. These stud through conferences with the dustry have given IRAC a mu greater knowledge than ever befo it is recognized. FCC Chief En neer Adair, meanwhile, is clos cooperating with the RTPB stud and panel sections.

Television Seers

Allen Dumont, president Dumont L oratories, and Thomas F. Joyce, R Victor, at N. Y. Sales Executives C meeting, March 14, when Joyce p sented figures to show vast empl ment and prosperity bound to follow wake of postwar television developm

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To design electronic devices, transformers, filters, etc.—mostly Audio frequency. Working knowledge of trigonometry and LC circuits necessary. Also some experience on communications equipment or mechanical manufacturing. Salary open. Draft exempt or deferrable by reason of education or experience. Excellent post-war prospects. USES referral card will be required. Audio Development Co., 2833 13th Avenue South, Minneapolis, Minnesota.

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KIRKLAND HEAVY DUTY UNITS, standard since 1931 on the products of America's finest manufacturers. All units feature: single hole mounting; easy lamp removal from the front; screw terminals in husky sockets; longer threaded area for thicker panels; and most important: NON-TURN lug to prevent the unit from turning in the mounting hole.

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THE H. R. KIRKLAND CO.
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Those 40,000 "Lend-Lease" Radios to England

Since the manufacture of civilian radio sets was curtailed by the War Production Board in April, 1942, approximately 40,000 standard-band broadcast receivers have been assembled from balanced sets of components left over from production of the civilian items, and have been sent to the British on a "cash purchase" basis. Manufacture of these sets began about March, 1943.

These radio sets, primarily intended for use by troops stationed in England for morale and recreational purposes, were made by a group of manufacturers selected because of their ability to assemble the units without affecting their regular military production schedules.

No new parts used

Although manufacture of these receiving sets for the British has been stopped completely, a very small amount of such sets are still being produced for shipment to American troops overseas. While absolutely no new parts were used in assembling these sets, the WPB has ruled that no more of these receivers for the British market will be made until the present policy changes. A limited amount of these component-assembled sets were turned over to the Foreign Economic Administration for use in South America.

The radios are of the regular United States domestic type, and no consideration was given to the European broadcast bands in their manufacture. In contrast to the 40,000 sets sent to the British since early 1943, it is interesting to note that in 1939 the allotment of radio sets to the British was 174,629.

According to recent newspaper cables from abroad, distribution of these radio sets in England has been held up pending price regulation by the British Board of Trade.

Cliff Estey Joins Zinc Products

The American Zinc Products Co., for many years a wholly owned DuPont subsidiary, is now owned by the Ball Bros. Co., Muncie, Ind., and is known as its "American Zinc Products Division." F. Clifford Estey, for nine years District Manager for the American Zinc Products Co. in Chicago, is now assistant general manager of the American Zinc Products Division, and will make his headquarters in Chicago for the duration. "Cliff" Estey is one of radio's pioneers, having been identified with the industry since its inception in key executive positions with several of the leading manufacturing organizations.

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See Page 224

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Electrical Apparatus Co., formerly at 1018 Commonwealth Ave., Boston, Mass., is now located in a new office building at 1200 Soldiers Field Road, Boston. Included is a completely equipped demonstration laboratory, with instruments and other facilities, in charge of a qualified engineer to furnish information and give demonstrations of all types of electric units and components for control systems.

Wheelco Expands

Assets of Wheelco Instruments Co., 847 W. Harrison St., Chicago have been purchased by Fred A. Hansen and Cary H. Stevenson, vice-presidents of the Lindberg Engineering Co., Chicago, and several associates. The business of the industrial instruments firm will be continued at the same location under a new corporation, the Wheelco Instruments Co. Officers of the new company are Hansen, president; Stevenson, secretary and treasurer; and Richard Schoenfeld and Theodore Cohen, vice-presidents of the old company, as vice-presidents. Wheelco Instruments owns a six-story building at Peoria and Harrison Streets, Chicago, where it manufactures a line of industrial instruments incorporating electronic control. The new company will expand further into other industrial applications of electronics and supersonics. Hansen and Stevenson will continue to be active in management of Lindberg Engineering Co.

