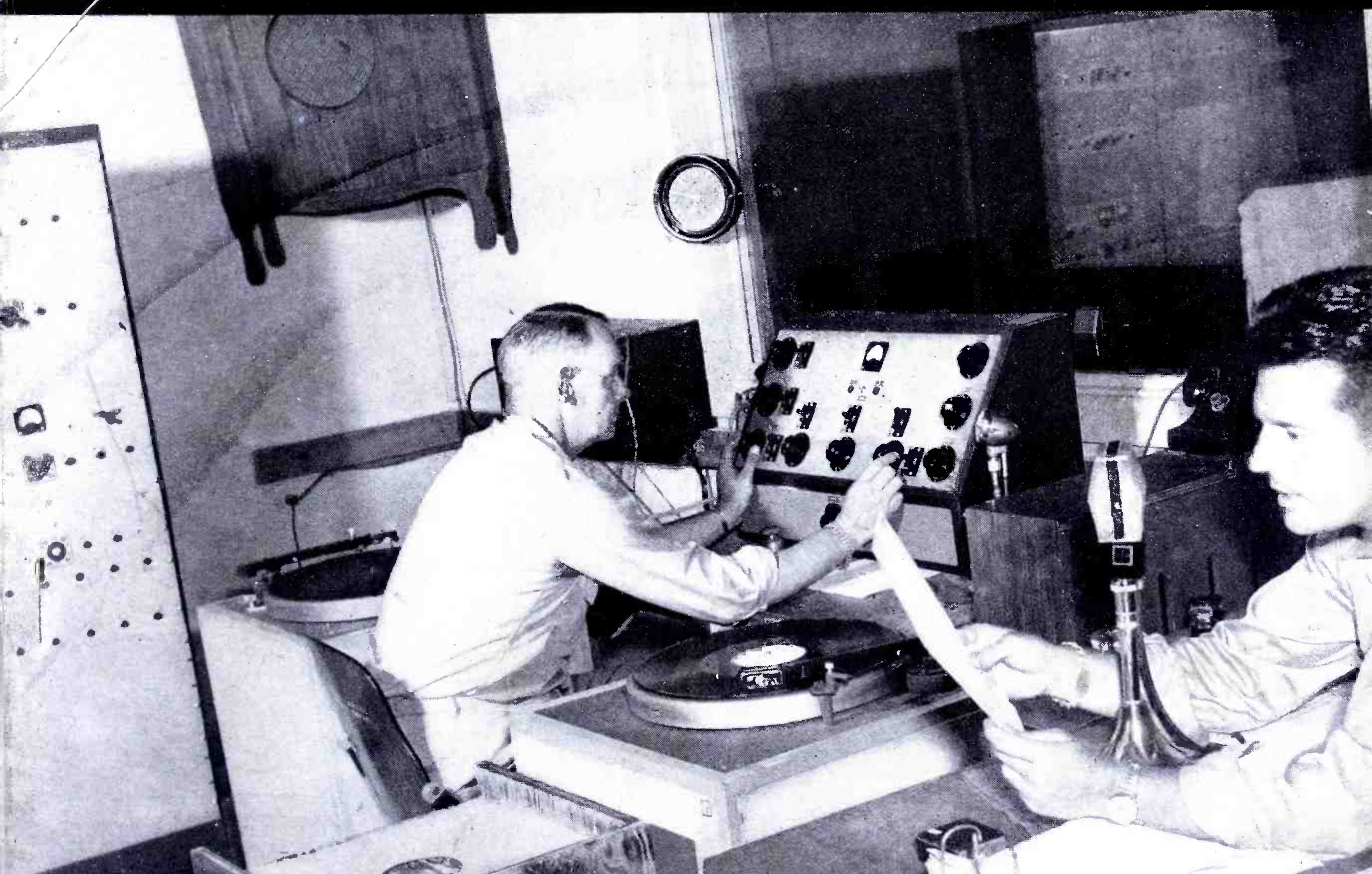
COMMUNICATIONS



JANUARY

★ RADIO ENGINEERING
★ EMERGENCY COMMUNICATION SYSTEMS
★ COUPLED CIRCUIT DESIGN
★ AERONAUTICAL COMMUNICATIONS
★ TBA CONFERENCE REPORT
★ TELEVISION ENGINEERING

1945

108 SERIES *Amplifiers*

WITH MOUNTING ACCESSORIES

TYPE 108-B two-stage Amplifier provides transformer input impedances for either 30 or 250 ohms with nominal output impedance 500 or 8 ohms. Variable gain 65/105 db. with electronic volume control. Frequency response better than ±1 db. 30/16,000 c.p.s. Power output +43 V.U. (20 watts) with less than 5% RMS harmonic content. Noise level full gain 56 db. below full output.

THE 108 SERIES consist of four different amplifiers available simply by changing one or two small input panels on the master chassis. Except for these input panels all amplifiers have the same transmission characteristics. Input impedance, gain and noise level depending on types listed below.

These units are designed for the highest type audio service having gain-frequency characteristics better than ±1 db. 30/16,000 c.p.s. Power output +43 V.U. (20 watts) with less than 5% RMS harmonic content.

TYPE 108-A two-stage Amplifier provides transformer input for either 600 ohm or bridging. 600 ohm input fixed gain 61 db. Bridging input variable gain 6/46 db. Noise level 68 db. below full output.

TYPE 108-B as illustrated and described above.

TYPE 108-C combines the input channels of the 108-A and 108-B Amplifiers. Channel 1—600 ohm input variable gain 20/60 db. Bridging input variable gain 2/42 db. Channel 2—high gain 30/250 ohm input variable gain 62/102 db. with electronic volume control. Noise level 56 db. below full output.

TYPE 108-D two-channel each 30/250 ohm input. Either channel variable gain 62/102 db. with electronic volume control. Noise level 56 db. below full output.

MOUNTING ACCESSORIES

TYPE 202-A Wall Mounting Cabinet permits universal installation of 108 Series Amplifiers to any flat surface. Well ventilated and designed for maximum accessibility, servicing and convenience of installation. Standard aluminum gray finish.

TYPE 9-A Modification Group permits 108 Series Amplifiers to mount on standard 19" telephone relay racks. Occupies 7" rack space. Allows servicing from front of rack. Standard aluminum gray finish.

The Langevin Company
INCORPORATED
SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
37 W. 65 St., 23	1050 Howard St., 3	1000 N. Seward St., 38

LEWIS WINNER, Editor
F. WALEN, Assistant Editor

We See...

AN EPOCHAL EVENT LAUNCHED the New Year . . . the FCC reallocation proposal covering the 25 to 30,000-mc spectrum . . . a proposal that provides for the greatest expansion in communications history. The FCC plan calls for new frequency assignments to railroads, rural telephones, general mobile services (trucks, buses, taxicabs, ambulances) and walkie-talkies for Mr. and Mrs. Public.

F-m received 90 channels between 84 and 102 mc. Twenty of these channels (84 to 88 mc) are for educational stations. A band of from 102 to 108 mc was set aside for f-m expansion. Television was given six 6-mc channels from 44 to 84 mc and six 6-mc channels from 180 to 216. And to permit development of high definition and color pictures, bands between 480 and 960 mc were also set aside for experimental television. The air services received substantial grants . . . almost exactly as requested. In offering these frequencies, FCC officials said . . . "aviation operations are wholly dependent upon the use of radio for insuring the safety of life and property in the air."

Twenty-two channels between 25 and 28 mc were proposed for relay broadcast operations. Studio-transmitter links were moved to the 900 to 960 mc band. Here incidentally f-m will be used.

The 460- to 470-mc band was set aside for a walkie-talkie service which will be available to practically anyone. Operators will have to abide by only the minimum requirements of the Communications Act and a few traffic rules. But no technical knowledge will be necessary, says the FCC. Doctors, farmers, sportsmen, department stores, boatmen and countless others will find this quite a handy service.

Police, fire, forestry and railroad services were assigned the 148- to 162-mc bands.

The proposal in its present or modified form will become a final program soon after oral hearings with industry specialists are held during the middle of February.

Congratulations to the FCC for a comprehensive appraisal and sturdy approach to a complex problem.

—L. W.

COMMUNICATIONS

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer. Registered U. S. Patent Office.
Member of Audit Bureau of Circulations.

JANUARY, 1945

VOLUME 25 NUMBER 1

COVER ILLUSTRATION

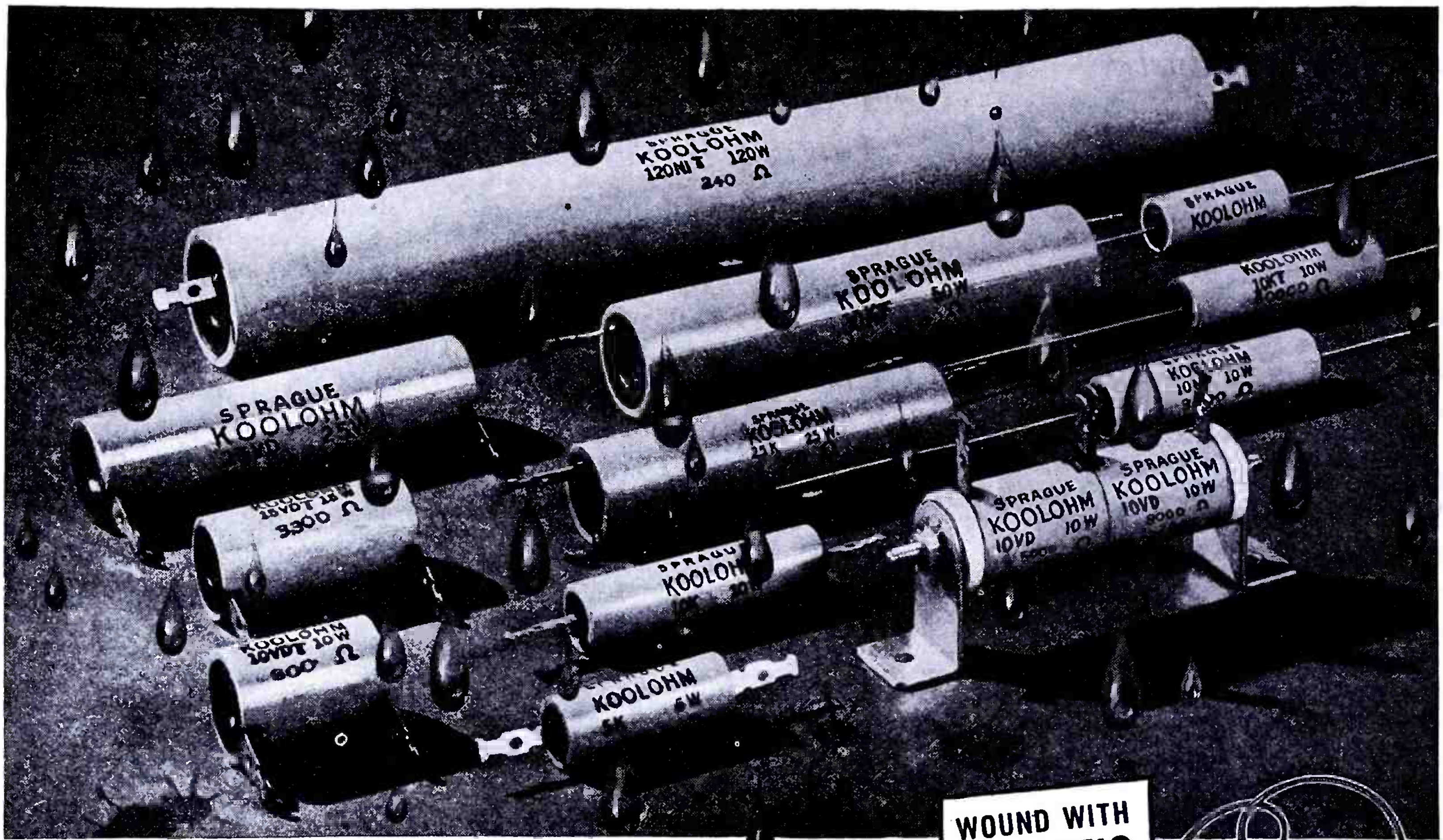
In the control room of AES at Noumea, New Caledonia.
(Courtesy U. S. Army Signal Corps)

Published Monthly by the Bryan Davis Publishing Co., Inc.

BRYAN S. DAVIS, President — PAUL S. WEIL, General Manager
F. WALEN, Secretary — A. GOEBEL, Circulation Manager

Advertising and Editorial offices, 19 East 47th St., New York 17, N. Y. Telephone PLaza 3-0483. Cleveland 6, Ohio; James C. Munn, 10515 Wilbur Avenue. Pacific Coast Representative: Brand & Brand, 816 W. Fifth St., Los Angeles 13, Calif.; Telephone, Michigan 1732. Wellington, New Zealand: Te Aro Book Depot. Melbourne, Australia: McGill's Agency. Entered as second-class matter October 1, 1937, at the Post Office at New York, N. Y., under the act of March 3, 1879. Yearly subscription rate: $2.00 in the United States and Canada; $3.00 in foreign countries. Single copies, twenty-five cents in United States and Canada; thirty-five cents in foreign countries.

Now! EXTRA HUMIDITY PROTECTION IS STANDARD



. . . designed for tropical conditions
. . . unbeatable on ANY job

Standard Sprague Koolohm Wire Wound Resistors now offer the same high degree of humidity protection formerly obtainable only on special order to match exacting military specifications. This construction, newly adopted as standard, includes a glazed ceramic outer shell and a new type of end seal. These features give maximum protection against even the most severe tropical humidity conditions. Type numbers remain the same except for the fact that the letter "T" has been added to designate the new standard construction.

Thus, again, Sprague leads the way in practical, truly modern wire wound resistor construction. Your job of resistor selection is greatly simplified. No need to study and choose between types or coatings. One type of Koolohms, the *standard* type, does the job —under any climatic condition, anywhere in the world!

SPRAGUE ELECTRIC COMPANY, North Adams, Mass.
(formerly Sprague Specialties Co.)

SPRAGUE KOOLOHM RESISTORS

TRADEMARK REGISTERED U.S. PAT. OFF.

The Greatest Wire-Wound Resistor Development in 20 Years

Seven years ago we started out as a west coast distributor of aircraft parts. We named our company Aircraft Accessories Corporation. Then we started developing aircraft hydraulics. The next thing we knew we were full-fledged manufacturers—and out of the parts business. Later, someone came along with an embryo electronic plant in Kansas City. Being young and ambitious—we bought it. To everyone's amazement—and somewhat to our own—we made it grow. And pay.

NEW NAME NEW HORIZONS

We're still young, ambitious. Our explorations in hydraulics, electronics and other fields promise post-war growing pains. And so we've outgrown our name. Aircraft Accessories Corporation no longer adequately describes our operations. We couldn't think of a name that did. So we coined one: **Aireon.** It's a name that's partly aircraft, partly electronics; but it will be largely what we make it. We hope—and intend—to make **Aireon** worthy of a place among America's most honored corporate and trade names.

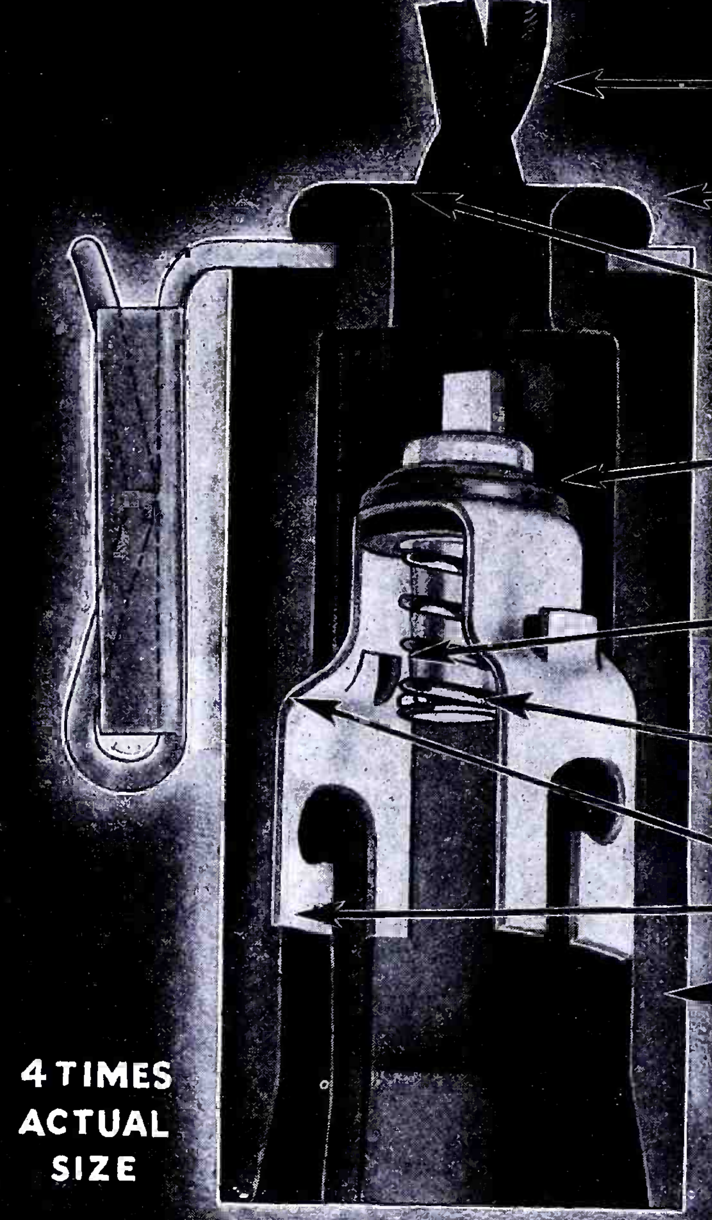
Aireon MANUFACTURING CORPORATION

Formerly *AIRCRAFT ACCESSORIES CORPORATION*

Radio and Electronics • Engineered Power Controls

NEW YORK • CHICAGO • KANSAS CITY • BURBANK

a New and Superior DIAL LIGHT SOCKET



Tensile strength of leads and connections far in excess of requirements.

Tough, plastic shell molded around bracket providing a secure bond with mechanical strength far beyond any normal requirement.

Rounded edge will not cut or fray wire insulation.

Voltage Breakdown between contacts—1200 Volts. Voltage Breakdown to ground —5000 Volts.

Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

Center contact mounted so that it cannot protrude from shell and short on chassis when lamp is removed.

Plastic shell is recessed for contacts, which cannot be pushed or pulled out of position.

Stronger, tougher, neavy walled plastic shell.

A variety of different mounting bracket styles available, suitable for practically any mounting.

For Your Present and Post-War Production

40TH ANNIVERSARY
1904-1944

This year Lenz celebrates its 40th year of service to the communications industry.

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

Consider these Lenz Dial Sockets for your present and post war production. Write for sample today.

LENZ

In Business *Since 1904*

LENZ ELECTRIC MANUFACTURING CO.

1751 N. WESTERN AVE. CHICAGO 47, ILLINOIS

ELECTRIC CORDS, WIRES AND CABLES

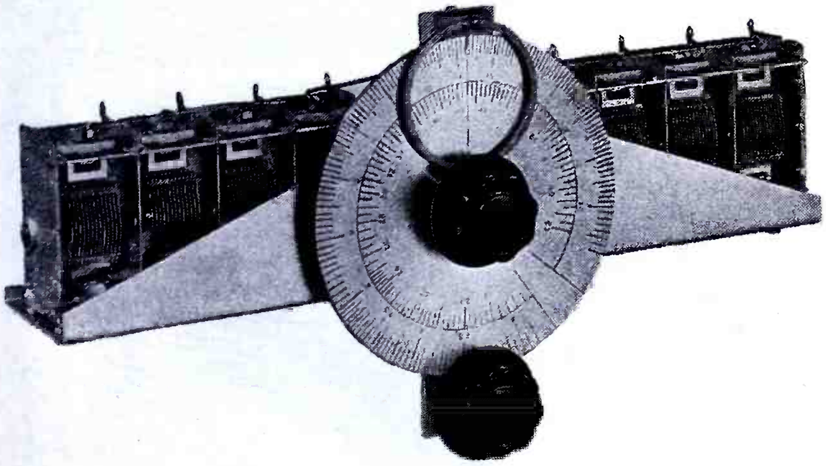
A NEW *-hp-* AUDIO OSCILLATOR

3 OUTSTANDING NEW FEATURES: 1. ACCURATE CONTROL DIAL

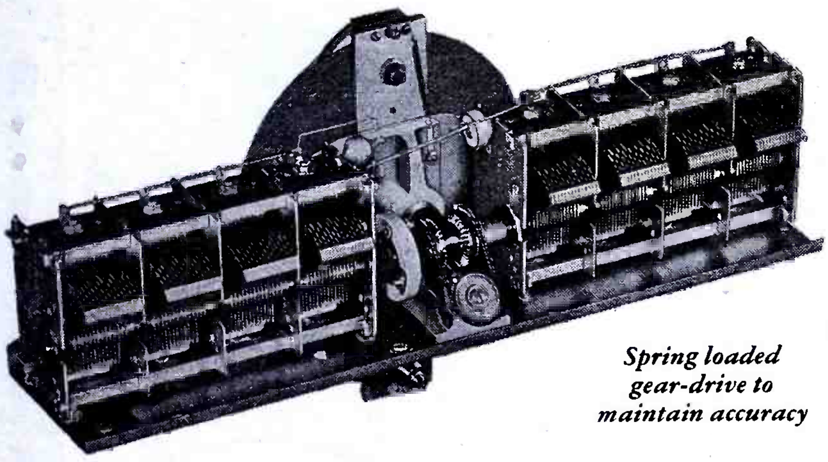
EASY TO READ • NO PARALLAX

2. RUGGED CONSTRUCTION

3. IMPROVED CIRCUIT

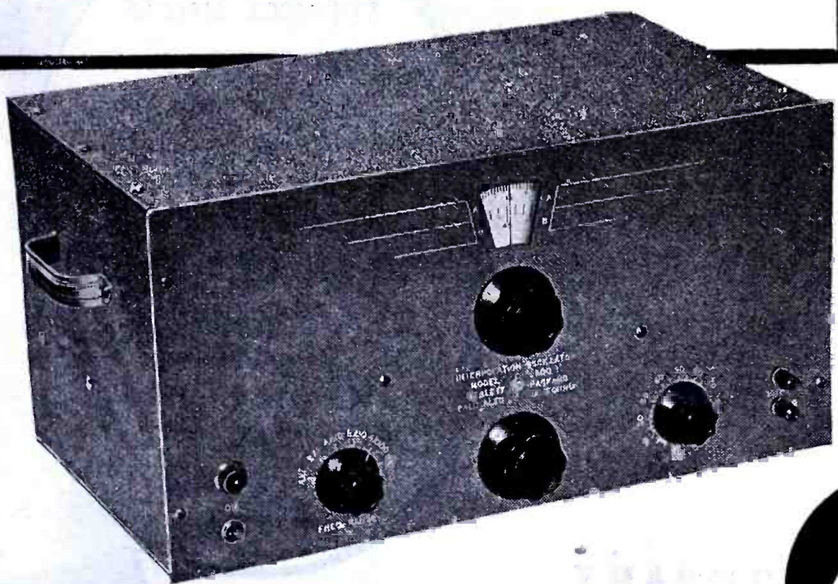


New friction driven dial provides hair-line accuracy



Spring loaded gear-drive to maintain accuracy

Rugged chassis construction on heavy cast frame



The Model 200-I is a resistance-tuned audio oscillator designed to provide high stability and accuracy for use in frequency measurements. It has a range from 6 cps to 6000 cps,* divided into six frequency ranges as follows: 6 to 20, 20 to 60, 60 to 200, 200 to 600, 600 to 2000 and 2000 to 6000 cps. Each of these ranges has an individual frequency adjustment so that the instrument may be set to a frequency standard such as the *-hp-* Model 100-B.

The large, 6-inch diameter, main frequency dial is calibrated over approximately 300 degrees, making possible a large number of calibrated points to cover the entire range. The dial itself rotates behind a fine wire locator which is visible through an opening in the panel. Parallax is completely eliminated and calibrations are spread over an effective scale length of nearly eight feet. Fast and extremely accurate settings are made easily with this dial. There are two manual controls: one direct action, and the second for vernier adjustments. An electronically regulated power supply is included to assure greatly improved stability.

The Model 200-I *-hp-* Audio Oscillator is but one among many new *-hp-* instruments which are to make public appearance as the cloak of military secrecy is removed. Preliminary technical information is available on this instrument now ...write for it! And watch for the early release of other new *-hp-* instruments.