Detrola Engineer

John Franklin Silver, who for the past two years has been chief production engineer for Collins Radio Co., is now assistant chief engineer for International Detrola Corp., Detroit; he has had long experience with a number of companies in the electronic field

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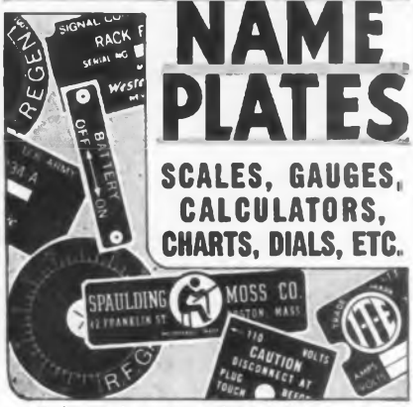

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Write, giving full details as to education, age, experience, family and draft status and salary desired.

If you are now engaged in essential industry at your highest skill please do not apply. We will welcome correspondence from honorably discharged service men who can qualify as radio engineers. Applicants living outside the Chicago area must obtain a "Statement of Availability" from their nearest U. S. Employment Service office.

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2600 WEST 50TH STREET
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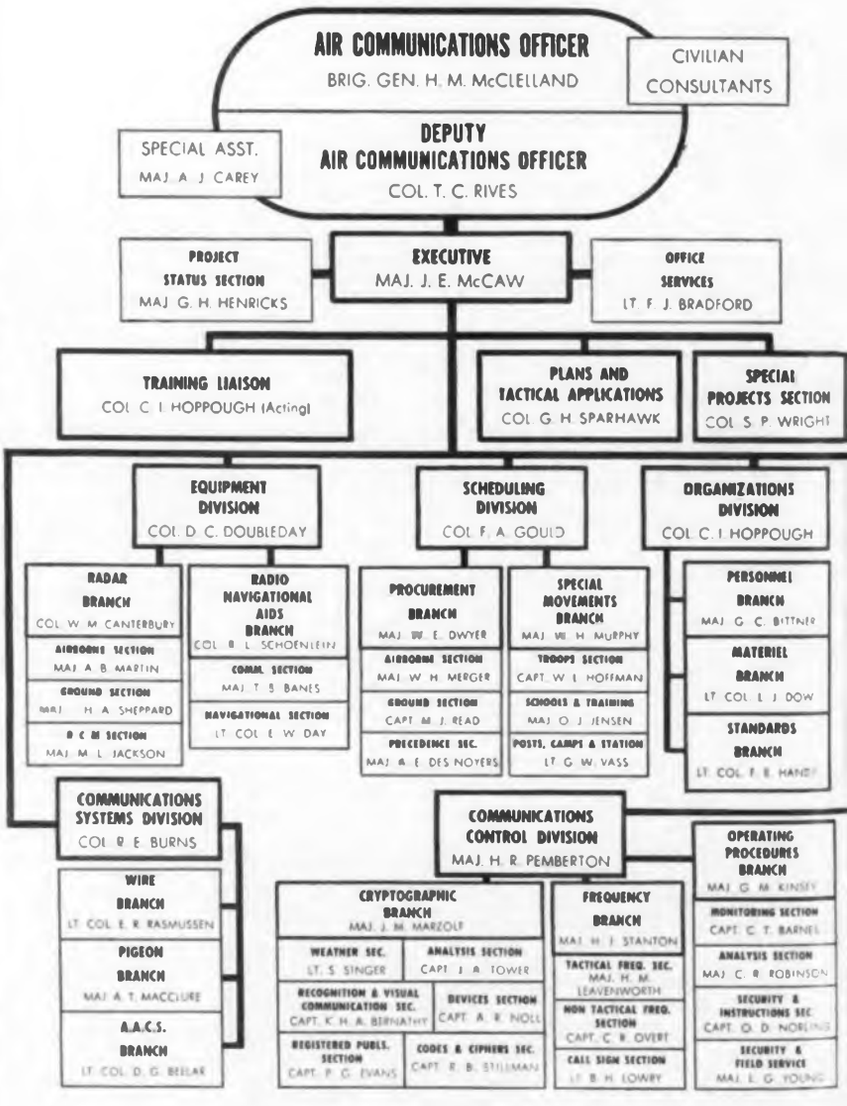
Admiral Bloch Cites Mallory Achievements