**This frequency coverage was selected for interpolation work. Other frequency ranges can be supplied from 6 cps to 100 kc on special order.*

HEWLETT-PACKARD COMPANY

Box 930E - Station A - Palo Alto, California

930

OHMITE RESISTORS

Many Types and Sizes Assure the Right Resistor for Each Control Job

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Fixed Lug
" Dividohm "
Wire Lead
"Corrib"
Ferrule
Edison Base
Precision
Bracket
Non-Inductive
Tapped
Cartridge
Strip

Many critical control problems are being readily and successfully solved with Ohmite Resistors. That's because the extensive range of Ohmite types and sizes makes possible an almost endless variety of regular or special units to meet each need best.

Ohmite core sizes range from 2½″ diameter by 20″ long to 5⁄16″ diameter by 1″ long. Wide selection of stock units are available.

These rugged resistors have proved their worth under toughest operating conditions, in every field of action. Ohmite engineers are glad to help on today's and tomorrow's control problems.

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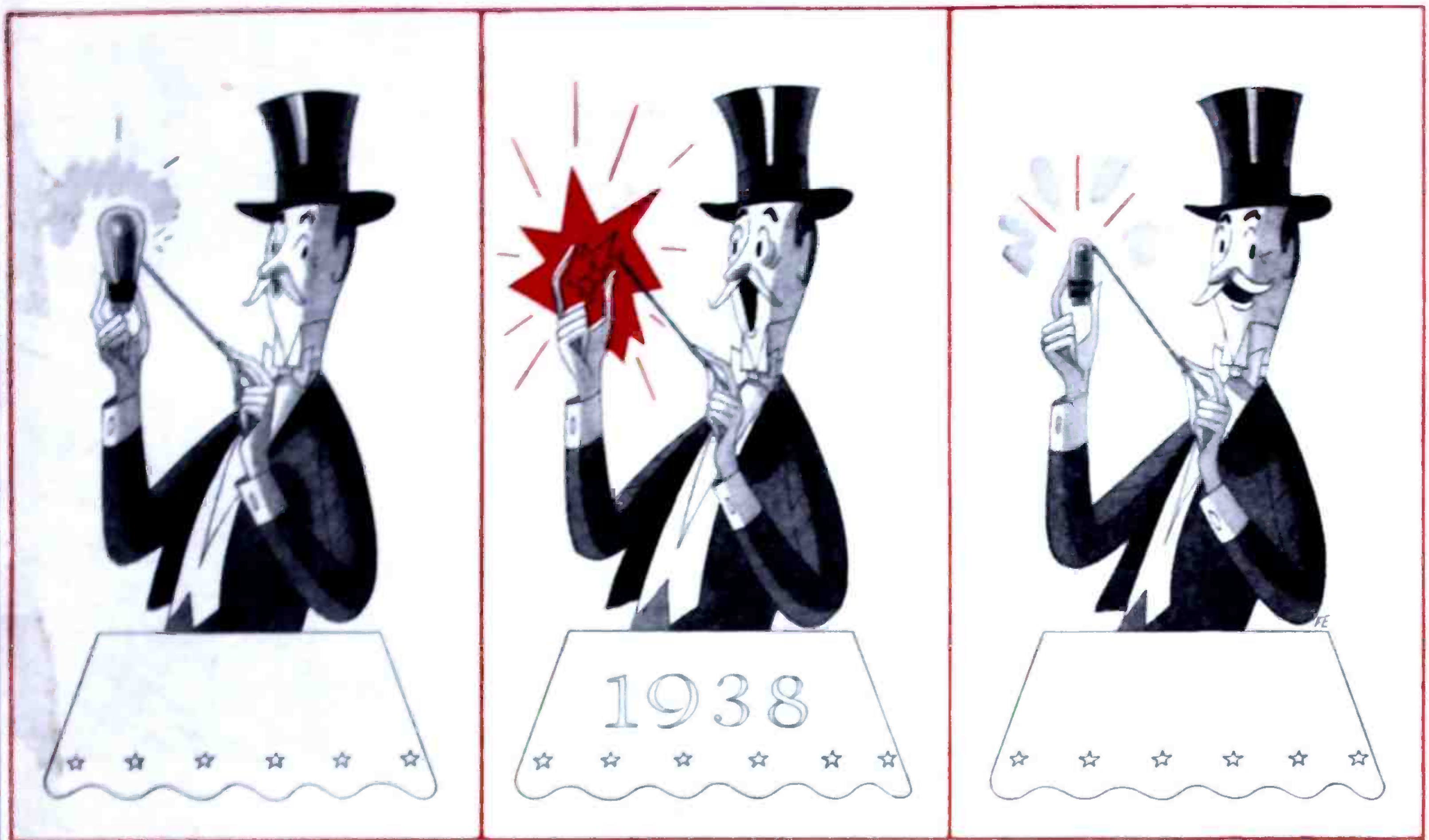
4869 Flournoy Street • Chicago 44, U.S.A.

Send for Catalog and Engineering Manual No. 40
Write on company letterhead for this complete, helpful guide on resistors, rheostats, tap switches. Address OHMITE, 4869 Flournoy, Chicago 44.

Be Right with **OHMITE**
RHEOSTATS • RESISTORS • TAP SWITCHES



THEY SAID IT COULDN'T BE DONE!

Back in 1938, Hytron began designing new dies and converting production machinery for the first BANTAM GT tubes. The industry said in effect: "You're crazy; it won't work. You can't telescope standard glass tubes to BANTAM size and get the same results." Beam tetrodes, such as the 50L6GT, particularly were considered impossibilities. The intense heat developed during normal operation would warp the elements and crack the small glass bulb.

But Bruce A. Coffin, originator of the BANTAM GT, stuck to his guns. In a few short years, Hytron developed over fifty GT types. The GT became the most popular receiving tube.* Short leads, low capacitances, advantages of shorter bombardment at lower temperatures, ruggedness of compact construction plus both top and bottom mica supports, smaller size, standardized envelopes and bases — all contributed to that popularity.

The BANTAM GT permitted new space economies in pre-war receivers. Only its universal acceptance as standard by all manufacturers makes possible fulfillment of the Services' demands for receiving tubes. In increasing numbers, as this war draws to its ultimate conclusion, Hytron will continue to supply you with the popular BANTAM GT tubes which everyone said just couldn't be made.

**1941 industry production figures: GT—52,000,000; metal—27,000,000; standard glass, G, and loctal—56,000,000.*

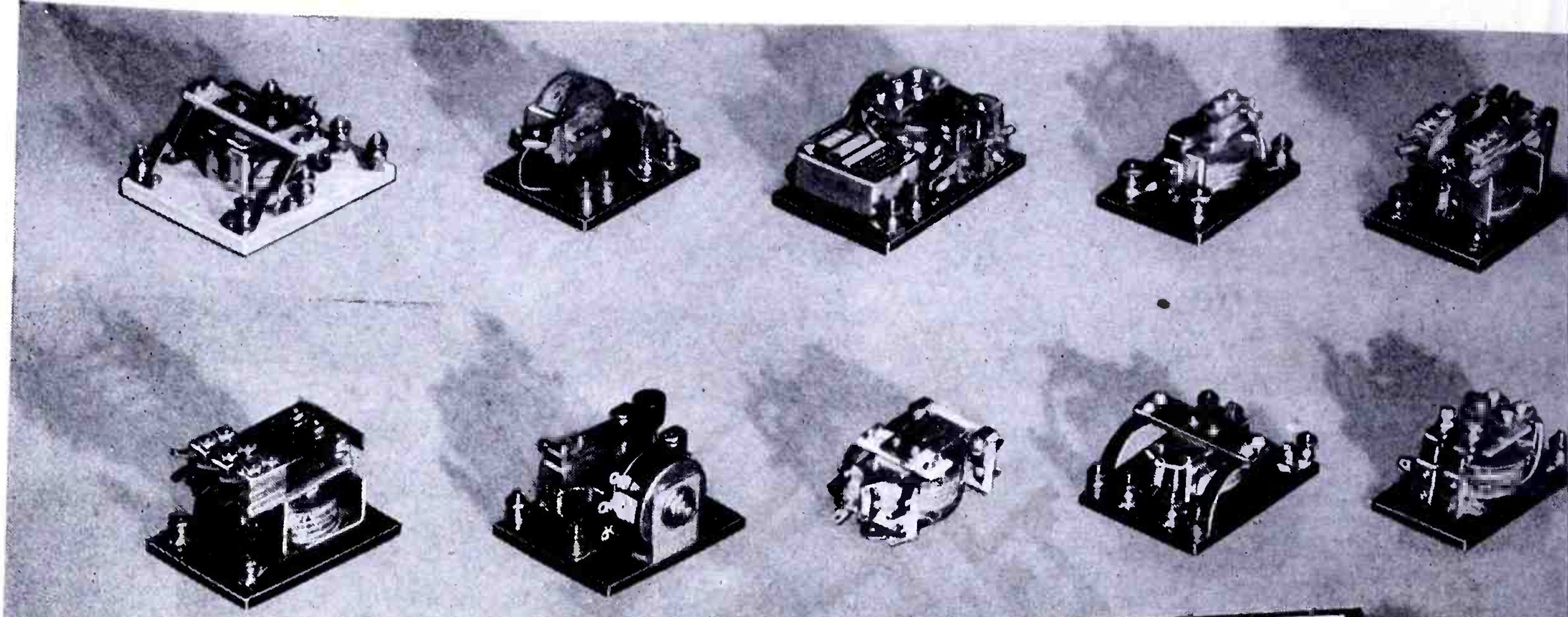
OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

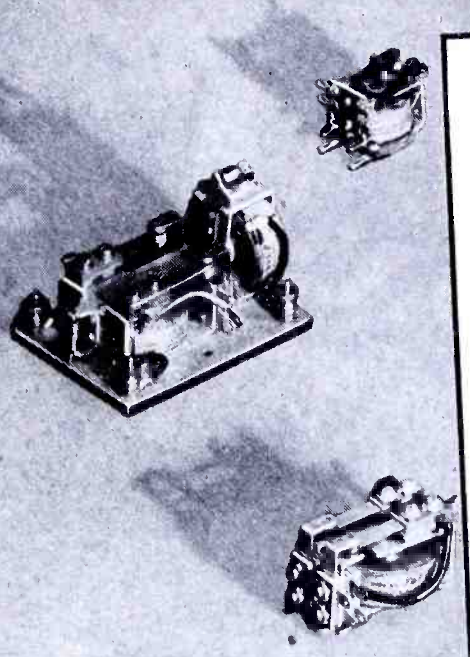
HYTRON CORPORATION

ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

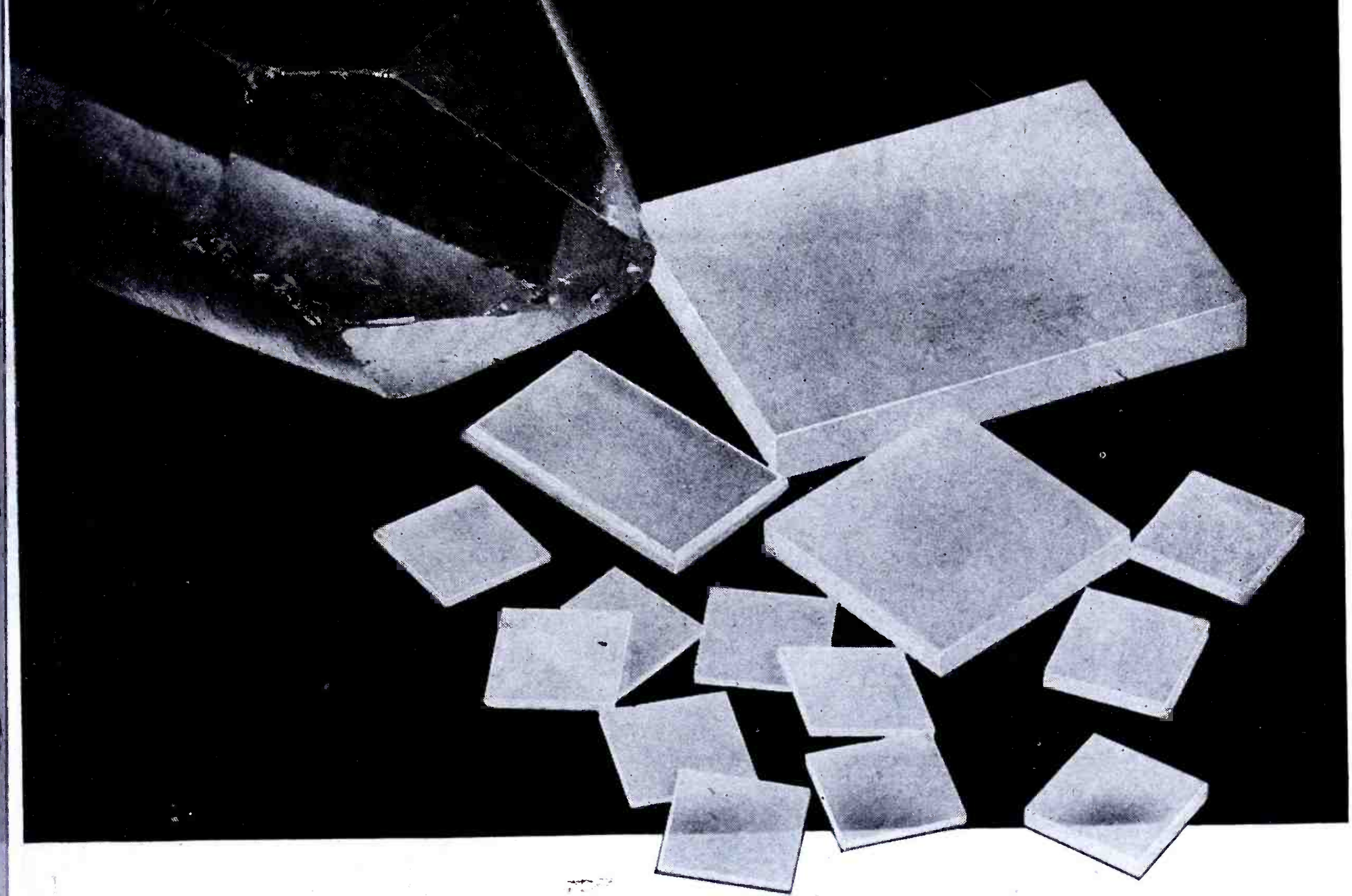
BUY ANOTHER WAR BOND





Crystal Blanks

TO YOUR SPECIFICATIONS



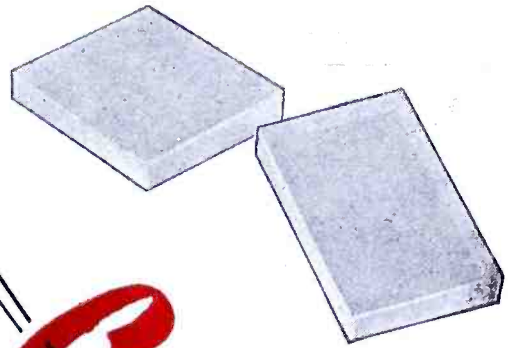
Crystal Products Company can supply Quartz Crystal blanks in any of the three stages of manufacture: (1) "rough-sawed" blanks, (2) "semi-finished" blanks, and (3) "electrically finished" blanks.

"Rough-sawed" blanks are cut to the specified angles and roughly sawed to dimensions.

"Semi-finished" blanks are blanks which have been brought to approximate dimensions by machine lapping, allowance being made for final hand finishing.

"Electrically-finished" blanks are finished by hand to the frequency desired and electrically tested.

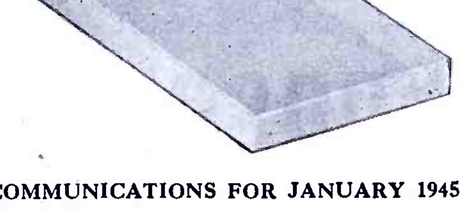
All crystal blanks are cut to specifications from selected Brazilian quartz and guaranteed free from all impurities such as optical twinning, electrical twinning, bubbles, fractures, scratches, mineral inclusions, and other mechanical and electrical imperfections. Dimensions, temperature coefficients, and frequencies are guaranteed within specifications listed. **Send us your holders for replacement of crystal blanks to exact specifications.**

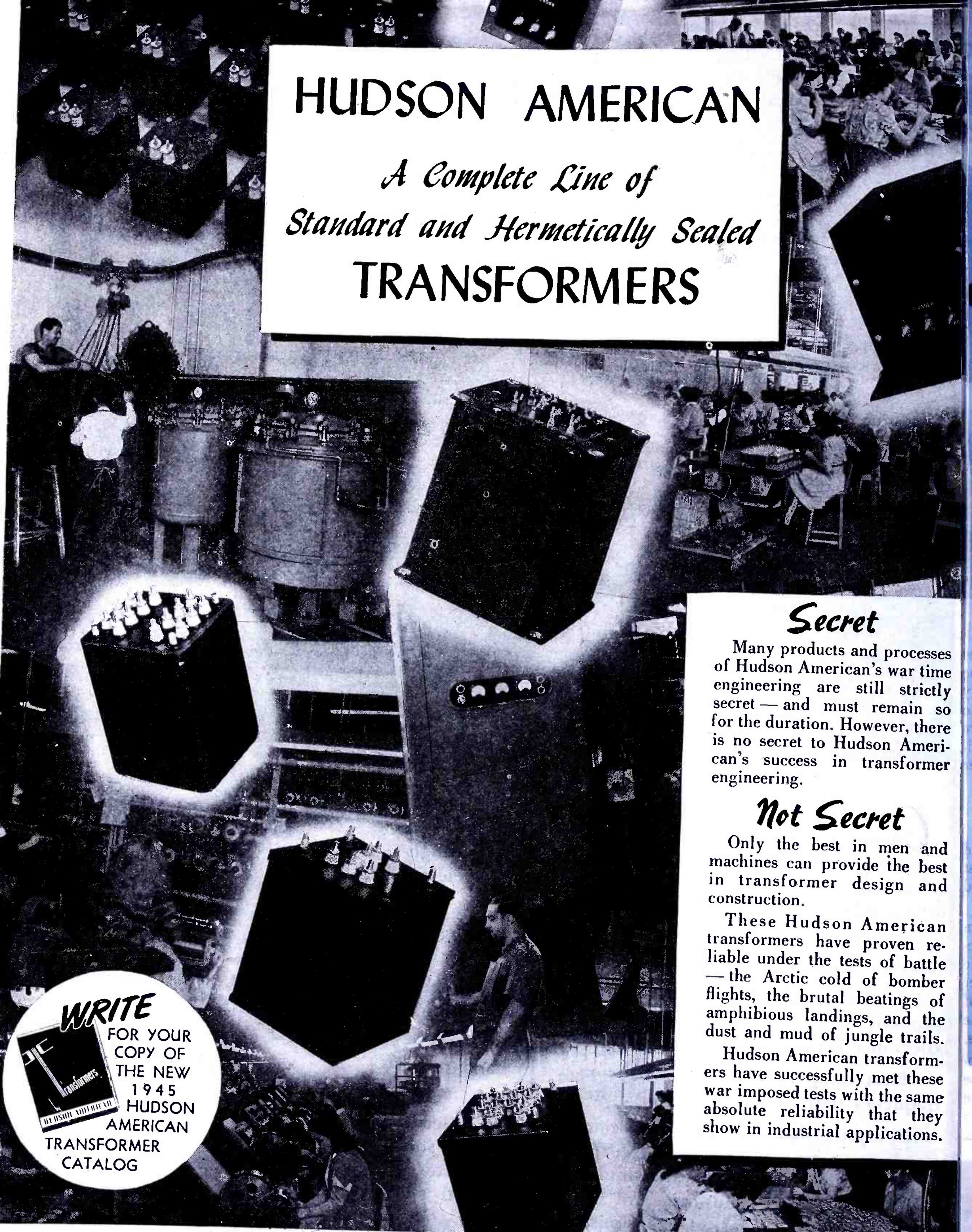


Crystal PRODUCTS COMPANY

1519 McGee Street, Kansas City, Mo.

Producers of Approved Precision Crystals for Radio Frequency Control





HUDSON AMERICAN CORPORATION

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History of Communications. Number Thirteen of a Seri

MILITARY RADIO COMMUNICATIONS

Today the allied military radio equipments represent the "tops" engineering design. Progress from the spark transmitter of World Wa to present-day equipment is, indeed, a far cry. Taking up where the left off December 7, 1941, Universal Engineers, with their added exper ence with precision military equipment, shall produce for the publi electronic devices not of fantastic design – but of proven utility an quality.

After Victory is ours, radio amateurs, affectionately known as "hams will be back after their experience with military radio equipment wit an even greater desire to operate their own "rigs." It will be then tha Universal will again have Microphones and recording component available on dealers' shelves.

< *FREE–History of Communications Picture Portfolio. Contains over a dozen pictures suitable for office, den, or hobby room. Write for your "Portfolio" today.*

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A NEW NAME ON THE ELECTRONICS POST-WAR HORIZON

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

MEC-RAD

DIVISION-BLACK INDUSTRIES

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AEROVOX *Electrolytics*

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The new Aerovox Capacitor Catalog now off the press lists 17 types of electrolytics—round-can, square-can, cardboard-case, tubulars, plug-ins, twist-prong base, etc. You will usually find a type listed that precisely meets your capacitance, voltage, mounting, terminal and container requirements. But if your requirements happen to be very unusual, this wide variety of designs enables Aerovox to work out a special type to meet those high-priority needs quickly, satisfactorily, economically.

● Write for Literature ...

Write on your business stationery for latest catalog on electrolytics. Submit that capacitance problem for our engineering collaboration, specifications, quotations.

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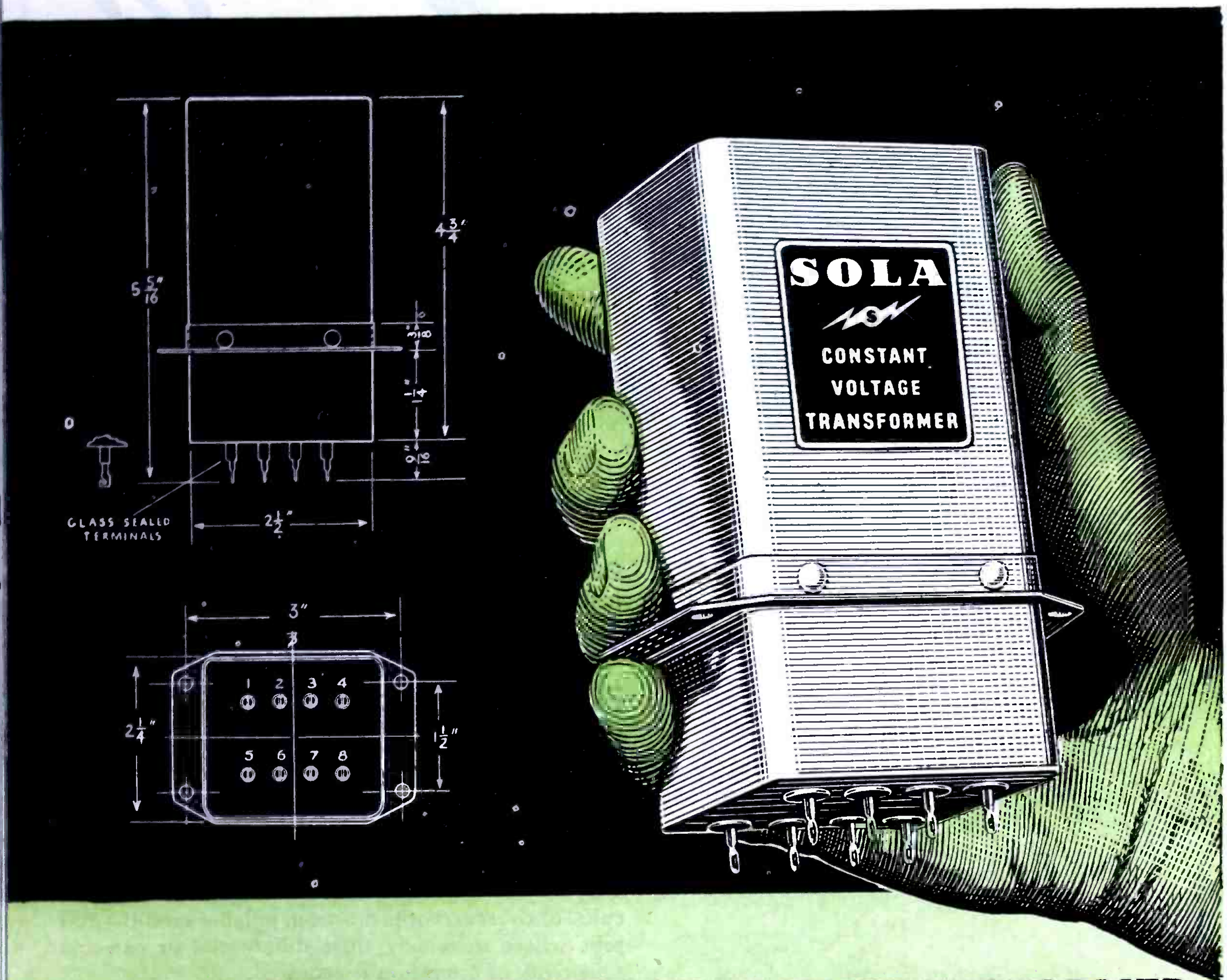


Another SOLA CONSTANT VOLTAGE TRANSFORMER

that has an important future in *YOUR* postwar plans

There may be one vulnerable spot in the design of *your* equipment that this Sola Constant Voltage Transformer will correct.