P. R. Mallory & Co., Inc., Indianapolis, Ind., manufacturers of electronic and metallurgical products, have been granted a fourth renewal of the Army-Navy "E" production award for meritorious services on the production front. Mallory was among the first plants to receive the original "E" and the award of four stars testifies to the maintenance of the company's outstanding production record. Addition of the coveted fourth star to the Mallory Army-Navy "E" flag was accompanied by the following citation from Admiral C. C. Bloch, Chairman of the Navy Board for Production Awards:

"The men and women of your plant have continued to maintain the high standards they set for themselves when they were originally awarded the Army-Navy 'E'. They may well be proud of their achievement. The additional white star, which the renewal adds to your Army-Navy 'E' flag, is the symbol of appreciation from our Armed Forces for your continued and determined effort and support so necessary for victory."

AACS—WORLD'S GREATEST SYSTEM

(*Continued from page* 107)



The Air Communications Officer, Brigadier General H. M. McClelland, and his organization perform the Staff functions for the Army Airways Communications System, which is a field command of the Army Air Forces. This means that for equipment and communications systems planning as well as for training and organizational procedures and requirements, the Office of the Air Communications Officer is responsible

General Radio Revises Personnel

At its recent annual meeting a number of changes in personnel and the revision of duties pertinent to the several positions were made by the General Radio Co., Cambridge, Mass. Messrs. Eastham, Locke, Richmond and Shaw, long identified with the company, continue as directors, joined by Frank L. Tucker, formerly comptroller, who was also elected treasurer and secretary. Melville Eastham, formerly president, and Henry S. Shaw, formerly chairman of the board, will hold no officership although the former will temporarily continue in charge of research and development with title of Chief Engineer. Harold B. Richmond was appointed chairman of the board and also chairman of the management committee. Errol H. Locke, formerly vice president, was elected president.

New appointments in addition to Mr. Tucker are Arthur E. Thiessen, formerly commercial engineering manager, as vice president in charge of sales, and Charles C. Carey, formerly superintendent, as vice president in charge of manufacturing. The directors, with the addition of Messrs. Carey, Thiessen and Charles T. Burke who is engineering manager, comprise the Management Committee. C. E. Hills, Jr., who has been associated with the company since 1922, nearly all of which as commercial manager, will continue in that position but in addition has been appointed assistant secretary and assistant treasurer of the company.

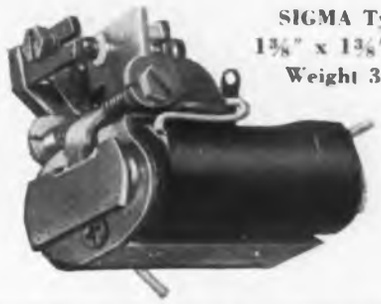
La Marque Appointed Graybar Sales Manager

J. W. La Marque, formerly manager, Radio Broadcasting Department at Graybar's Varick Street, New York district office has been made radio sales manager at the Graybar Executive Headquarters in New York. He succeeds D. B. McKey, formerly general communications engineer, who has become technical supervisor of radio properties (Stations WKZ, KLZ and KBOR) of the Oklahoma Publishing Co., Oklahoma City.

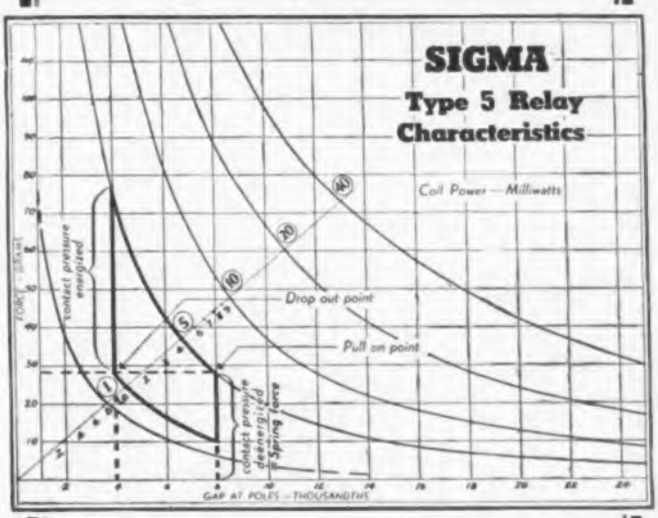
Jim La Marque brings with him to his new duties over twenty-four years of experience in radio, having been associated with RCA and Haynes-Griffen in the early '20's and later as eastern sales manager of the Crosley Radio Corp. He came with Graybar in 1928 as radio department manager at the Varick Street, New York office, and for two years was in charge of all radio merchandising activities at that location. In 1930, and for a six year period following, he

Versatility & Sensitivity

OUTCLASSING ALL PREVIOUS STANDARDS



SIGMA Type 5F
1⅜" x 1⅜" x 1⅝"
Weight 3½ oz.



The contributions which Sigma Instruments have made in the relay field are but a promise of significant new developments to come.

Study the typical operating cycle of the new Sigma Series 5 Relay shown above —notice that it is operating at 5 Milliwatts with 4 mil air gap between contacts, and 4 mil air gap at poles. Notice further, that contact pressure of over 40 grams is provided in the energized state and 28 in the deënergized state.

The possibilities of this relay can be imagined when it is realized that a contact pressure of only 20 grams is sufficient (on the Series 5) to withstand 11 g's vibration.

COIL RESISTANCE	5 MILLIWATTS	0.5 MILLIWATTS
.001 Ohms	2.24 Amp. — .00224v.	0.707 Amp. — .000707v
1.0 Ohms	70.7 MA — .0707v.	22.4 MA — .0224v.
100. Ohms	7.07 MA — .707v.	2.24 MA — .224v.
1000. Ohms	2.24 MA — 2.24v.	.707 MA — .707v.
10000. Ohms	.707 MA — 7.07v.	.224 MA — 2.24v.
20000. Ohms	.500 MA — 10.00v.	.158 MA 3.16v.

SIGMA

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worked as a special sales representative for the Graybar Electric Co. on Western Electric radio, sound systems and hearing aids in Connecticut and Westchester County, New York. Since 1936, he has been closely identified with radio broadcasting and allied electrical industries in the Eastern District.

IT&T Appointments Announced

Board of Directors of the International Telephone and Telegraph Corp. has appointed four new vice-presidents and four second vice-presidents. The new vice-presidents are: H. C. Roemer, vice-president and comptroller of Federal Telephone and Radio Corp., a manufacturing affiliate of IT&T; W. H. Freng, assistant general attorney, who has also been appointed solicitor; Charles D. Hilles, secretary of the corporation; and Francis White, vice-president of the International Standard Electric Corp., another IT&T affiliate. The second vice-presidents appointed are F. F. Davis, Harold H. Buttner, G. A. Ogilvie, Leonard Jacob II.

Harold H. Buttner received his B. S. degree in Electrical Engineering in 1915 from the University of California. After graduation, he was employed by the U. S. Navy Department on a number of important radio projects in the Pacific including construction of the High Power Radio Station at the U. S. Naval Station in Samoa.

He enlisted in the first World War as a machinist's mate in the Navy and remained in France after the war as a U. S. employe to complete the Lafayette Navy High Power Radio Station. He returned to the United States in 1921 and was employed by the Navy Department as an expert radio aide. He left the

H. H. Buttner, 2nd vice-president IT&T

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ELECTRONIC INDUSTRIES

Advertisers—April, 1944

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service of the Navy Department in 1922 to enter the employ of the Western Electric Co. and Bell Telephone Laboratories, where, for a number of years, he did development work on radio broadcasting and power line carrier equipment. He became associated with IT&T in 1926 and since that time he has been engaged principally in the development of communications equipment. During the period between 1928 and 1938 he traveled extensively in Europe and South America for the Company.

Sylvania Enlarging Tungsten Plant

Less than six months after the original plant went into production of war-needed tungsten products, Sylvania Electric Products, Inc., has started work on a $100,000 addition to the plant. The contract calls for completion in three months of a brick structure which is to provide 19,000 sq. ft., of which 5,000 will be used for offices and the remainder for manufacturing.

Webster Expands

Construction work has just been completed on an addition to the plant of Webster Products, 3825 W. Armitage Ave., Chicago, Ill., increasing the previous floor space by nearly 20 per cent. Dynamotors, voltage regulators and inverters constitute the principal wartime output of Webster Products. One feature of the addition will be a separate division for impregnating and baking operations.