Your customers do not have the stable line voltage called for on your label. They will blame *your* equipment for inefficient operation, *not* the fluctuating voltages that really cause it.

Build this Sola Constant Voltage Transformer into your product and you can be certain that the operating voltages will always be within ±1% of rated requirements regardless of line fluctuations as great as 30%.

This Sola Constant Voltage Transformer is built to fit your equipment. (Note the small, compact dimensions.) Its low cost will fit your production budget. Its automatic operation will eliminate the need for other costly components, and relieve your customers of the responsibility of making manual voltage adjustments.

There's a powerful sales story behind a product equipped with a Sola Constant Voltage Transformer.

SOLA

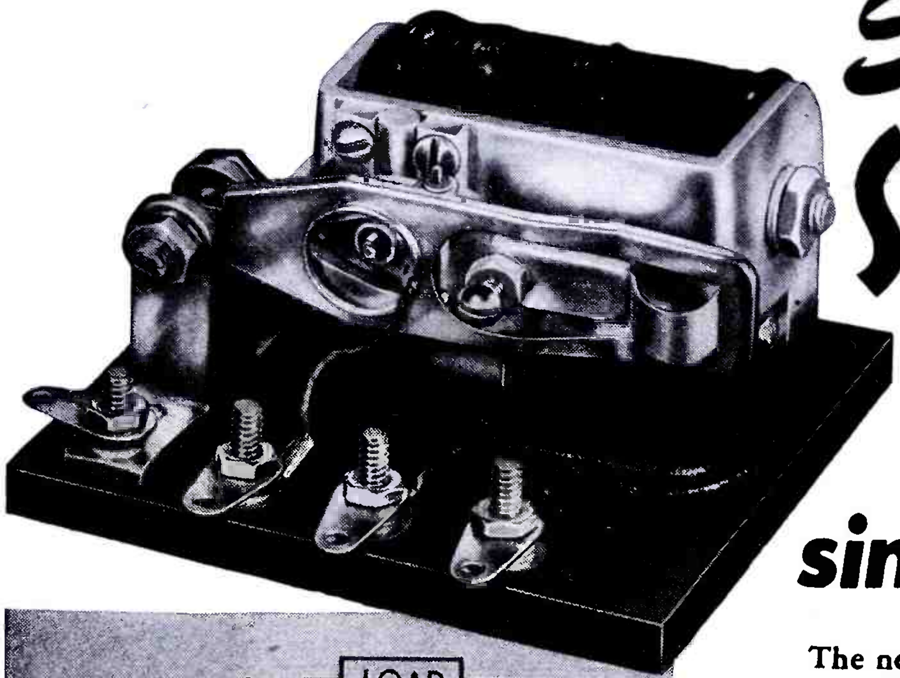
Constant Voltage Transformers

To Manufacturers:

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

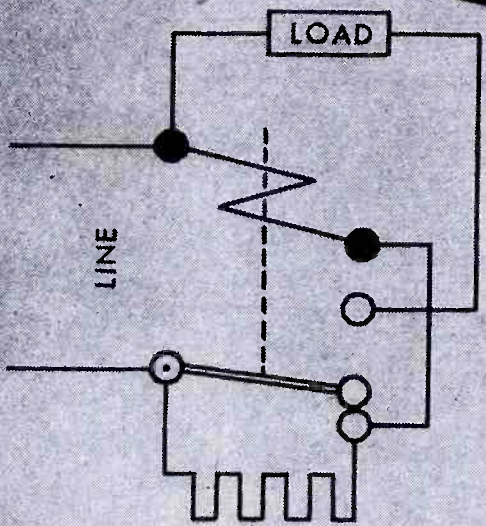
Ask for Bulletin ECV-103

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.**



Sensitive SNAP-ACTION

...in a new, simplified design



A TYPICAL CLOSE DIFFERENTIAL APPLICATION

In using the Struthers-Dunn 79XAX Relay, extremely close differential between pick-up and drop-out may be obtained for potential operation as shown above. The resistor is chosen so that, when the armature closes, the coil current is automatically reduced to a value just sufficient to hold it closed. Any further decrease in voltage will cause the relay to return to its normal de-energized position as shown.

The new, simplified construction of the Struthers-Dunn Type 79XAX Sensitive Snap-Action Relay makes it particularly suitable for a wide range of applications because of its ease of adjustment. Snap-action contacts eliminate the erratic, undependable action normally encountered in ordinary sensitive relays when a slowly varying coil current tends to balance the armature tension spring, and to hold closed the normally closed contacts.

The armature of the 79XAX almost completes its travel in either direction before the contacts snap into the new position. This feature permits an unusually broad range of use from vacuum tube circuits, to overcurrent protection, pulsing circuits, and jobs where extremely close differential or extreme sensitivity of operation is required.

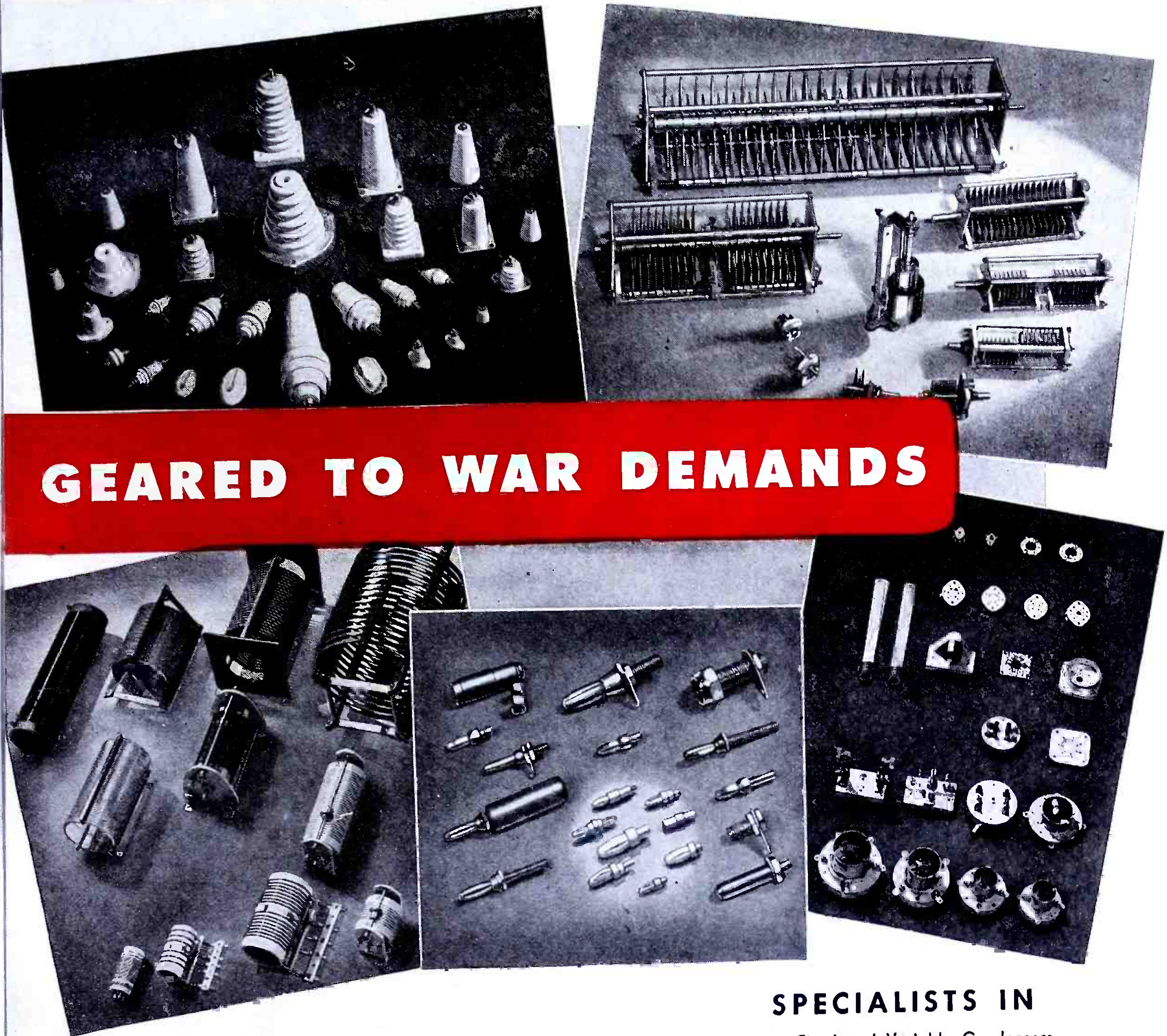
The standard adjustment using 60 ampere turns in the coil at approximately .02 watts results in contact pressures of 5 grams with contacts rated 5 amperes, 115 volts a-c; or 0.5 amperes, 115 volts d-c, non-inductive. Contact ratings up to 10 amperes, 115 volts a-c may be obtained with 100 or more ampere turns and a corresponding increase in power. A sensitivity of 0.005 watts, with 30 ampere turns, is obtainable with reduced contact pressures and ratings, and at an increase in price of the unit.

STRUTHERS-DUNN INCORPORATED
1321 ARCH STREET, PHILADELPHIA 7, PA.

STRUTHERS-DUNN

5,312 RELAY TYPES

DISTRICT ENGINEERING OFFICES: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND DALLAS • DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO • WASHINGTON



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- Fixed and Variable Condensers
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Johnson production facilities are flexible - - 10 or 10,000 - - standard specifications or special - - repeat items or new - - any plating - - any metal or alloy - - any insulation. If it's metal or insulation or a combination of both, try Johnson first.

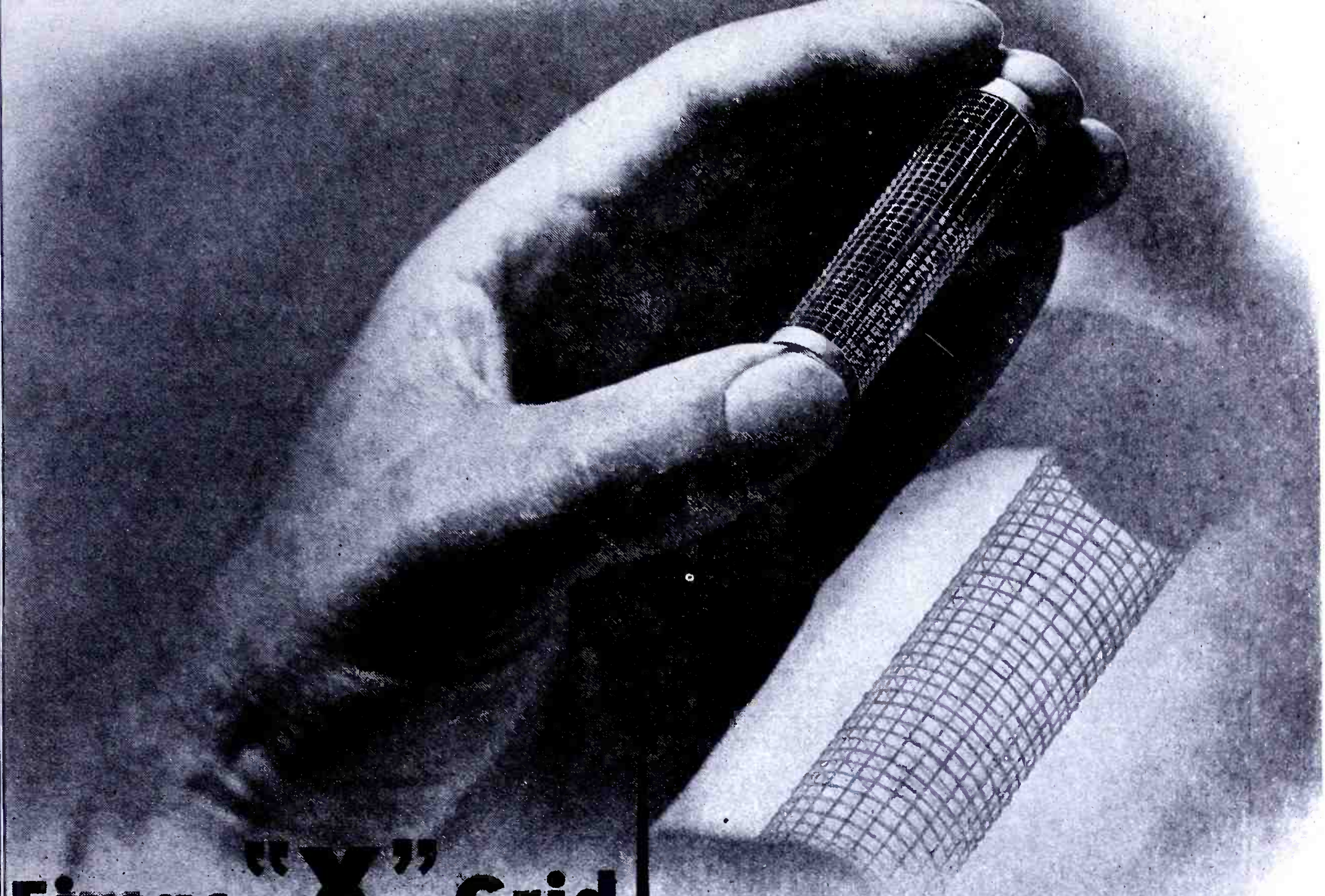
Ask for Catalog 968 (E)

ARMY NAVY

JOHNSON

a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA



Eimac "X" Grid

Solves grid emission problem!

Grid emission, with the resulting instability of operation, parasitic oscillations and prematurely burned out filaments, has become a thing of the past. The new Eimac "X" grid will not emit electrons even when operated at incandescent heat.

The solution to the problem of grid emission lifts a great barrier which has long stood in the path of electron vacuum tube development and the progress of electronics. Eimac Engineers in developing the "X" grid have made a real contribution . . . and a very important one . . . toward the development of new and more efficient vacuum tubes. It is such heads-up Engineering that has made Eimac first choice of leading electronic engineers throughout the world . . . and maintained them in that position year after year.

Follow the leaders to

Eimac REG. U. S. PAT. OFF **TUBES**

ELECTRONIC TELESIS

The layman's handbook of Electronics will be sent you upon request without cost or obligation.

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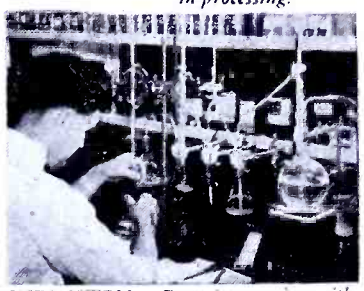
The Science Behind the Science of Electronics

is the focusing of all branches of science upon the development and improvement of electron vacuum tubes.

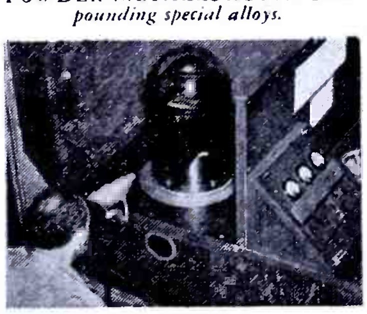
PHYSICS . . . Especially designed electron microscope enables operator actually to view electron emission.

OPTICS . . Photomicrographic studies help achieve perfection in processing.

POWDER METALLURGY . . . Compounding special alloys.



CHEMISTRY . . . Experimentation with metallic components and preparation of chemical compounds.



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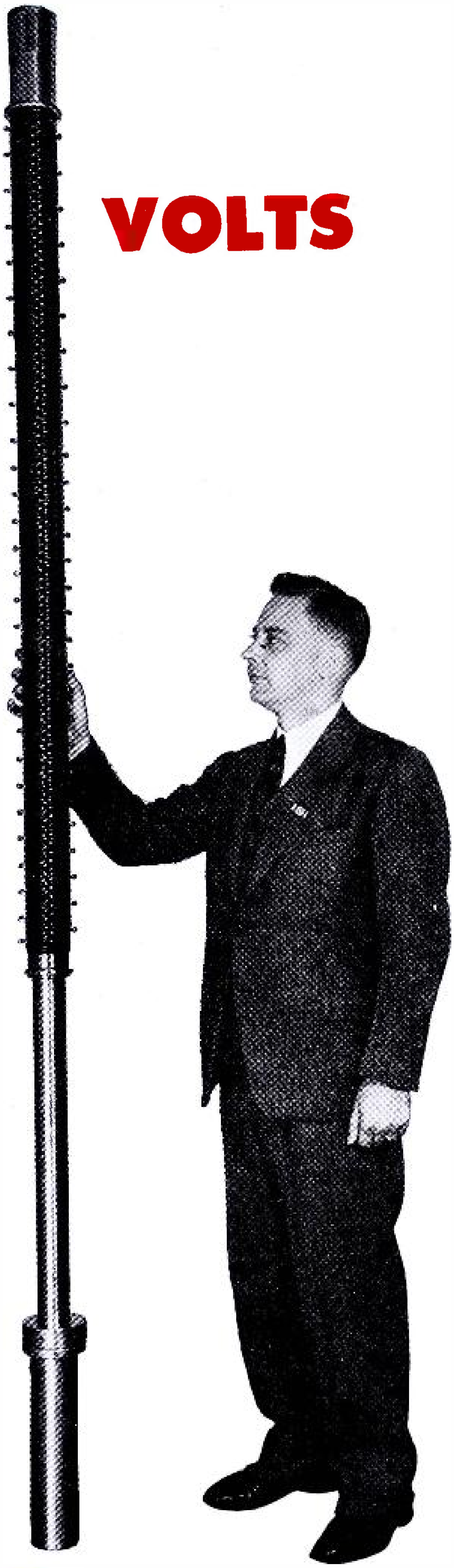

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WE ARE not going to tell you here why this tube was made, what it does, or what it is for. The important thing about it to you as a user of radio oscillator, amplifier and rectifier tubes for communications or induction heating is that it represents the toughest assignment ever handed the electronic tube industry, and that of all tube makers only Machlett perfected the techniques that made the tube possible.

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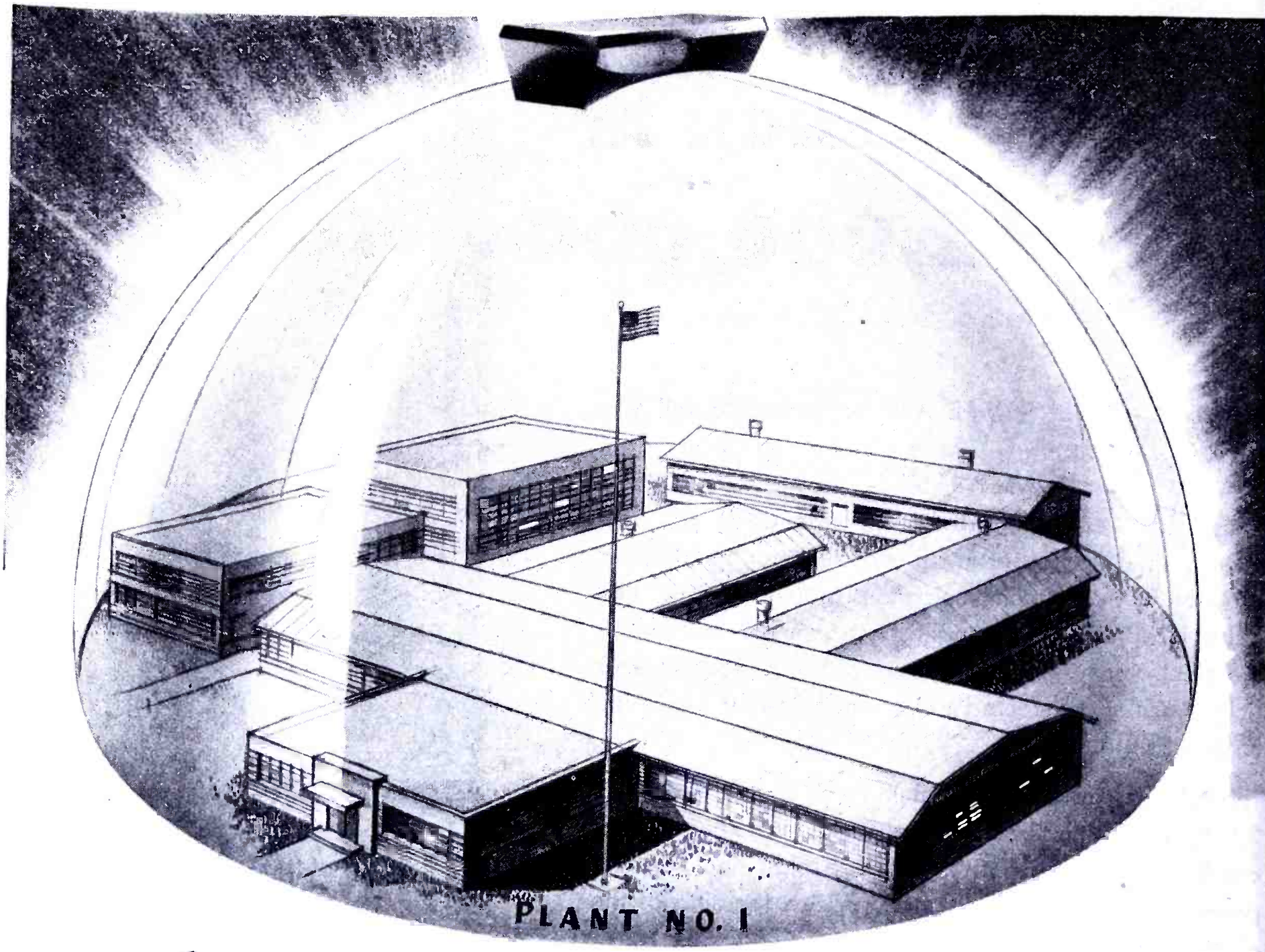

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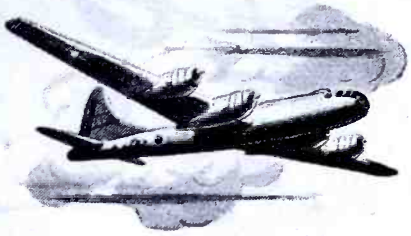

American airmen never fly alone! Riding with them go the combined skills and efforts of many thousands of war workers and technicians. To their targets... and safely back to their bases . . . the finest equipment that man can produce flies with them.

Eastern is proud of the part its equipment plays in these great missions. Before the war, amplifiers were thought of only for their use in sound amplification. Today, thanks to the tremendous advancement in Army and Navy practice, amplification finds new fields of service in step with vital war instruments.

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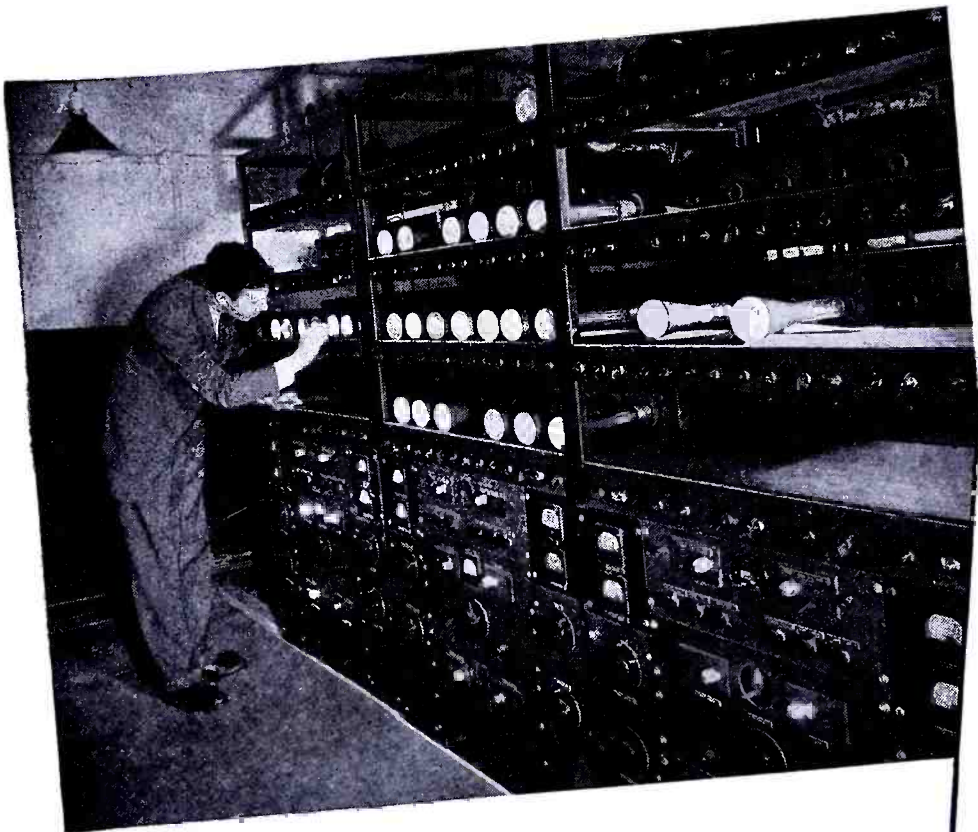

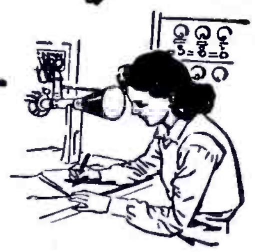

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Percentage sample tests—some 100%—are made on production runs for the following:

Brilliance and screen condition—color, spots, burns, etc.

Examination of cathode by using tube as an electronic microscope. The few thousandths of an inch diameter gun aperture is magnified to ½ inch circle to check uniformity of emitting surface. Cathode emission current is measured.

Deflection sensitivity is tested to determine amplitude of signal required to deflect beam by given amount.

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And other critical and vital factors entering into satisfactory, long, economical tube performance.

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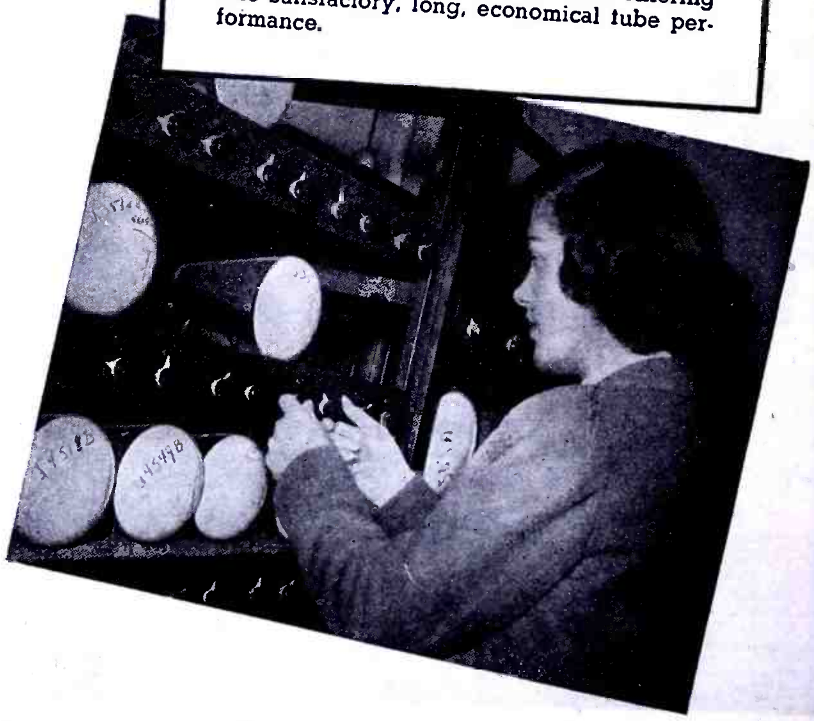

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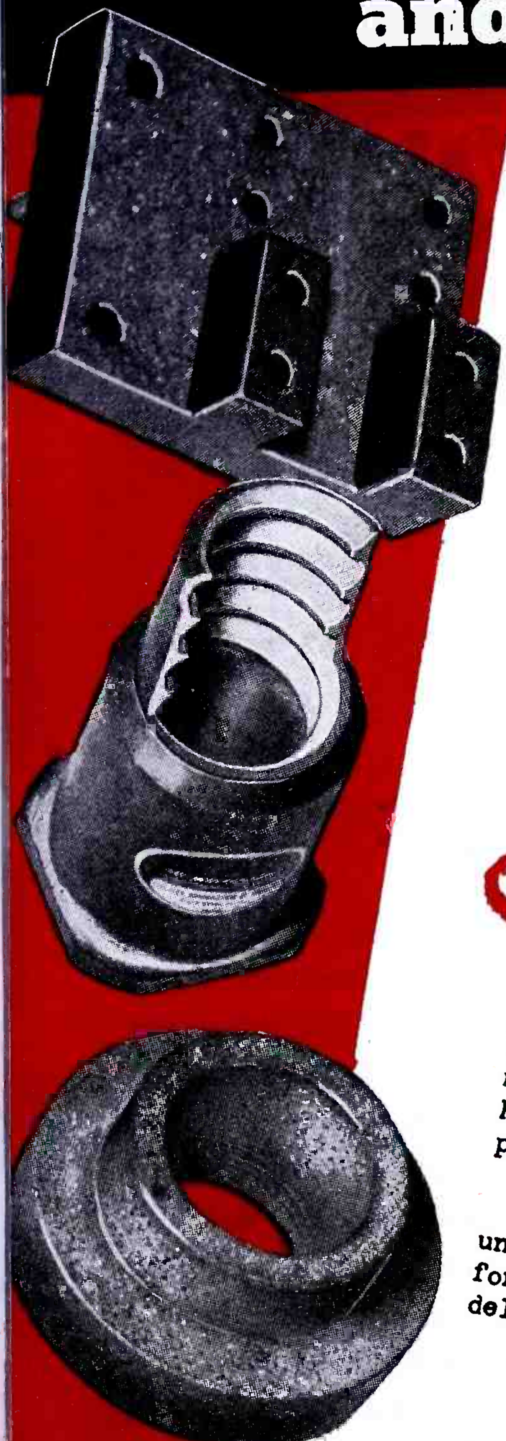

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September 15, 1944

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Attention: Mr. Jerome Taishoff, President

Gentlemen:

In the development of special apparatus, to be supplied on a Navy contract by Hazeltine Electronics Corporation, it was found necessary to utilize a material with a dielectric constant of 12-15.

We put our problem in the hands of your company.

The cooperation which we received from your organization is to be very highly commended. The special material, which was developed after much experimentation and research on your part, has maintained a constant dielectric all through production.

We have delivered a quantity of these units to the Navy, and we wish to again thank you for the large part you played in making the delivery of these vital equipments possible.

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J. E. Gray

J. E. GRAY
Co-ordinating Engi...

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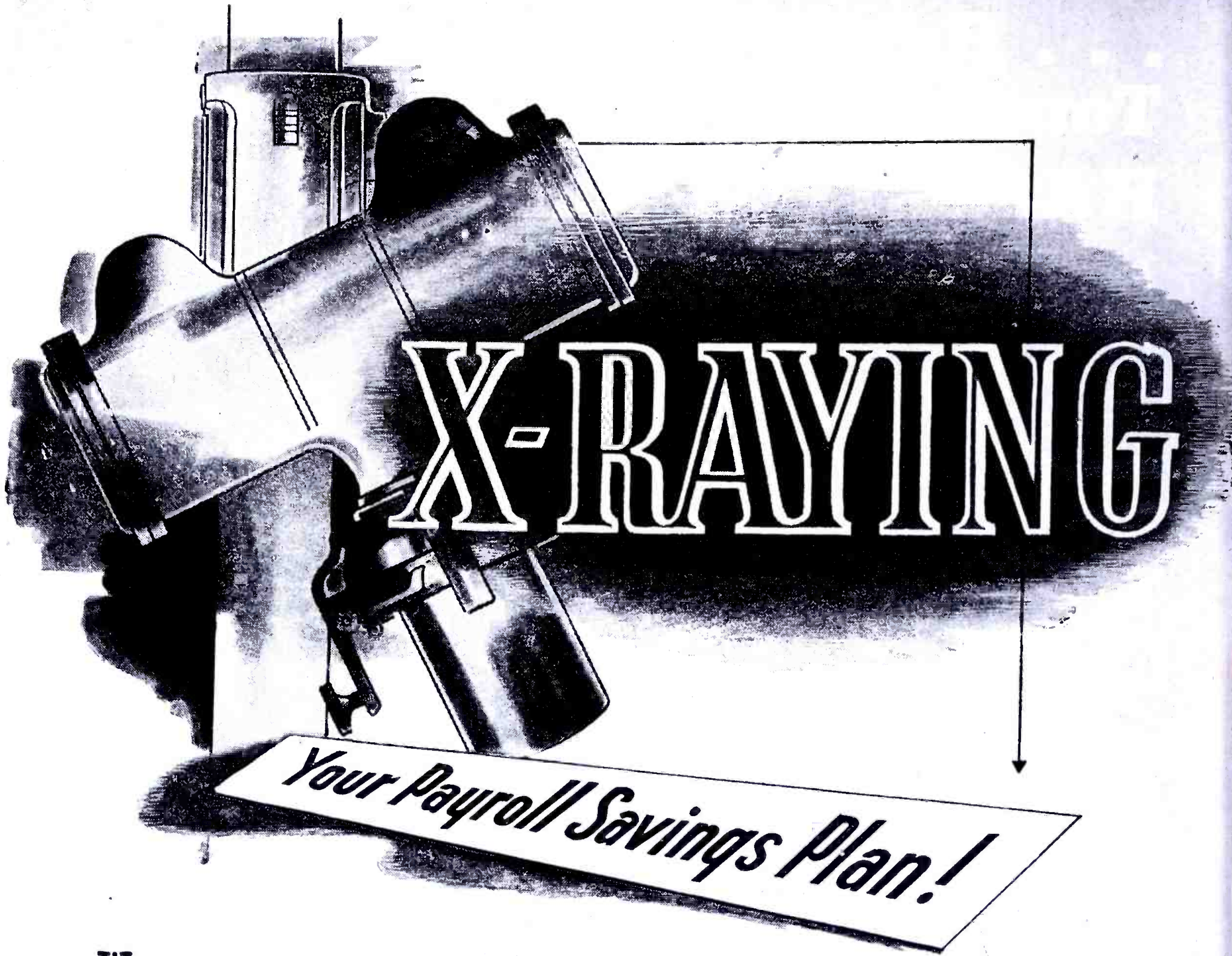

We can all see with the naked eye that the Payroll Savings Plan provides the most stable method of war financing. Analyze it under the X-ray of sound economics and other important advantages are evident.

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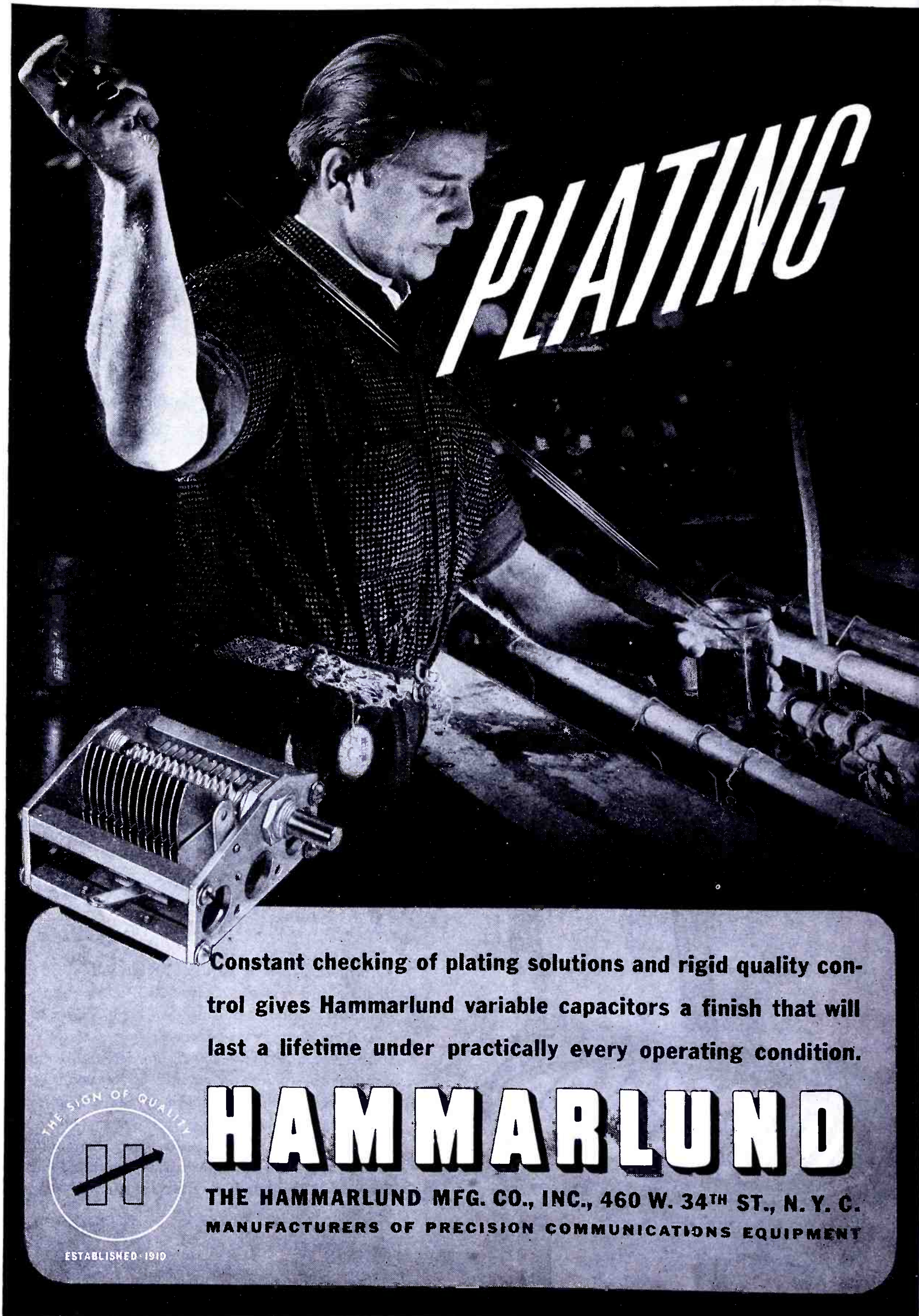
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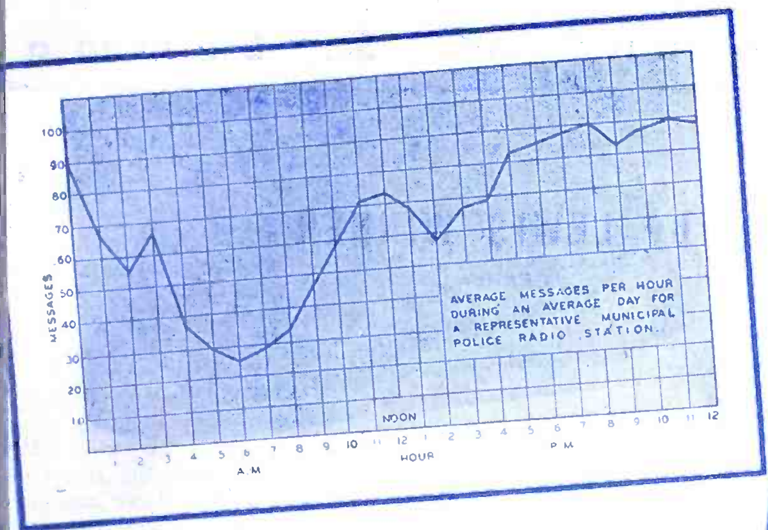
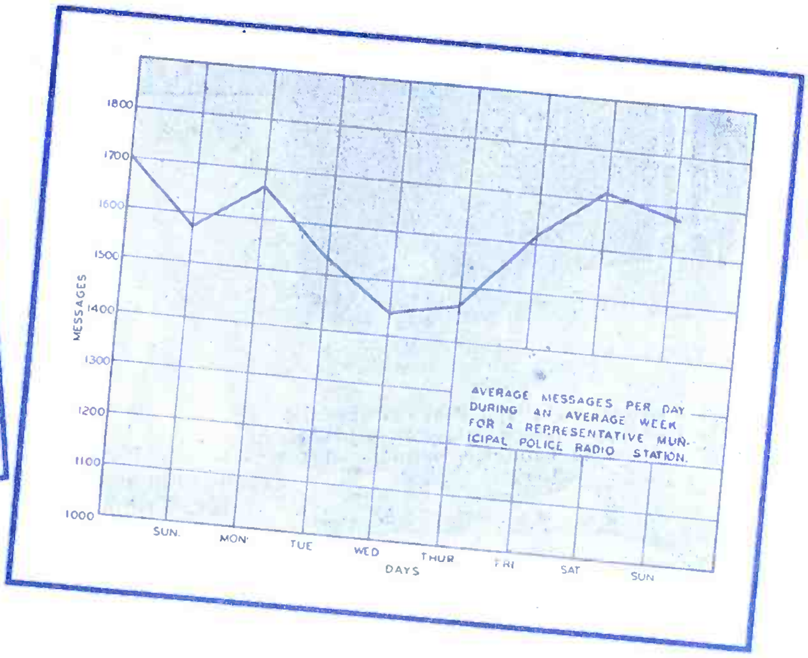
COMMUNICATIONS

LEWIS WINNER, Editor

* * JANUARY, 1945 * *





Figures 1 and 2
Graphs illustrating daily and hourly message traffic of a typical municipal police radio station.

POLICE COMMUNICATION

PROBLEMS FACING ENGINEERS TODAY

by LEWIS J. BOSS

Captain, Radio Supervisor
Warwick Police Department
Apponaug, R. I.

THE postwar development and expansion of the communication services of law-enforcing organizations presents emergency radio-communication engineers with immediate problems more serious than any group of radio men have ever attempted to solve. The expansion of existing safety and law-enforcement communication services and the establishment of new services on a firm economic and engineering basis will require the highest degree of understanding and cooperation between the regulatory branches of government and the communication divisions of the safey organizations themselves.

Radio communications in the police department has, from its inception over fifteen years ago, amply proved its value in the apprehension of criminals and in the coordinating of the activities of the mobile units of the police department. Law-enforcement agencies entrusted with the responsibility for public safey within the areas protected by them must necessarily depend upon an adequate communication system if they are to successfully combat crime. Without adequate and reliable means of communication their organizations and equipment are helpless and will fail to achieve their intended purpose in exactly the same degree as their communication systems are inadequate and unreliable.

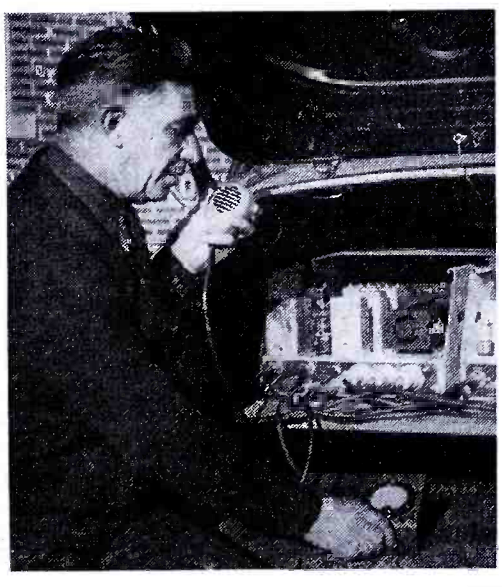


Figure 3
Captain Boss testing an h-f f-m two-way unit used by the Warwick police.

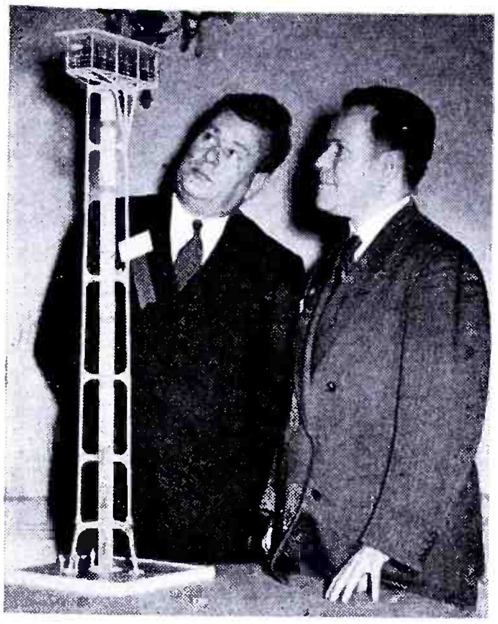
Metropolitan Area Problems

Approximately 68,403,000 persons live in the metropolitan areas of the United States. In these heavily congested areas there is a vital necessity for immediate and direct communication between headquarters and those peace officers assigned to duty throughout the area. In these localities, cities and towns closely adjoin each other and their respective police departments use the radiotelephone for communication to police cars very extensively.

In the metropolitan New York area there are instances where fifteen or more police radio systems are trying to communicate on the same frequency. It is estimated that there are some 3,000 po-

(*Continued from page 77*)

A REPORT ON THE TECHNICAL PANEL



Highlights of Comment

By M. A. Trainer, J. E. Keister and W. S. Lemmo

by LEWIS WINNER

Editor

Walter S. Lemmon, right, and Paul Chamberlain with model of the automatic relay tower I.B.M. and G.E. propose to build for multiplex operation.

THE first annual TBA conference, held in New York City recently, saw over 1000 in attendance. Among the many interesting features offered was a technical panel meeting presided over by C. A. Priest of General Electric.

Among those appearing on the panel were: Merril A. Trainer, RCA; J. E. Keister, G.E.; Walter S. Lemmon, International Business Machines; Dr. Peter C. Goldmark, CBS; Paul Chamberlain, G. E.; and David B. Smith, Philco.

Camera and Picture Tube Developments

Mr. Trainer introduced his phase of anaylsis with data on television pickup tubes that were in general use before the war. He pointed out that the most important of these have been the iconoscope, the image dissector tube and the orthicon.

He said that wherever sufficient light was available the iconoscope has been the first choice, because of its superior resolution capability and its desirable gamma characteristic. The iconoscope's light range and gamma property make it particularly suitable for scenes with ample lighting without any difficulties due to high light saturation, he stated. Thus it is quite useful for out-door pickup.

He also pointed out that the general cleanness of the picture obtained with an iconoscope had made it almost universally used as the camera tube for live talent studios. Describing resolution of the iconoscope, he said that it is sufficient at the present time to reproduce practically any picture detail which can be transmitted over the standard television channel. And, he continued, because of its *storage* property, the iconoscope has also been generally used in film cameras. Modified intermittent type projectors are used in this application, he explained. That is, the picture is flashed on the mosaic during the vertical blanking time and the mosaic is scanned during the following dark period.

Mr. Trainer also discussed some of the undesirable features of the iconoscope. There are, he said, spurious shading signals and flare which must be electrically compensated in producing a good picture. At times such compensation represents an added complication in a practical setup, he explained. In addition, he said, the relatively large size mosaic used in an iconoscope requires the use of large camera lenses. For telephoto shots this may result in relatively unwieldly cameras. Another requirement for the iconoscope is the use of keystone correction scanning, he said. This was once a more serious problem from the circuit standpoint than it is at present. He said that this draw-back might be classified more as a nuisance than a limitation.