Heads RMA Publicity

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NOW A Miniature Thyratron With a Man-Size Rating

RCA-2D21—For Control Jobs Where Lightness and Small Size Count

STURDY construction—stable operation—high control ratio—yet this new RCA thyratron, the 2D21—is a true miniature. It weighs but ½ ounce; stands just 2⅛ inches high. And it will handle 100 milliamperes average; 500 milliamperes peak. The 2D21 is a gas-type tetrode electrically similar to the well-known RCA-2050.

In addition to its small size, RCA-2D21 has many application advantages—for example:

Low Internal Drop: Only 8 volts!

Any-position Mounting: The 2D21 is xenon-filled; no mercury to limit mounting position, or to restrict motion while in operation.

Wide Temperature Range: The 2D21 has wide temperature limits: −55 to +90°C, with little change in operating characteristics over the entire range.

Quick Heating: Anode voltage may be applied not less than 10 seconds after application of heater voltage.

Stable Operation: The inherent stability of this type of gas-filled thyratron makes greater control-circuit sensitivity possible. Low grid-anode capacitance makes the 2D21 insensitive to line-voltage surges.

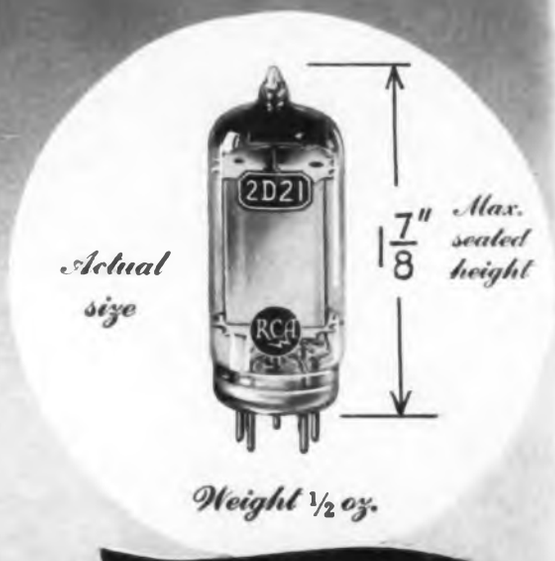
Versatility of Control: You can control the operation of the 2D21 by means of both the shield grid and the control grid. This makes for flexibility of control where needed.

Low Preconduction Current: Electrode structure provides low preconduction current right up to the start of conduction.

High Sensitivity: Grid current of this tube is very low; hence, a high resistance can be used in the grid circuit, providing high sensitivity. A high-vacuum phototube can be coupled to a 2D21 without intervening amplifier.

High Current Ratings: For periods up to 6 seconds out of 30, the 2D21 will safely carry 0.5 ampere plate current. It will carry 0.1 ampere continuously.

Need further information? RCA application engineers will be glad to help you in applying the RCA-2D21 and other RCA tubes to your design problems. Write to Commercial Engineering Section, Radio Corporation of America, Harrison, N. J.



TECHNICAL DATA

RCA - 2D21 — $3.75

Heater volts (A.C. or D.C.)	6.3
Heater ampere	0.6
Tube drop (Approx.)	8 volts
Max. overall length	2⅛ in.
Max. seated height	1⅞ in.
Bulb	T-5½
Base	Miniature Button 7-pin
Ambient Temp. Range	-55° to +90°C.

MAXIMUM RATINGS

Peak Forward Anode Volts	650
Peak Inverse Anode Volts	1300
Shield-grid Volts	-100
Control-grid Volts	-100
Peak Cathode Milliamperes	500
Average Cathode Milliamperes	100
Max. Control-grid Circuit Resistance	10 Megohms

Typical A-C operation: RMS Anode Volts, 400; Shield-grid Volts, 0; RMS Control-grid Bias Volts, 5; Control-grid Signal Volts (Peak), 5; Control-grid Circuit Resistance, 1 megohm; Anode Circuit Resistance, 2000 ohms.

RCA

SEND THIS FOR DATA SHEET

RCA, 711 So. Fifth Street, Harrison, N. J.
Please rush data sheet containing curves, drawings, and other application data on RCA-2D21 miniature thyratron to:

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