Large orthicons are generally used for out-of-door events where the lighting is usually more unfavorable, according to Mr. Trainer. He said that its sensitivity is 4 to 5 times better than that of the iconoscope. However, he pointed out, the picture as compared to an iconoscope picture has a tendency to lack snap because of the strictly linear gamma characteristic. Accordingly, an increase of picture detail brightness by a factor two in the orthicon will increase the video signal by a factor two, explained Mr. Trainer. In the iconoscope this increase can be much less. This gamma characteristic, tending to compress whites appears to be very desirable, said Mr. Trainer. And in an orthicon camera it can be obtained by the introduction of gamma correction in the video amplifiers, but at the expense of increased noise in the picture. Mr. Trainer also pointed out that the smaller mosaic not only allows the use of shorter focal length lenses for a given field but the use of longer focal length lenses of large effective aperture for telephoto effects. The limited light range was described as one of the major and somewhat annoying limitations of the orthicon.

According to Mr. Trainer, when viewing a scene, the mosaic will charge up with picture highlights above a rath[er] definite value, and unless the beam cu[r]rent is increased under these conditio[ns] the charge can spread over the enti[re] mosaic, completely obliterating the pi[c]ture. A spot pickup such as is encounter[ed] at a football game offers a practic[al] example of this limitation. He said th[at] it is very possible to have a scene whic[h] may consist of part sky and part grou[nd] or a highly illuminated section of t[he] field together with a shadowed portio[n]. In such a case explained Mr. Traine[r] the operator has a choice of allowing t[he] highly illuminated portion to stick to so[me] degree, wiping out detail in the hig[h]lights rather completely, or stoppi[ng] down the lens to the point where t[he] highly illuminated portion is satisfactori[ly] transmitted, but generally at the expen[se] of insufficient illumination in the lo[w] lights. The iconoscope automatical[ly] provides for this range characterist[ic] which can be so troublesome, continue[d] Mr. Trainer.

The so-called *S* distortion and ion sp[ot] formation, a prewar orthicon limitatio[n] was also analyzed. Mr. Trainer said th[at] this distortion, has been due mainly [to] practical limitations of the electron-opti[c] design, which is relatively more com[p]licated than in other pickup tubes. Wi[th] new developments it is probable that t[he] distortion introduced by an orthicon pickup of a scene can be reduced to [a] very acceptable value.

Discussing the image dissector, M[r.] Trainer pointed out that it has not bee[n] used extensively as a live talent came[ra] tube because of its relatively low se[n]sitivity. However, he said, because of t[he] absence of shading signal from the di[s]sector tube it has found use as a fil[m] camera tube. This is because the tu[be] inherently does not have memory [or] storage. Thus it is used with a continuo[us] film projector to produce satisfacto[ry] pictures free of shading.

Improvements in tube design were al[so] analyzed by Mr. Trainer. He showed th[at] the resolution capability of the iconosco[pe] has been increased by the use of an in[m]proved gun design to produce a bett[er]

SESSION AT THE TBA CONFERENCE

fined scanning spot. In addition, special ocessing and electrode arrangement ve helped to reduce edge flare and ading troubles. He said that a large ctor in the improved performance of e iconoscope has been our increased preciation of the role of bias and edge hting.

The orthicon tube appears to provide e greatest possibility for radical im-rovement in pickup tube performance cording to Mr. Trainer. Thus far great rides have been made mainly in the rection of increased sensitivity and nge.

Covering factors which represent goals r performance, Mr. Trainer offered four ctors These were:

(*1*)—Increased sensitivity, allowing for eration under adverse lighting condi-ons or reduced studio lighting.

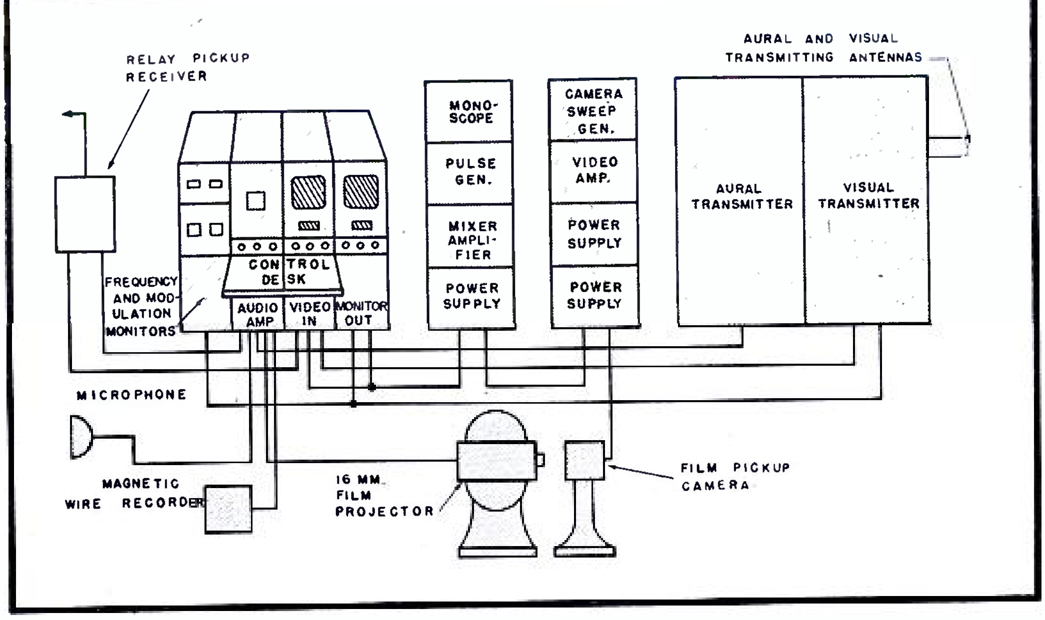
(*2*)—Resolution, which should be suf-ciently good to reproduce at least all etail which can be transmitted over as-gned frequency channels. This resolu-on requirement may be tempered by the erformance of a tube under low light nditions. That is, a tube which has tremely good sensitivity may have mewhat less resolution than the ideal nd still be a very useful device for pick-g up spot broadcasts.

(*3*)—The operating light range shall e sufficient to reproduce satisfactorily enes in which illumination can vary idely. The tube shall be free from icking in the highlights and yet give etail in the darker portions of the pic-ure. The gamma characteristic should e under control so as to give desirable hite signal compression.

(*4*)—The geometrical distortion such s *S* distortion in the orthicon shall be o low as to be unnoticeable on the verage transmitted scene.

icture Tubes

Mr. Trainer said that the most sig-ificant development in picture tubes has een the combination of a high-voltage rojection type kinescope with a Schmidt-ptical system to make a practical pro-ection receiver for home use. He xplained that a 4" or 5" kinescope perating at 25 to 30 kilovolts in a Schmidt-optical system having a 12" to 4" spherical mirror and a suitable cor-ecting lens will produce a very satisfac-ory 15" x 20" picture. Such a picture, e said, has a brightness of approximately foot-lamberts in the highlights and, at he present time, a contrast range of 5 to 1. He pointed out that experiments with many types of translucent projection creens used with this system indicate hat it may be possible to increase the ontrast ratio to approximately 40 to 1, which is about as good as can be obtained n a direct viewing kinescope. Describing he Schmidt optical system, he said it has n equivalent *f* number of 0.9 and a hrow of 34" to 36"; capable of 1500-ine resolution and should therefore in-roduce no loss in detail with a 525-line icture. He explained that a polished and luminized glass spherical mirror with molded-plastic correcting lens repre-ented the most satisfactory Schmidt system combination for projection receivers at the present time.



Typical setup of equipment that will be employed by satellite stations, according to J. E. Keister of General Electric.

Postwar direct-viewing picture tube improvement trends include operation of the kinescope with 12,000 volts or more on the second anode instead of the 6000 volt rating used before the war, according to Mr. Trainer. This voltage provides a substantially brighter picture. Horizontal back-kick rectifier systems will probably provide the necessary d-c voltage, he said. Flat-faced tubes appear to be another trend. Two types which give promise of being widely used according to Mr. Trainer, are the 10" flat-face round tube and the 14" diagonal flat-face rectangular tube. Mr. Trainer said that the use of these tubes will allow for a more pleasing picture of larger size than was practical with tubes of prewar design.

Ion spot formation common to prewar kinescopes, will probably be greatly retarded or eliminated completely in postwar kinescopes, disclosed Mr. Trainer.

SATELLITE TELEVISION STATIONS

THE place of satellite stations in a television system served as a basis of a discussion by J. E. Keister. He said that a satellite station in its simplest form is one which originates no local live talent programs, serving its locality by broadcasting programs fed to it by a network. In some localities satellite stations may be installed by the television network operators themselves to serve the smaller communities he said. Thus, he explained, stations serving smaller communities can supply the quality of entertainment or educational programs which otherwise could only be justified by a few installations in densely populated areas.

Mr. Keister explained that most relay systems contemplated at present expect to supply at least two channels in each direction on the main artery. Thus two sources of programs can be originated simultaneously on a single network set-up. A satellite station then has a choice of programs with the accompanying benefit of variety to fit its own particular needs, he said.

It usually can be assumed that the satellite station is off the main artery and so a simple one-way branch relay will be used, according to Mr. Keister. In many cases a single jump from the main relay tower to the satellite station will suffice, he explained. If not, simple one-way repeater stations would be installed at the required intervals.

Describing the satellite station itself, he said that it consists essentially of a receiving antenna to pick up the relayed signal, receiver for amplifying and demodulating both the aural and visual components, monitor to provide a running check on the signal, and finally the main transmitter for broadcasting the sound and picture to the surrounding area. The actual power output will depend on the topography and area served, he said. Since the FCC in authorizing the construction of satellite stations doubtless will require some means of both aural and visual station identification, equipment for such identification will be necessary, Mr. Keister stated. This would involve the inclusion of a monoscope signal generator, as associated pulse generator and sweeps, and suitable audio and transcription equipment; personallized monoscopes can be anticipated with the stations own call letters inscribed.

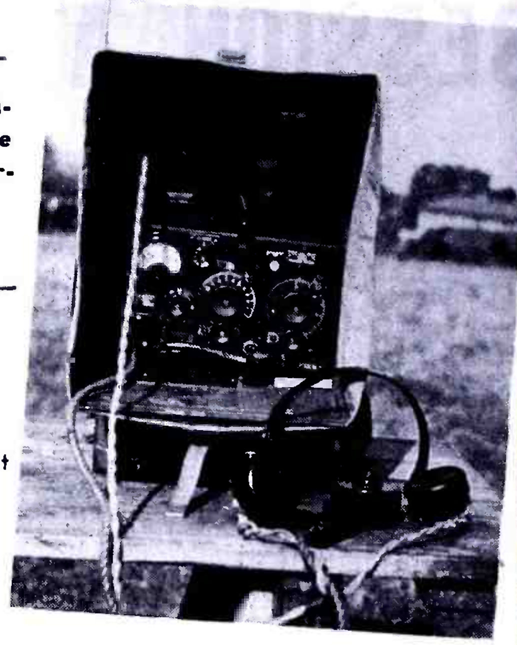
Since the interest shown in local news events will usually justify the addition of equipment for the origination of film programs, many satellites will require a motion picture projector, film pick-up camera, camera amplifier and control equipment. With these film origination facilities available, said Mr. Keister, the local satellite station operator can, with a 16-mm silent motion picture camera, take pictures of local events.

By capitalizing on this simplified type of station to augment the stations serving

(*Continued on page* 75)

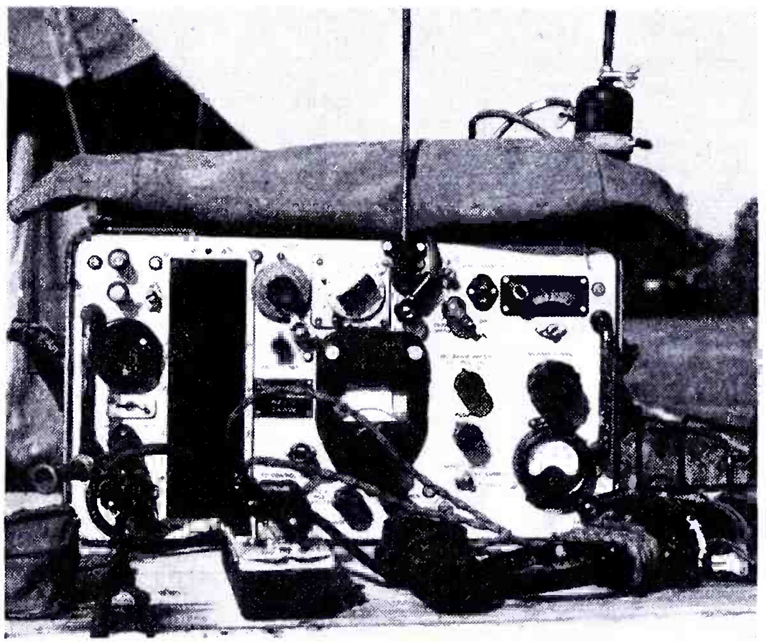
Equipment shown in these British Official photos was designed for airborne operations, such as those recently carried out in Holland.
(*Crown Copyright Reserved*)

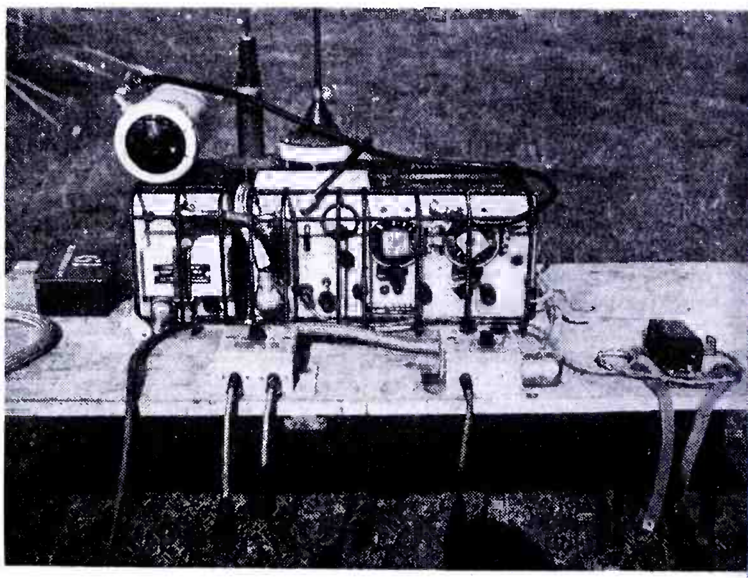
Right, a short-range radiotelegraph unit used by the infantry.



Radiotelegraph pack set used by the infantry.

BRITISH AIRBORNE COMMUNICATIONS EQUIPMENT





Left, above: A medium-range unit for telephony and telegraphy used in vehicles and by ground stations. Left, below: Medium range radiotelephone set for tanks or trucks.

(*Truck view, courtesy U. S. Signal Corps*)

Above, a medium-range radiotelephony set similar to that shown mounted in command car at lower left. Below, the telephony and telegraphy unit, shown at left above, in container for dropping by parachute.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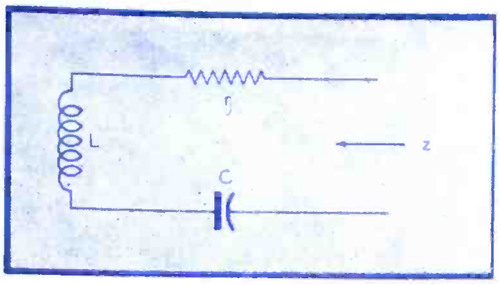
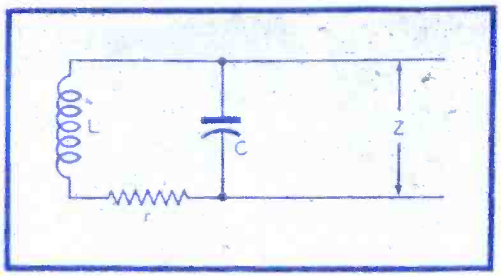
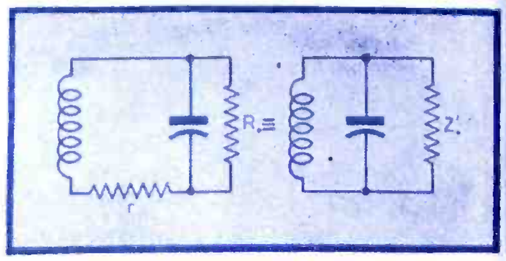
ELECTRONIC AND RADIO TUBES
DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS







Figures 1, 2 and 3 (left to right, above)

Figure 1, a single-tuned circuit with a series impedance z. Figure 2, the single-tuned circuit with a parallel impedance Z. Figure 3, circuit with a resistor across to reduce effective Q, providing a resonant impedance Z'_o.

COUPED CIRCUIT

by J. E. MAYNARD

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This paper is based on notes taken for the most part from a course, "Radio Engineering II," developed by the author for the ESMWT program at Rensselaer Polytechnic Institute. An objective of the course was to develop the quantitative approach to radio circuits, to correlate theory and practice. In laboratory experiments and problems the prediction of results by calculation was emphasized.

ONE of the subjects treated in some detail in the ESMWT RPI course was that of tuned and coupled circuits. It may be shown that[1] a single tuned circuit has the series impedance z, Figure 1,

$$z = r\,(1 + jS) \qquad (1)$$

and has the parallel impedance Z, Figure 2,

$$Z = Z_o/(1 + jS) \qquad (2)$$

$$S = Q_o\,(\Delta f/f_o)\,(1 + f_o/f)$$

in which zero subscripts refer to values at resonant frequency f_o, where, by definition, $X_L = X_C = X_o$. Frequency deviation $(f - f_o)$ is represented by Δf, and Q_o is the quality factor of the circuit at f_o. The impedance Z_o is parallel impedance at resonance, $Z_o = X_oQ_o$. Equation *2* is a very close approximation if Q_o is 10 or more, which covers essentially all coils used in tuned circuits. If Δf is 10% of f_o or less we can make a further simplification by the approximation

$$S = (2\Delta f/f_o)\,Q_o \qquad (3)$$

Now if we place a resistor across the circuit, which is often done to reduce the effective Q of the circuit, its effect may be accounted for by considering the circuit to be one having a new resonant impedance Z'_o.

$$Z'_o = Z_oR_o/(Z_o + R_o) \qquad (4)$$

Since $Z_o = X_oQ_o$, the new circuit has a new quality factor

$$Q'_o = Q_oR_o/(Z_o + R_o) \qquad (5)$$

The reactance X_o is, of course, the same in either case under the approximations we have made.

Coupled Circuits

Any pair of tuned circuits may be coupled in several ways, Figure 4. Pi networks may always be reduced to equivalent T networks[2] and circuits coupled by inductive fields may always be reduced to an equivalent T of inductive coupling, although it may require a fictitious negative inductance for reversal of polarity.

Now if we disregard the case in which capacitive and inductive coupling become equal and opposite, a possibility for one polarity in circuit (*f*), then all these cases may be represented by one general circuit, Figure 5.

This represents a primary resonant circuit of series impedance z, coupled to a secondary resonant circuit of series impedance z_2 by a common impedance z_m. It will be assumed that z_m contains no resistive components and further that its value remains fixed at its resonant frequency reactance. The result of these assumptions is symmetry about f_o. This conforms closely to practical performance when Δf is less than 10% of f_o, and when the coupling impedance has a normal quality factor.

The circuit of Figure 5 may be solved for either i_1 or i_2 in terms of the driving voltage e. Starting from the circuit equations

$$e = i_1z_1 - i_2z_m \qquad 0 = i_2z_2 - i_1z_m \qquad (6)$$

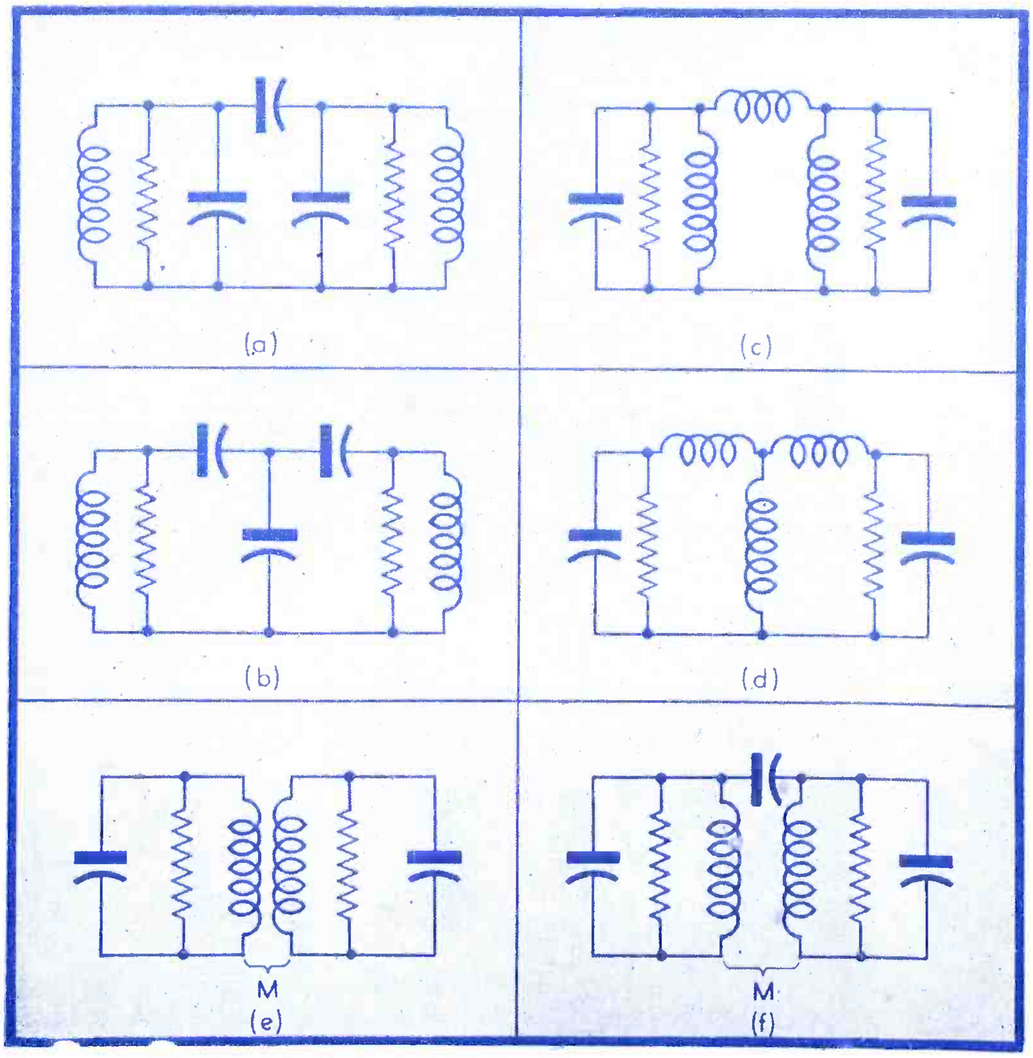

Figure 4
Various methods used to couple circuits.

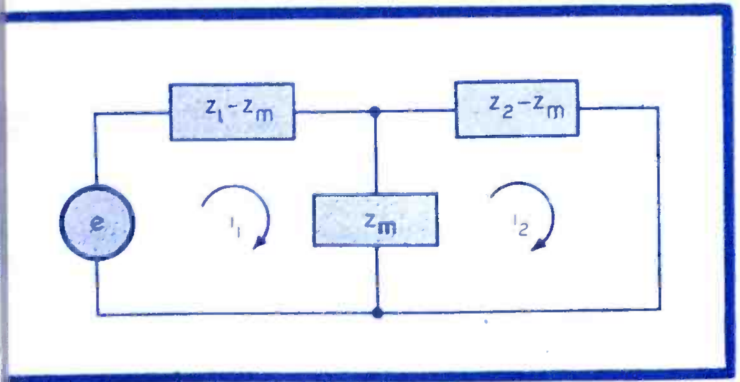

Figure 5
A general circuit, covering all cases, if we disregard the case in which capacitive and inductive coupling become equal and opposite.

DESIGN

e obtain

$$= i_1 (z_1 - z_m^2/z_2) \quad (7)$$

$$(z_m/z_1) = i_2 (z_2 - z_m^2/z_1) \quad (8)$$

These solutions illustrate a concept of he circuit operation which is often conenient. The impedance in the primary nd also in the secondary has been hanged by a *coupled-in* impedance z_m^2/z_2 the primary and z_m^2/z_1 in the secndary. The driving voltage in the secndary may be considered as the driving oltage *e* divided in the ratio z_m/z_1. hese two equations are the fundaentals of a pair of coupled circuits. rom equation *8* we can determine what appens to a signal as it passes through; om equation *7* we can determine what rt of impedance the primary presents the driving circuit.

oupled Circuit Selectivity

The values of z_1 and z_2 are the series npedances $r(1 + jS)$ for the primary d secondary respectively. The common npedance z_m becomes $+jX_m$ for inctive coupling or $-jX_m$ for capacitive upling. Using the coefficient of couping $K = X_m/\sqrt{X_1X_2}$ and defining the llowing new terms

geometric mean	$Q = Q_g = \sqrt{Q_1Q_2}$	(9)
arithmetic mean	$Q = Q_a = (Q_1 + Q_2)/2$	(10)
equivalent equal	$Q = Q = Q_g\,(Q_g/Q_a)$	(11)
selective variable	$S = (Q/Q_1)S_1 = (Q/Q_2)S_2$	(12)
oportional coupling	$C,\ 1 + C^2 = (Q_g/Q_a)^2 + K^2Q^2$	(13)
attenuation	$U = (\text{gain at } f_o)/(\text{gain at } f)$	

may be shown[1] that the attenuation or lectivity curve for a pair of coupled rcuits is

$$U = \frac{\sqrt{(1 + C^2 - S^2)^2 + 4S^2}}{1 + C^2} \quad (15)$$

his follows from equation *8* and is a eneral expression for attenuation which ay be utilized for circuits having the me or different *Q* in primary and secndary. The proportional coupling *C* as a value of 1.0 for a flat characristic at the transition from single to ouble peaks.

To reduce Figure 5 to a practical sysm, let us consider the circuit of Fige 6. The tube is now providing the iving voltage *e* of Figure 5, all circuit ading is lumped in the resistors R_1 and R_2 so that $Q_{o1} = R_1/X_{o1}$ and $Q_{o2} = R_2/X_{o2}$. It is, however, notable that the tube is driving across the primary, whereas *e* in Figure 5 is a series driving voltage. The two situations may be reconciled. A tube driving a load may be represented as a voltage source or as a current source, Figure 7.

The voltage e_z developed across *Z* must be the same by either representation.

$$\mu e_g Z/(R_p + Z) = g_m e_g[ZR_p/(Z + R_p)] \quad (16)$$

Since $g_m = \mu/R_p$ the identity of results is apparent. Figure 6 may therefore be represented by a current $g_m e_g$ operating into the primary with R_p absorbed in R_1. Now we can relate Figures 5 and 6 through Figure 8. Circuit (*a*) represents Figure 5 and circuit (*b*) represents Figure 6.

The relation to be established is that the current *i* be identical in the two cases. This means that the voltage drop $g_m e_g Z_1$ must equal the driving voltage *e*. The impedance Z_1 may represent the reactance of C_1, and Z_x the impedance of the remainder of the circuit including R_1 and the coupled-in impedance from the secondary. Z_1, of course, varies with frequency; this produces non-symmetry which will be neglected so that *e* may be assumed constant with frequency variation for practical calculations

$$e = -jg_m e_g X_{o1} \quad (17)$$

Primary Impedance

If we are interested in the plate voltage appearing at the primary circuit either for determining overload conditions or for determining performance of such circuits as discriminators, avc rectifiers, etc., we will want to know the impedance at the primary from plate to ground. Suppose, therefore we identify the a-c plate current in Figure 6 as i_p and a-c plate voltage as e_p, then primary impedance $Z_p = e_p/i_p$. In equation *7* the driving voltage $e = -jX_{o1}i_p$ and the primary circuit current $i_1 = e_p/-jX_{o1}$. From these relations we find

$$Z_p = -X_{o1}^2(i_1/e) \quad (18)$$

or, using equation *7*

$$Z_p = -X_{o1}^2 z_2/(z_1 z_2 - z_m^2) \quad (19)$$

From equation *8*

$$z_m(e/i_2) = z_1 z_2 - z_m^2 \quad (20)$$

Secondary voltage $e_2 = -jX_{o2}i_2$. Substituting for *e* and i_2

$$-X_{o1}X_{o2}(i_p/e_2)z_m = z_1 z_2 - z_m^2 \quad (21)$$

Using $i_p = g_m e_g$ and substituting for $z_1 z_2 - z_m^2$ in equation *19*

$$Z_p = (X_{o1}/X_{o2})(z_2/z_m)(e_2/g_m e_g) \quad (22)$$

From equation *22* we can anticipate the shape of the primary impedance curve with frequency variation. Thinking in terms of a constant applied grid voltage e_g, the secondary voltage e_2 will trace out the familiar coupled circuit response. We may assume everything constant except e_2 and z_2 and z_2 is the series resonant characteristic of the secondary circuit, $r_2(1 + jS_2)$. The z_2 multiplier serves to produce a dip in the characteristic at resonance. Physically the secondary is acting as an absorption circuit, reducing primary impedance at resonance. The primary impedance will always have a deeper dip at resonance than the overall response curve.

The attenuation on a selectivity curve, *U*, has been defined as the ratio of gain at resonance, A_o, to gain at another frequency, A_f. Since e_2/e_g is gain at any frequency, it may be replaced by A_o/U. A_o may be obtained from equation *21*.

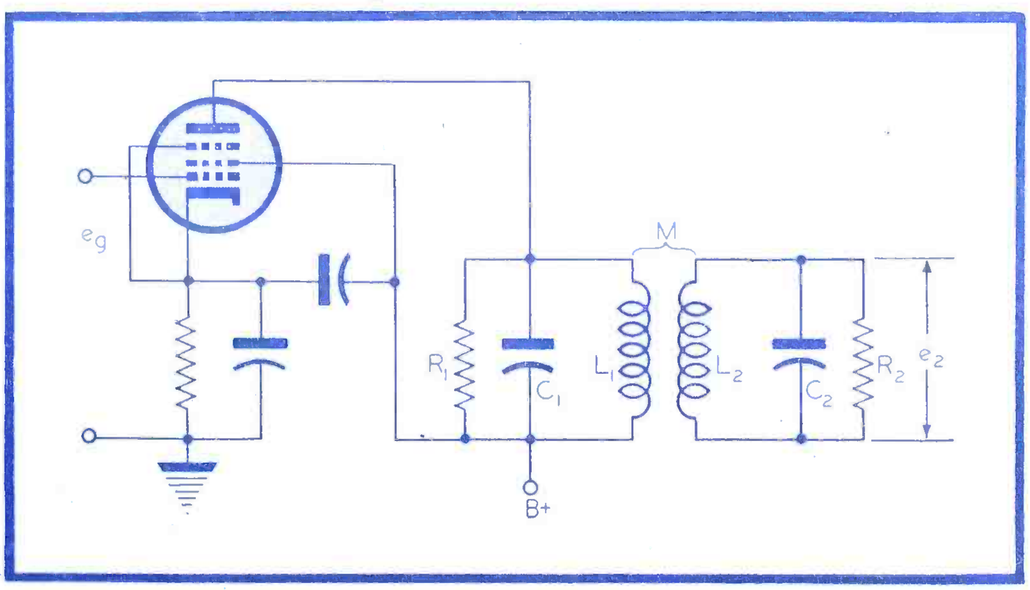

Figure 6
Figure 5 reduced to a practical system, with the tube providing the driving voltage *e* and all circuit loading lumped in resistors R_1 and R_2.

At resonance $z_1z_2 = r_1r_2$, using $i_p = g_me_g$ and $z_m = \pm jX_m$,

$$e_2/e_g = -g_mz_mX_{o1}X_{o2}/(r_1r_2 - z_m^2) = \pm jg_m(X_{o1}X_{o2}/r_1r_2)\,[X_m/(1 + X_m^2/r_1r_2)] \quad (23)$$

Substituting $K = X_m/\sqrt{X_{o1}X_{o2}}$ the resonant gain becomes

$$A_o = e_2/e_g = \pm jg_mZ_{og}[KQ_g/(1+K^2Q_g^2)] \quad (24)$$

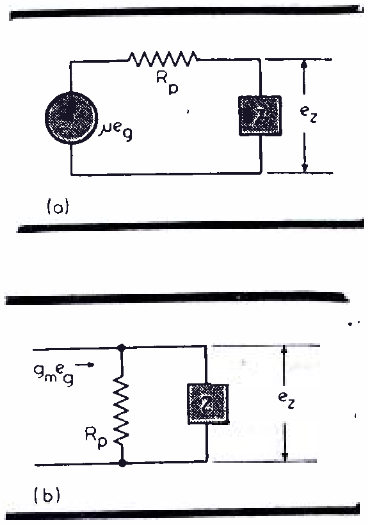

Figure 7 (right)
Tube as a voltage source (*a*); and as current source (*b*).

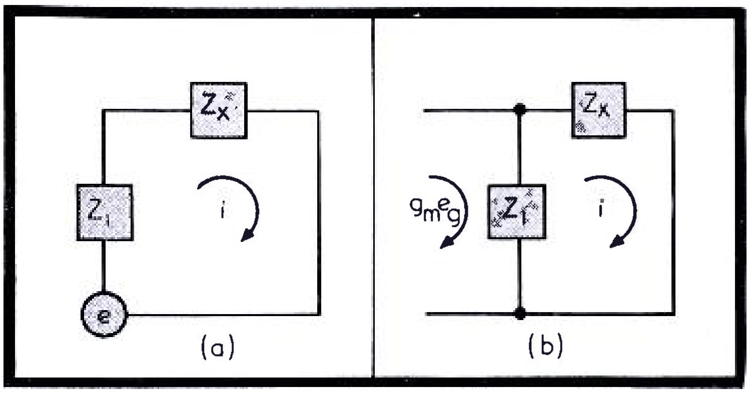

Figure 8

Representations of Figure 5(*a*) and Figure 6(*b*). Figure 6 can be representated by a current g_me_g operating into the primary with R_p absorbed in R_1.

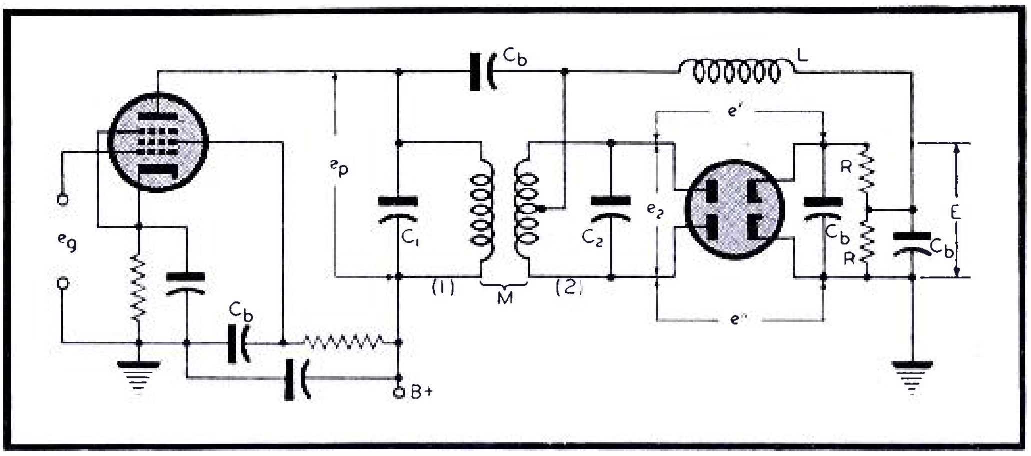

Figure 9

A form of the Foster-Seeley discriminator circuit.

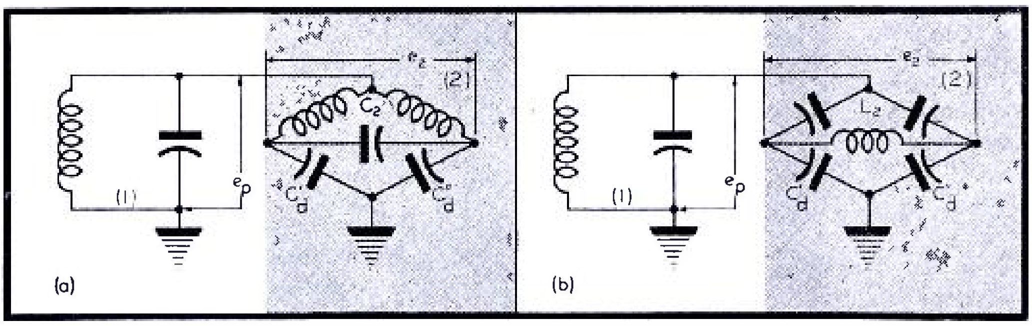

Figure 10

Fundamental i-f circuit involved in Figure 9, redrawn as a bridge and omitting *M*. In (*a*), primary is connected to center of secondary coil; (*b*), primary is connected to center of secondary capacitor.

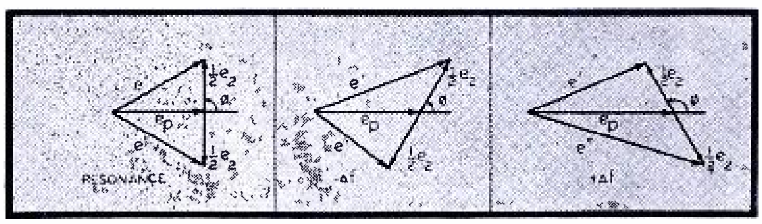

Figure 11

Resultant vector voltage relations.

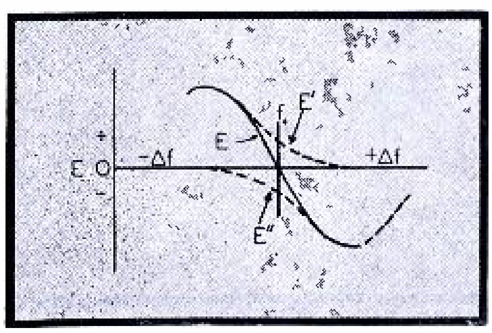

Figure 12

The discriminator *S* curve. In plotting this curve, the following data and Figure 11 were used: The voltage *e'* is rectified to produce a positive d-c voltage *E'*, and *e''* is rectified to produce a negative d-c voltage *E''*. The resultant voltage *E* is the algebraic sum of *E'* and *E''*. And at the larger frequency deviations, the selectivity of the circuits reduces all voltages.

where $Z_{og} = X_{og}Q_g$, $X_{og}^2 = X_{o1}X_{o2}$. From equations *24* and *11* it can be deduced that the greater the difference between secondary and primary *Q*, the greater is the bandwidth (less equivalent equal *Q*) that will be obtained for a given amount of gain.

Equation *22* may be rewritten with the aid of equation *24* and some algebraic manipulation

$$Z_p = [Z_{o1}/(1 + K^2Q_g^2)]\,[(1 + jS_2)/U] \quad (25)$$

The expression for *U* given in equation *15* omits phase; if phase relations are retained, it may be shown that

$$U = (1 + C^2 - S^2 + 2jS)/(1 + C^2) \quad (26)$$

With this information we can readily calculate the impedance in phase and magnitude into which a tube works with any pair of coupled circuits at its plate. This impedance may then be plotted on the tube characteristics as a load line or ellipse to determine maximum power output and overloading point at any frequency.

Discriminator Circuit

One form of the Foster-Seeley discriminator[3] is shown in Figure 9. *L* is a choke coil which provides a d-c return path for the diodes and C_b is in each case a blocking or a bypass capacitor. The coupling in this circuit is shown as existing in the inductive field between primary and secondary. Capacitive coupling is also possible in a discriminator circuit. In fact both types of coupling will ordinarily exist simultaneously in a circuit such as figure 9. To understand the nature of the capacitive coupling it is best to view the circuit as a bridge. The fundamental i-f circuit involved, omitting *M*, is redrawn as a bridge in Figure 10. Two possibilities are shown: in circuit (*a*) the primary is connected to the center of the secondary coil, while in circuit (*b*) it is connected to the center of the secondary capacitor. The driving voltage for the bridge is e_p and its output voltage is e_2. C'_d and C''_d are the stray capacities to ground from the plates of the two diodes. If the arms of the bridge are perfectly balanced no secondary voltage is produced and we have zero coupling. If the center of the coil or capacitor is not electrically true, we have inductive or capacitive coupling respectively. If C'_d and C''_d are unbalanced we have capacitive coupling. Any mutual coupling between coils will, of course, add algebraically with coupling due

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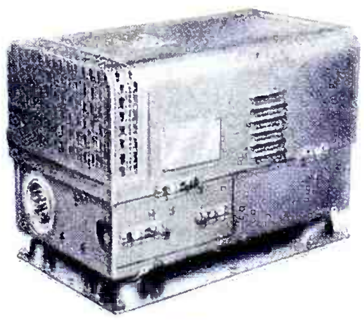

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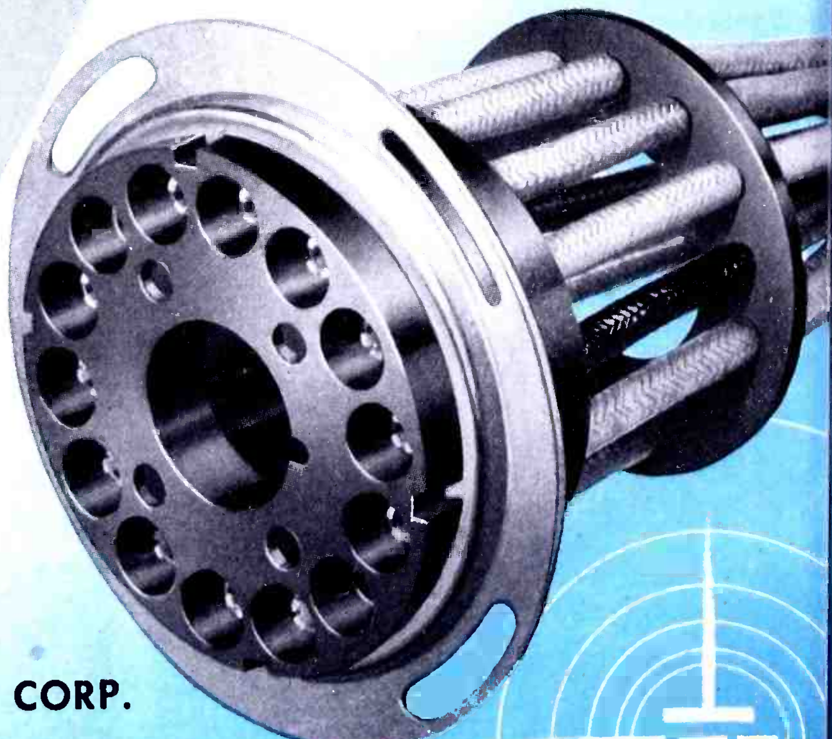

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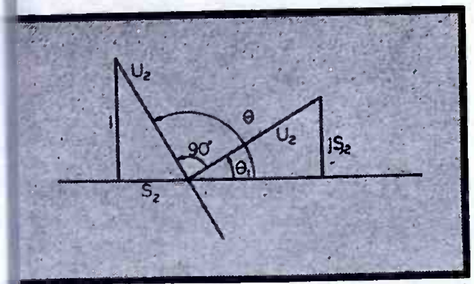


Figure 13
Evaluating cos ϕ in terms of $\Theta = \tan^{-1} S_2$.

idge unbalance. Coupling by bridge unllance can often be used to advantage, ;., for obtaining a discriminator characristic from such devices as crystals[4].

iscriminator Analysis

The Foster-Seeley discriminator transrmer develops the *S* curve of voltage ainst frequency by rectifying, in opsition, voltages resulting from the ctor addition of the primary and secdary voltages in the coupled circuits. rom Figures 9 and 10*a* the vector a-c ltages from the diode plates to ground e seen to be

$$= e_p + e_2/2 \quad (27)$$

$$= e_p - e_2/2 \quad (28)$$

r one polarity of coupling; signs will reversed for a reversal of coupling. hese voltages must, of course, be added ctorially. We must, therefore, deterine the vector primary and secondary ltages. The primary voltage is a-c ate current ($g_m e_g$) multiplied by rimary impedance, Z_p. Using equations and *26*, and letting $1 + jS_2 = U_2$, we ave

$$= [g_m e_g Z_{o1}/(1+K^2Q_g^2)](U_2/U) \quad (29)$$

ince $A_t = A_o/U$, equation *24* may be sed to determine the vector voltage e_2.

$$= (j g_m e_g Z_{og}/U)[KQ_g/(1+K^2Q_g^2)] \quad (30)$$

The variations in phase positions of hese voltages are dependent on U_2 and . At resonance ($S = 0$), U_2 and U re both real and unity so that primary nd secondary voltages are in quadrature. he ratio of magnitudes and the phase ngle between the two voltages can be btained from the quotient of the vectors.

$$_p/e_2 = j(U_2/KQ_g)\sqrt{Z_{o1}/Z_{o2}} \quad (31)$$

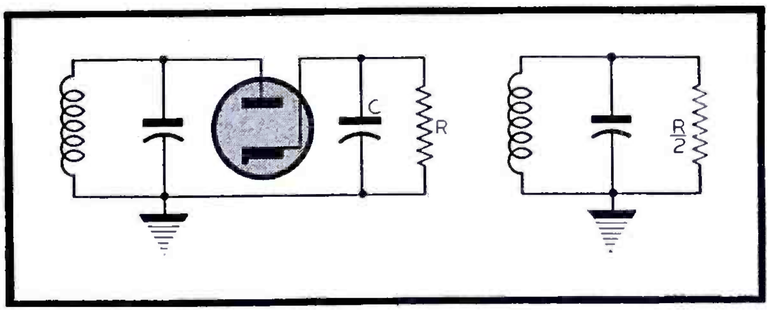


Figure 14
A diode rectifier circuit where the peak d-c voltage developed is 1.414 *E*; the i-f voltage driving the diode is represented by an rms value *E*.

Since $U_2 = 1 + jS_2$ the phase angle between e_p and e_2 is

$$\phi = \tan^{-1}S_2 + 90° \quad (32)$$

The resultant vector voltage relations are shown in Figure 11.

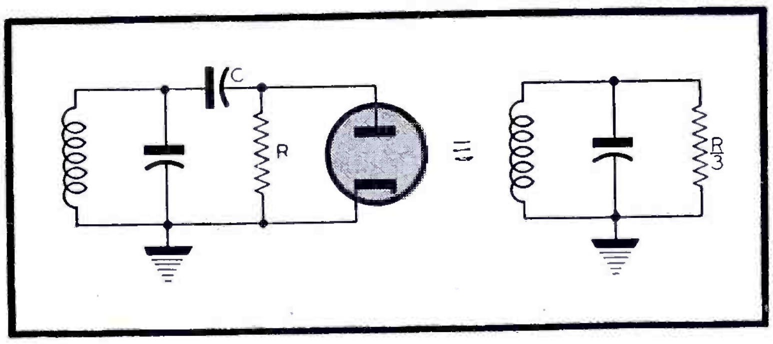


Figure 15
Another diode rectifier circuit. Here, however, with the same *R-C* time constant the performance will be the same as that of Figure 14, except for the appearance of i-f, as well as the d-c voltage across *R*.

The voltage e′ is rectified to produce a positive d-c voltage E′, and e″ is rectified to produce a negative d-c voltage E″. The resultant voltage *E* is the algebraic sum of E′ and E″. At the larger frequency deviations, the selectivity of the circuits reduces all voltages. From these considerations and Figure 11 the manner in which the discriminator S curve is obtained will be apparent, Figure 12.

Discriminator Equations

A method of calculation may be obtained from Figure 11.

$$(e')^2 = e_p^2 + (e_2/2)^2 + e_p e_2 \cos\phi \quad (33)$$

$$(e'')^2 = e_p^2 + (e_2/2)^2 - e_p e_2 \cos\phi \quad (34)$$

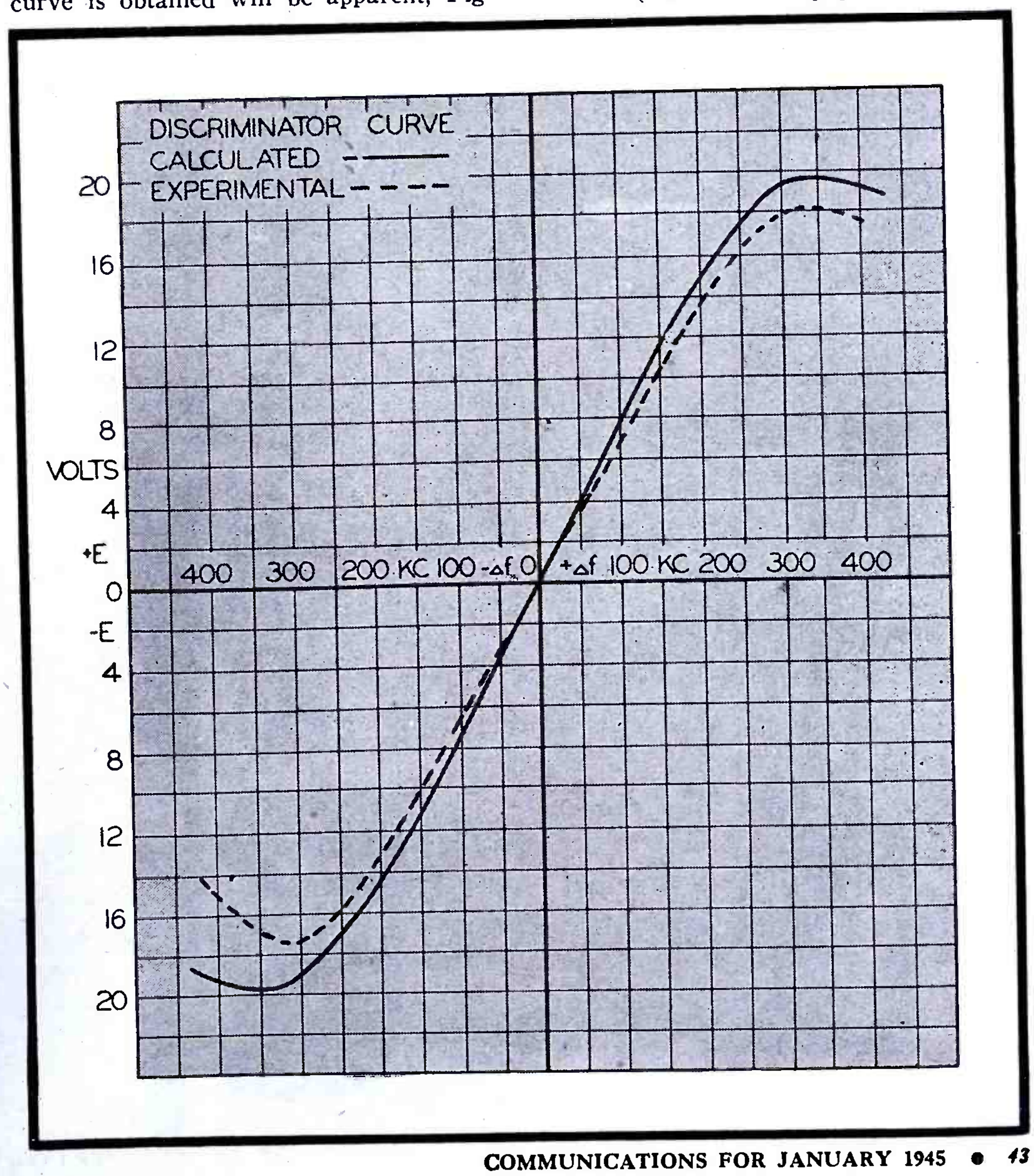
Cosϕ may be evaluated in terms of $\Theta = \tan^{-1}S_2$, Figure 13.

$$U_2^2 = 1 + S_2^2 \quad (35)$$

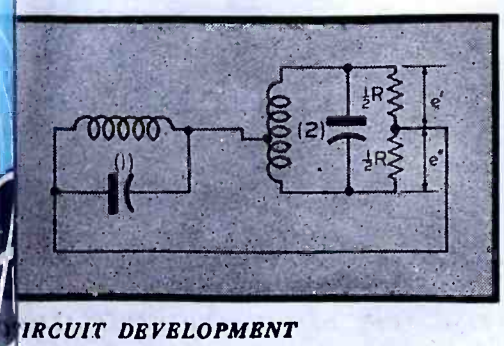
$$\cos\phi = -S_2/U_2 \quad (36)$$

And we have

(*Continued on page* 68)



Figures 16 (below) and 17 (right)
A loaded i-f circuit representing the discriminator circuit of Figure 9. The effect of the diode loads is incorporated in the fictitious resistors ½*R*. Figure 17, a discriminator curve plot.



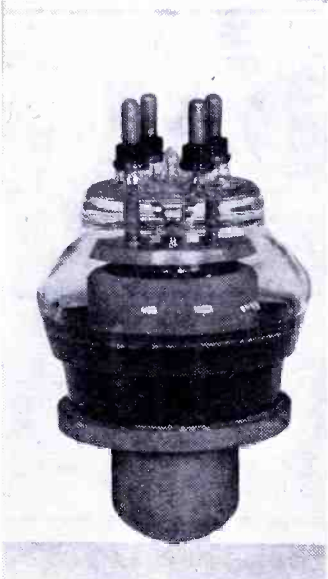
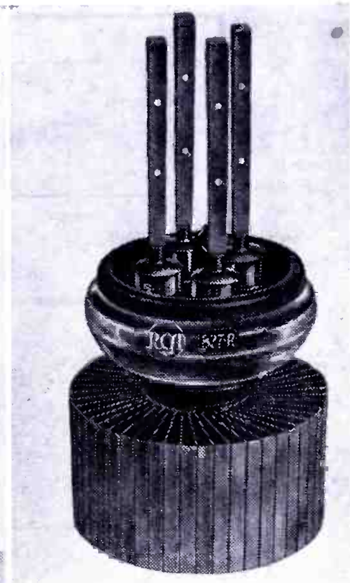


Figure 1*a*
Extreme left, an external anode-type tube (GL-880) made by G.E.



Figures 1*b* and *c*
Center, RCA 827-R; and right, Westinghouse WL 895R, external anode-type tubes.

EXTERNAL ANODE TRIODES

CHARACTERISTICS AND APPLICATIONS

[*PART I OF A FOUR-PART PAPER*]

by A. JAMES EBEL

Chief Engineer
WILL, University of Illinois

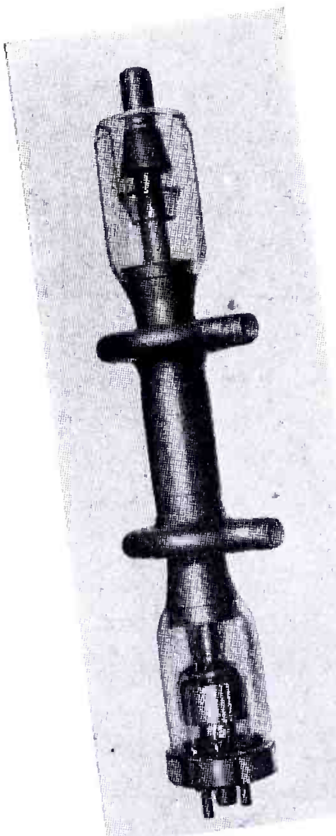
EARLY in the development of high-power radiotelephone transmitters it became apparent that vacuum tubes cooled by direct radiation could never fulfill the dissipation requirements imposed by operation in the kilowatt-power ranges. First, the dissipation of each tube was limited by certain physical factors in the tube design; and second, the operation of a number of tubes in parallel led to the well-known parasitic instabilities of such circuits. A solution to the problem was found in the external anode type of tube. The perfection of the metal-to-glass seal paved the way for the development of these high-dissipation power tubes.

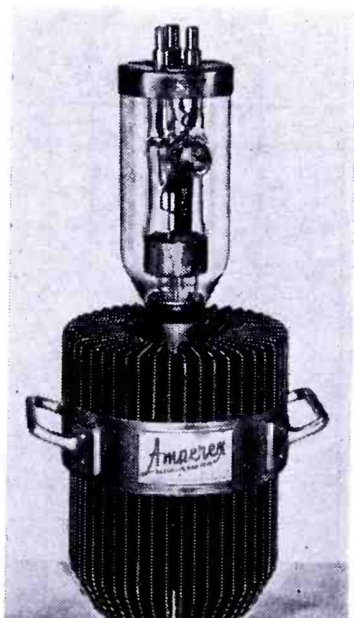
Today there are many types of external-anode vacuum tubes varying greatly in size and design. Some are cooled by circulating water, and others by forced air. The dissipation for the various types ranges from 1.2 kilowatts to 250 kilowatts. The smallest can be held in the palm of the hand, whereas the largest stands nearly as tall as a man. A representative cross section of these tubes is shown in Figure 1*a*, *b*, *c*, *d*, *e* and *f*.

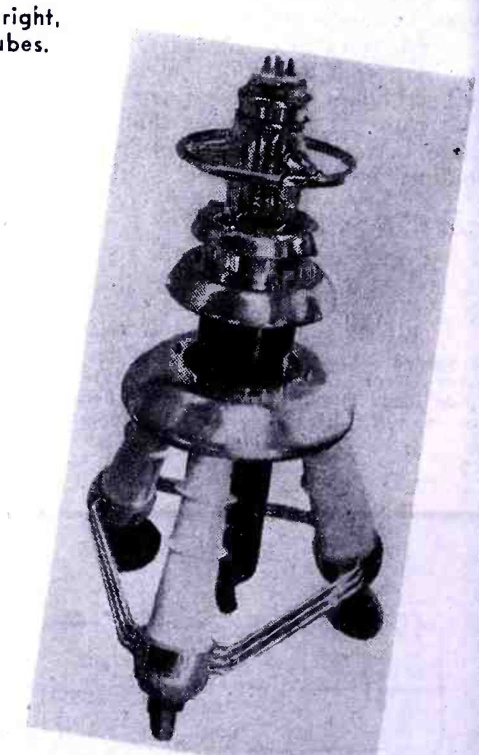
Until recently such tubes were used principally in radio transmitters. But the recent introduction of high-frequency heating technique into many industrial operations has opened up a new field of application that promises to surpass the utilization in radio. It is important that the operators of equipment using external anode tubes understand fully their characteristics, their proper care, and something of their general construction. The purpose of this paper is to offer such information.

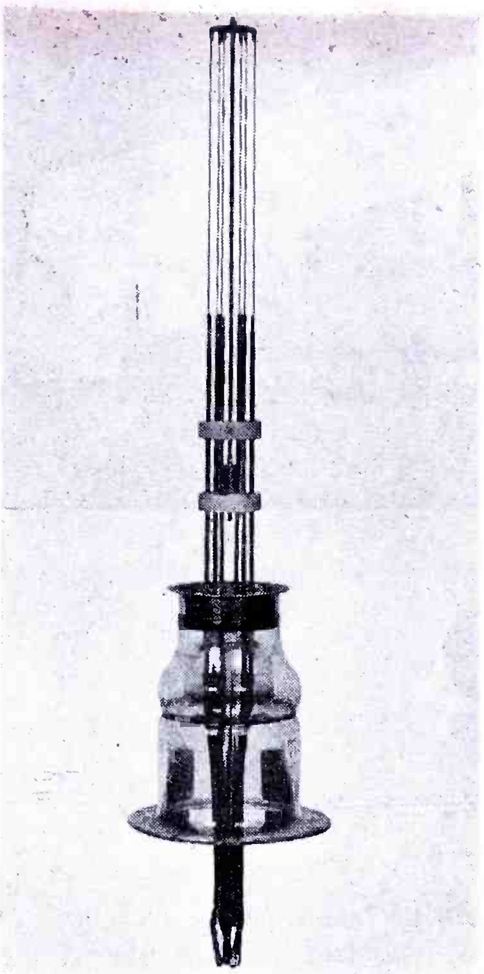
With the scarcity of materials and manufacturing facilities during war comes the necessity for increased attention to any details which tend to prolong the life

Figures 1*d*, *e* and *f*
Extreme left, Western Electric 240B; below, Amperex; and right, FTR 3067A (with water jacket and truck) external anode-type tubes.

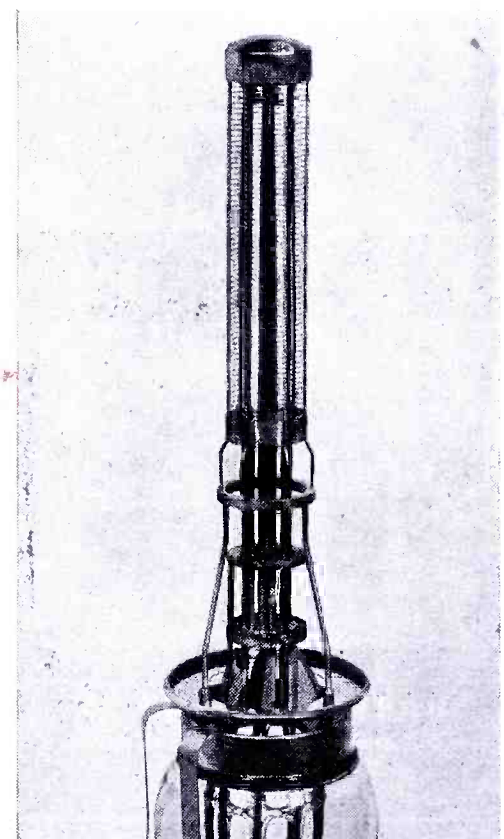








Figures 2 (above) and 3 (below).
Figure 2, six-strand filament of a high-power triode. (*Courtesy G.E.*) Figure 3, detailed view of high-powered triode grid structure. (*Courtesy FTR.*)



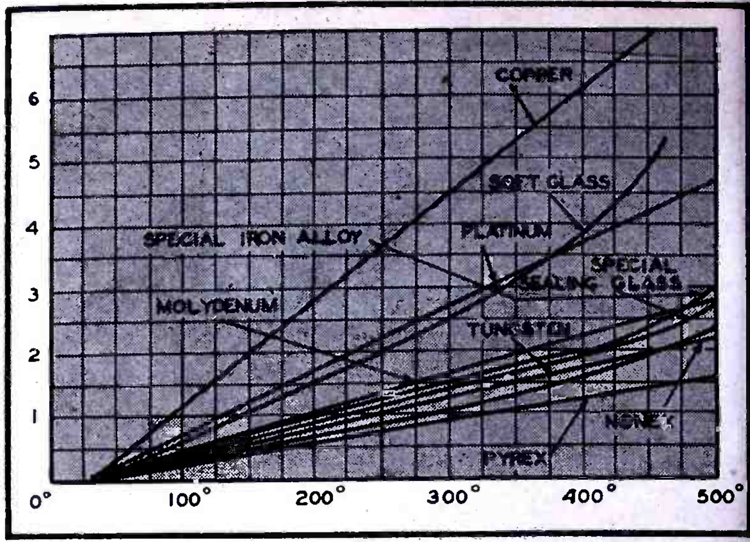


Figure 4.

Plot illustrating thermal expansion of selected metals and glass.

(*Courtesy FTR*).

of such tubes. A wealth of valuable material has been published[1, 2, 3] on this phase of tube operation and will be referred to, in this paper, from time to time.

The filaments of external-anode tubes are composed of pure tungsten. In its pure form this element has the highest melting point of any ductile metal (3655° K) and emits electrons in satisfactory quantities when operated at temperatures at which exaporation is not impractically great. Figure 2 shows the construction of a six-strand filament for a high-power triode. It will be noted that leads are brought out from each of the strands so that the filament may be connected for single-, three-, or six-phase operation. The pure metal becomes ductile when properly worked and can be drawn into strands of the proper size. After being heated to incandescence, the metal returns to a crystalline form as it cools, and becomes very brittle. To prevent these brittle strands from shattering, they are mounted with springs at either end to take up the slack caused by expansion when the filament is heated and to protect the strands from physical shock. One of the fundamental necessities in the care of tungsten emitters is to protect them from all shocks because they are so easily fractured. At least one leading transmitter maintenance authority[4] recommends that the tubes not be removed from their sockets during their entire life. Other considerations bearing on the advisability of this procedure will be mentioned later.

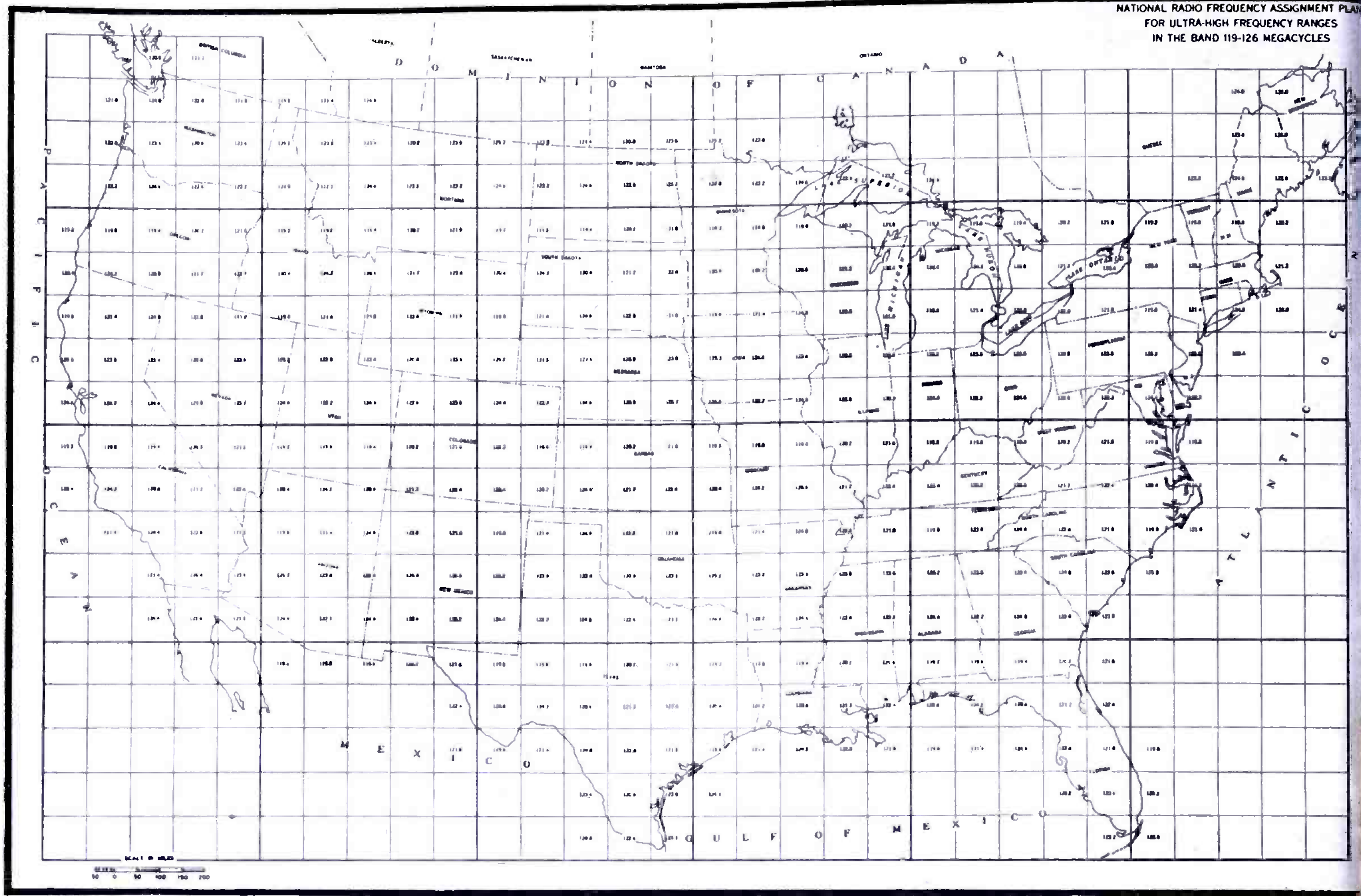
The grid structure is generally a helix wound around several supporting rods so that the spacing between the grid wires and the geometrical configuration of the filament strands are uniform. The grid operates at a fairly high temperature and is called upon to dissipate considerable power. The grid size is a compromise between a thick strand, which is best for heat dissipation purposes, and a fine strand, which has the best electrical characteristics. The material must have a high melting point and a high work function for mechanical stability and low secondary emission. Such metals as tungsten, tantelum, and molybdenum are normally used for both the grid wires and the supports of these wires. Special consideration must be given to the grid lead to provide high insulation, low capacity to other elements, and low I^2R loss. In Figure 3 we have a detailed picture of the grid structure of a high-power triode. The supports for the grid and filament structure must be carefully machined to provide accurate spacing and to maintain that spacing. Any warping will cause a change in tube characteristics and may lead to interelectrode shorts. In the case of some ultrahigh-frequency tubes this spacing is as low as .06", indicating the necessity for carefully maintaining the correct alignment.

Since it is particularly important that the copper used be oxygen-free, the anodes of these tubes are made of the purest copper available. The metal used in each tube must be from stock that has been carefully analyzed for foreign materials and gases, and throughout the manufacturing process careful checks must be made to see that no gas, especially oxygen, has been introduced into the copper. Pure copper is necessary to effect a good metal-to-glass seal, to give proper strength, and to maintain the vacuum within the tube. For a successful metal-to-glass seal the glass must wet the metal; that is to say, it must flow over the metal rather than collect in a globule as water does on a greasy surface. Furthermore, it is necessary to provide for the differential expansion of the metal and the glass. Figure 4 shows the expansion of the normally used metals and glasses as related to temperature changes. Note that the expansion of glass and copper are decidedly different. In spite of this differential, the high ductility and the low yield point of copper make possible the successful combination of these two materials. It is necessary, however, that the copper be thin at the junction, a fact which tends to produce mechanical weakness in the tube. This is another reason for careful handling of the tube. The seal of the external anode tube is mechanically its weakest point and must be treated as such. In a typical 5-kw tube the anode wall thickness is .065". This thinness is required almost entirely by thermal considerations.

High temperature is destructive to the seal. Fortunately there is generally a noticeable discoloration of the seal as the temperature becomes too high. This is especially noticeable in the copper-to-glass seals where the change is from the normal reddish copper hue through green to a dark metallic color.

As has been stated, there are two methods of cooling the anodes of these tubes, water cooling and forced-air cooling. The water-cooled tube is mounted in a jacket with provision for water entering the bottom of the jacket and leaving the top. Since the anode of the tube operates at a high d-c potential, it is necessary to provide adequate insulation in the water circulating system be-

(*Continued on page* 104)



CAA checker-board radio-range frequency assignment plan dividing the country into 100-mile squares with one range station within each square

AERONAUTICAL COMMUNICATIONS IN THE POSTWAR ERA

by McMURDO SILVER
Consulting Engineer

FROM War I up to about 1940 aeronautical radio communications seems to have "just growed." It can hardly be said, since no one could prophesy the extent of character of aviation as of 1940 at any significantly earlier date, that any particularly intelligent planning for the future could have been engaged in. Thus the assignment of aircraft communication and navigation frequencies, establishment of policies for regulation of aeronautical radio communication and a host of other details had, of necessity, to await the development of a sufficiently clear-cut aviation situation.

By approximately 1940 the aviation communications and navigation outlook for at least the immediate future had crystallized sufficiently to permit of intelligent long-range planning. The results of such government planning were partially set forth in *FCC Rules and Regulations Governing Aviation Services*, (Title 47—Telecommunication—Chapter I, Part G), effective August 1, 1939 and revised to November 1, 1942. This publication, available from the Superintendent of Documents, Washington, D. C., at a price of five cents, together with a copy of the *National Allocation Plan For Assigning Radio-Range Frequencies in the Band* 119-126 *Megacycles* which was printed by *CAA* as *Technical Development Report No.* 28 in May, 1941, and which was prepared by L. H. Simson of *CAA* constitute *must* information for anyone seriously interested in the probable extensive expansion of aeronautical communications after V-Day.

Desiring not to explore in detail the data set forth in referenced publications, but rather to consider briefly a number of aspects of *postwar* aeronautical radio communications the writer will pass lightly over the postwar frequency situation, particularly as, while in principle it will probably conform to the excellent plan already devised, it is possible that actual frequencies may be somewhat different.

In the prewar period government and commercial aeronautical radio services operated upon a number of different bands. Possibly most familiar is the 200- to 400-kc low-frequency band in which were located radio-range, communication and navigation services. In this band 278 kc was uniformly assigned to a port control stations for communicati with civilian, itinerant and other aircr in flight. Such aircraft were expected call and work the airport within ran on 3105 kc in daylight or 6210 after dark. In practice, 6210 kc was lit used, probably because 3105 kc provid sufficient distance range even after da to satisfy the limited-range flight of t average civilian flyer—and it is with h and his brothers-legion that the writer primarily concerned.

Experience having indicated these l and medium frequencies to offer int ference possibilities incompatible with future concept of one or more airpo in almost every community, and th sands of civilian-itinerant aircraft flight simultaneously, the *u-h-f allocat plan* was wisely devised. Under this p it was proposed to shift all such ae nautical radio communication and navi tion services up into the range of to 156 megacycles—a far cry indeed fr the older low and medium frequenc which were to be progressively abandon Such a shift was most logical and s sible, for frequencies within the r

(*Continued on page* 76)

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Left, mixer attenuator. (*Courtesy Cinema Engineering Company*)
Above, precision attenuator box. (*Courtesy General Radio Company*)

RESISTIVE ATTENUATOR, PAD AND NETWORK

Theory and Design

In part *II*, the fundamental method of procedure in the design of the various types of attenuating networks was briefly outlined and a few of the more elementary forms of networks were considered. The second set of *Tables of Hyperbolic Functions of a Real Variable* was also presented, accompanied by charts showing in compact form all of the information needed for the use and design of the simpler types of networks. The series, shunt, series and shunt, and the L-type taper pads were described. The two charts also contained formulas, in explicit form, and are particularly applicable to the tables presented in the first three parts of this series.

In this installment, part *III*, two additional charts are shown with explicit formulas for the complete design of the *T*, *π*, *bridged-T*, *lattice*, and the *multiple-bridge* types of networks. These charts, like those in part *II* have been designed for specific use in connection with the *Tables of Hyperbolic Functions of a Real Variable*. The first two sets of these tables were presented in parts *I* and *II*. The third set of tables appears with this installment. The design of attenuators proceeds with a continuation of the *L*-taper networks, followed by the *T*-type network.

Appendix *I* shows the hyperbolic formulas which were used for the calculation of all of the *Tables of Hyperbolic Functions of a Real Variable* presented in this series of papers.

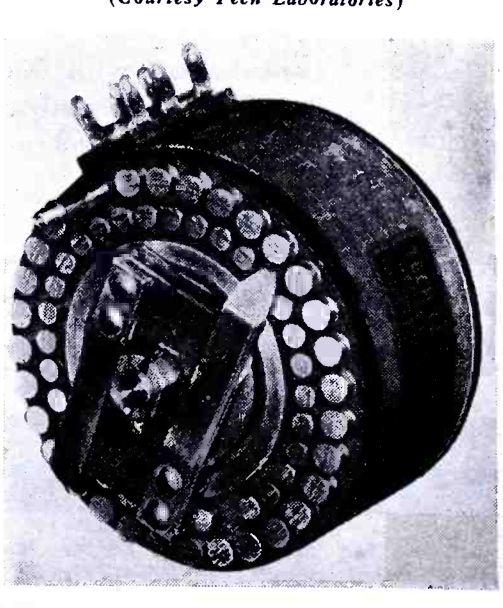
Appendix *II* describes a useful mathematical tool, little known by radio or communication engineers, the *Gudermannian Function*, which may be used for the calculation and interpolation of hyperbolic functions of a real variable. When any one of these is known, all of the remaining functions may be found by direct application of common tables of the natural trigonometric functions from circular function theory.

[PART THREE OF A FOUR-PART PAPER]

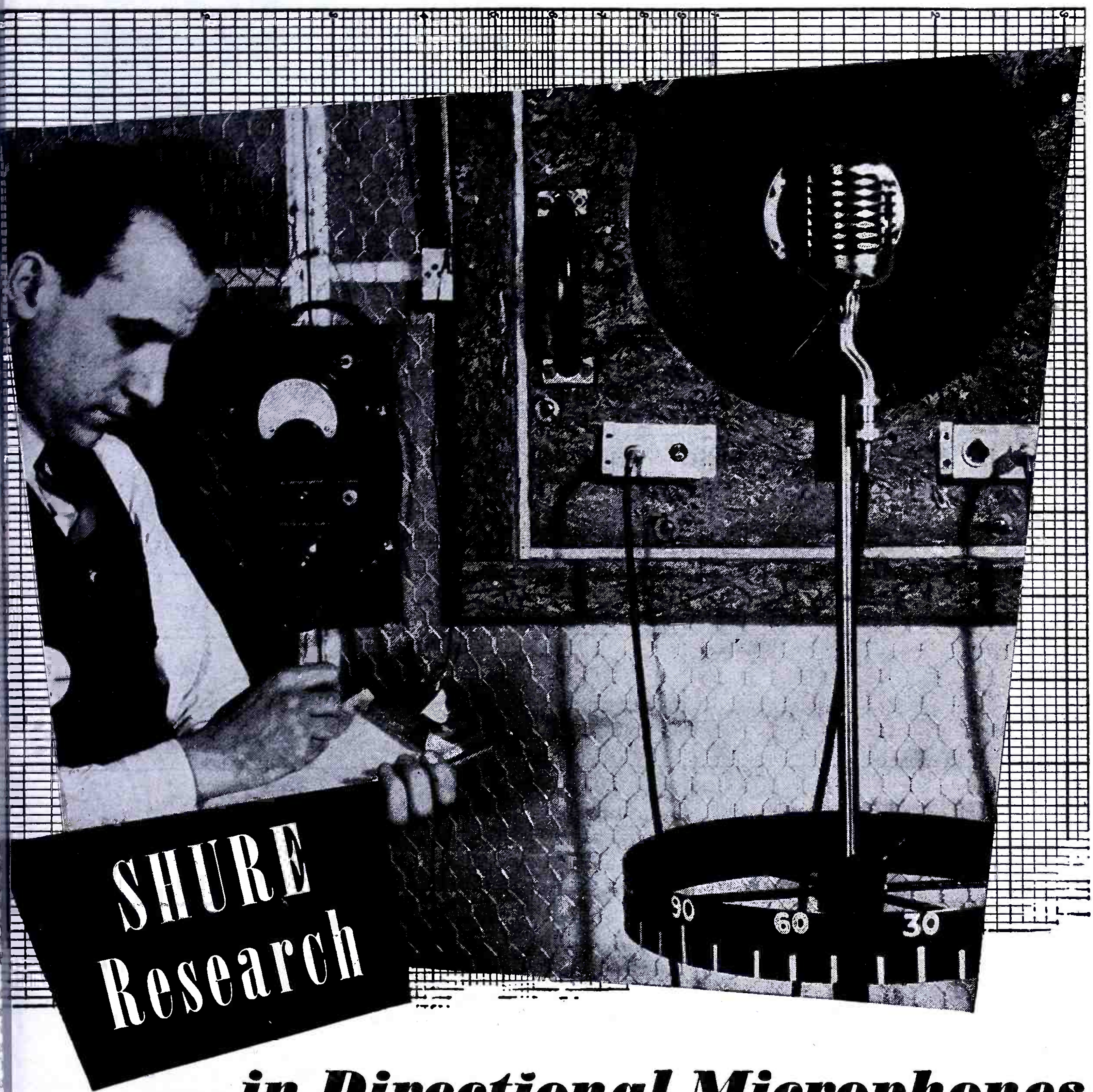
by PAUL B. WRIGHT
Communications Research Engineer

IT is convenient for design purposes to utilize the unbalanced form of network configuration on a unit basis for the *T*, *π*, *and bridged-T structures.* These configurations are shown in the accompanying charts, as well as those of the lattice and multiple bridge types of networks. Complete design information is contained in these charts to enable the engineer to obtain the transmission loss incurred by their use in any system when operated between image impedances having the values given in the charts. The network elements are presented in symbolical form so that the equations may be solved in the most direct manner through use of the *Tables of Hyperbolic Functions of a Real Variable* presented in parts *I*, *II* and this installment. The definitions and requirements which must be met for the equations to be valid appeared in charts accompanying part *II* and this presentation, also.

It should be noted that the impedance ratio shown in the charts and development of equation is $s^2 = Z/z$. The ratio of the terminating image impedances can of course be replaced by an ideal transformer having an impedance transformation ratio of s^2 to 1. This procedure places the network proper upon an unconditionally unit basis, with the high side of the transformer terminated by an impedance of s^2 ohms, and gives unit or one-ohm terminations to the network. The reduction of a network to a unit basis is known as *normalizing*. However, throughout this paper, the ideal transformer will be omitted and the more direct approach of the actual terminations used for the network will be used. The image impedance theory usage results in considerable simplification of the final form of the derived equations. The image propagation function, Θ, is sometimes referred to as the image transfer constant. Numerically, it is equal to



T-pad, 600-600 ohms; 20 steps, 2 db per step. (*Courtesy Tech Laboratories*)



... in Directional Microphones

It is not enough to design a Microphone that merely converts sound waves into electrical impulses. A Microphone, to be truly useful in modern broadcasting, should be discriminating enough to accept wanted sounds —and reject unwanted sounds. Shure Research was the first to develop a single unit uni-directional Microphone, both crystal and dynamic.

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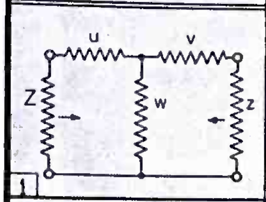
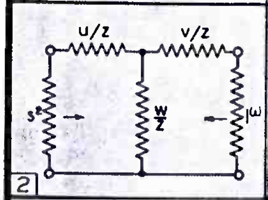
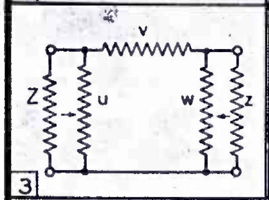
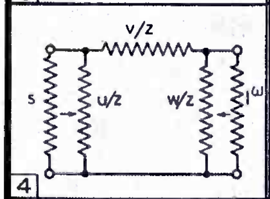
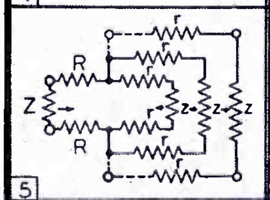
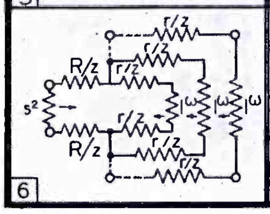
NETWORK CONFIGURATION	TYPE	IMPEDANCE BASIS	DECIBELS TRANSMISSION LOSS $20 \log_{10} k$	IMAGE IMPEDANCES	NETWORK ELEMENTS	DEFINITIONS AND REQUIREMENTS
1 	T	FULL MATCHED IMAGE IMPEDANCES	$k = s(1+\frac{v+z}{w})$	$Z = (\Phi\beta)^{\frac{1}{2}}$ $z = (\Phi/\beta)^{\frac{1}{2}}$	$u = cZ - w$ $v = cz - w$ $w = ay$	$Z \geq z$ $s^2 = Z\,z \geq 1$ $y = \sqrt{Zz}$ $c = \coth\theta$ $a = \operatorname{csch}\theta$ $\Phi = uv + uw + vw$ $\beta = \frac{u+w}{v+w}$
			$k = (1+\frac{v+z}{w})$	$z = [u(u+2w)]^{\frac{1}{2}}$	$u = v = Dz$ $w = az$	$Z = z$ $\theta = 0.115129 \times$ No(db) $D = \tanh\frac{\theta}{2}$ $a = \operatorname{csch}\theta$
2 	T	UNIT MATCHED IMAGE IMPEDANCES	$k = s(1+\frac{v'+1}{w'})$	$s^2 = (\Phi'\beta')^{\frac{1}{2}}$ $1 = (\Phi'/\beta')^{\frac{1}{2}}$	$u' = cs^2 - w$ $v' = c - w'$ $w' = as$	$Z \geq z$ $s^2 = Z/z \geq 1$ $a = \operatorname{csch}\theta$ $u' = u/z$ $v' = v/z$ $w' = w/z$ $\Phi' = u'v' + u'w' + v'w'$ $\beta' = \frac{u'+w'}{v'+w'}$
			$k = (1+\frac{u'+1}{w'})$	$1 = [u'(u'+2w')]^{\frac{1}{2}}$	$u' = v' = D$ $w' = a$	$Z = z$ $s^2 = 1$ $a = \operatorname{csch}\theta$ $D = \tanh\frac{\theta}{2}$ $u' = u/z$ $v' = v/z$ $w' = w/z$
3 	π	FULL MATCHED IMAGE IMPEDANCES	$k = (1+\frac{v}{w}+\frac{v}{z})/s$	$Z = u(\sigma\rho)^{\frac{1}{2}}$ $z \;\; w(\sigma/\rho)^{\frac{1}{2}}$	$u = y^2/(cz-ay)$ $v = Ay$ $w = y^2/(cZ-ay)$	$Z \geq z$ $s^2 = Z/z \geq 1$ $y^2 = Zz$ $A = \sinh\theta$ $c = \coth\theta$ $\sigma = v/(u+v+w)$ $\rho = \frac{v+w}{u+v}$
			$k = (1+\frac{v}{w}+\frac{v}{z})$	$z = \frac{uv}{[v(v+2u)]^{\frac{1}{2}}}$	$u = w = dz$ $v = Az$	$Z = z$ $s^2 = 1$ $A = \sinh\theta$ $d = \coth\frac{\theta}{2}$ $\theta = 0.115129 \times$ No(db)
4 	π	UNIT MATCHED IMAGE IMPEDANCES	$k = (1+v'+\frac{v'}{w'})$	$s^2 \;\; u'(\sigma'\rho')^{\frac{1}{2}}$ $1 = w'(\sigma'/\rho')^{\frac{1}{2}}$	$v' = As$ $w' = s/(cs-a)$	$Z \geq z$ $s^2 = Z/z$ $A = \sinh\theta$ $u' = u/z$ $\rho' = \frac{v'+w'}{u'+v'}$ $c = \coth\theta$ $w' = w/z$ $\sigma' = v'/(u'+v'+w')$
			$k = (1+v'+\frac{v'}{u'})$	$1 = \frac{u'v'}{[v'(v'+2u')]^{\frac{1}{2}}}$	$u = w = d$ $v' = A$	$Z = z$ $s^2 = 1$ $A = \sinh\theta$ $u' = u/z$ $d = \coth\frac{\theta}{2}$ $v' = v/z$ $w' = w/z$
5 	MULTIPLE BRIDGE	FULL MATCHED IMAGE IMPEDANCES	$k = n_m s$	INFINITE	$R = \frac{1}{2}[cZ - ay]$ $r = \frac{1}{2}[cz - ay]$	$Z \geq z$ $s^2 = Z/z \geq 1$ $y^2 = Zz$ $a = \operatorname{csch}\theta$ $c = \coth\theta$ $n_m =$ No. of branches in multiple
			$k = n_m$	INFINITE	$R = r = \frac{1}{2}Dz$	$Z = z$ $s^2 = Z/z = 1$ $D = \tanh\frac{\theta}{2}$
6 	MULTIPLE BRIDGE	UNIT MATCHED IMAGE IMPEDANCES	$k = n_m s$	INFINITE	$R' = \frac{1}{2}[cs^2 - as]$ $r' = \frac{1}{2}[c - as]$	$Z \geq z$ $s^2 = Z/z \geq 1$ $c = \coth\theta$ $a = \operatorname{csch}\theta$ $n_m =$ No. of branches in multiple
			$k = n_m$	INFINITE	$R' = r' = \frac{1}{2}D$	$Z = z$ $s^2 = 1$ $D = \tanh\frac{\theta}{2}$ $R' = R/z$ $r' = r/z$

Figures 1 to 6
The transmission losses and element values for the *T, Pi* and *Multiple Bridge* networks in terms of the *Hyperbolic Functions.*

$0.115129 \times$ No. (db) loss of the network. It is also equal to one-half the natural logarithm of the ratio of the power delivered to the network to the power delivered to the load. This ratio has been designated a factor, k^2.

Charts

The charts which have been prepared giving detailed design information for all of the standard as well as non-standard attenuating types of resistive networks were especially designed for direct application of the *Tables of Functions* that are described in Appendix *I*.

In the application of the formulas involving networks placed upon a unit basis, the use of primes or subscripts is undersirable and unnecessary, but to avoid some confusion which might arise in transcribing formulas from the chart, the subscript or the prime has been used. In practice, the network would be designed on the unit basis with simple regard to designation, then the multiplying factor, z, would be applied to all elements and terminations of the network to place it on a full impedance basis.

To reduce the unwieldly form of some expressions to a form more suitable for writing and manipulation, some compression has been made possible by the use of Greek symbols as well as English symbols. This was necessary to avoid duplication of the meaning of English characters and the pitfalls resulting from placing various subscripts with the same characters to designate different things. This method of writing expressions frequently permits a minimum of operations to be performed with the equations of the network, completely devoid of the cumbersome algebraic expressions which frequently obscure the objective. As examples of this method, by inspection, one may write for the product and quotient of the image impedances of the T network, from Figure 1, $Zz = \varphi = uv + uw + vw$, and $Z/z = \beta = (u+w)/(v+w)$; and for the π network, of Figure 3, $Zz = uw\sigma = uvw/(u+v+w)$, and $Z/z = u\rho/w = u(v+w)/(w(u+v))$. Other useful relationships may be utilized to quickly check the accuracy of the calculations of the network elements obtained from the tables. An example of this may be shown from Figure 7, where $t = Dz$ and $u = dz$; hence, $tu = z^2$, since $Dd = 1$, or from Figure 3,

$$\frac{1}{w} - \frac{1}{u} = c\left(\frac{1}{z} - \frac{1}{z}\right), \text{ etc.}$$

T Network

Referring to Figure 2 and the notation used for the element values, t[he] image impedances on a unit basis may [be] written,

$$s^2 = u' + \frac{w'(v'+1)}{v'+w'+1} \quad (\ldots$$

and

$$1 = v' + \frac{w'(u'+s^2)}{u'+w'+s^2} \quad (\ldots$$

The power delivered to the network fr[om] a constant current generator produci[ng] unit current and having an internal i[m]pedance of Z ohms is

$$W = i^2 Z = Z \quad (\ldots$$

The power delivered from the netwo[rk] output terminals to the load impedance $w = i_z^2 z = (w'/(v'+w'+1))^2 z$ (

From expressions *3* and *4* the power ra[tio] is

$$W/w = k^2 = ((v'+w'+1)/w)^2 s^2 \quad (\ldots$$

where

$$\epsilon^\theta = k \geq 1 \quad (\ldots$$

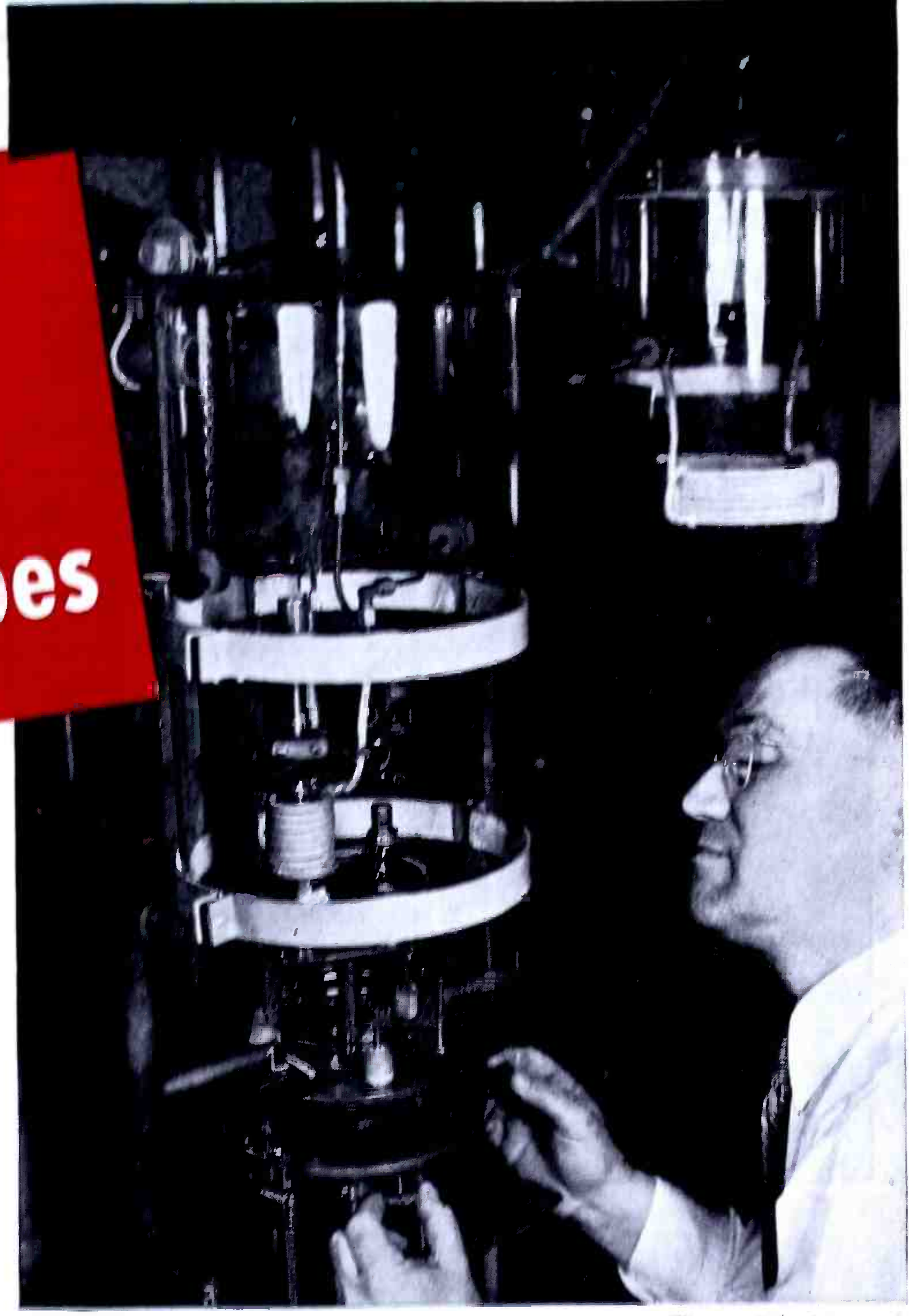
and

$$s^2 = Z/z \geq 1 \quad (\ldots$$

Since the loss in

$$\text{db} = 10 \log_{10}(W/w) \quad (\ldots$$

A knack for making difficult tubes



The metal plate and grid terminal posts of an 833-A being bonded to the glass envelope by means of radio-frequency heating in a nitrogen atmosphere.

ORTH AMERICAN PHILIPS is one of the few producers of electronic tubes success-ly manufacturing the type 833-A transmit-g triode tube in quantity. The assembly alone ls for unusual skill and resourcefulness on part of our engineers and craftsmen, and cially designed equipment.

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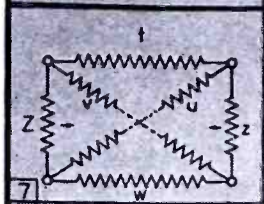
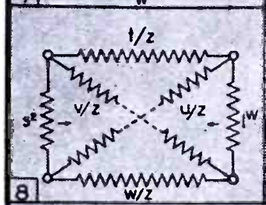
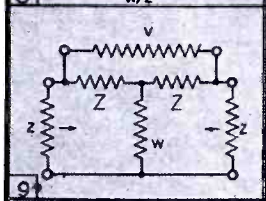
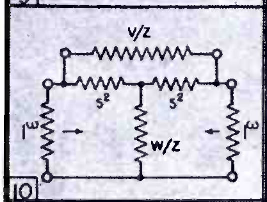
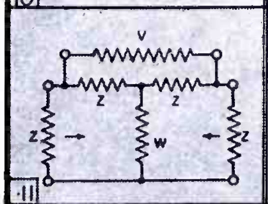
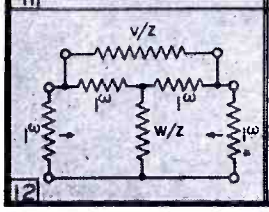
Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Div.); Lewiston, Me. (Elmet Div.)

NETWORK CONFIGURATION	TYPE	IMPEDANCE BASIS	DECIBELS TRANSMISSION LOSS $=20 \text{ Log}_{10} k$	IMAGE IMPEDANCES	NETWORK ELEMENTS	DEFINITIONS AND REQUIREMENTS
 7	LATTICE	FULL MATCHED IMAGE IMPEDANCES	$k = s\left[\frac{z\psi + x_2 y_2}{uv - tw}\right]$	$Z = \left[tu\frac{x_1 y_1}{x_2 y_2}\right]^{\frac{1}{2}}$ $z = \left[tu\frac{x_2 y_2}{x_1 y_1}\right]^{\frac{1}{2}}$	$t = [y(s+cx)/(c+as)]$ $u = [y(s-cx)/(c-as)]$ $v = [y(s+cx)/(c-as)]$ $w = [y(s-cx)/(c+as)]$	$Z \geq z$ $s^2 = Z/z \geq 1$ $vw = tu$ $\psi = (x_1 + y_1) = (x_2 + y_2) = (t+u+v+w)$ $x_1 = t+u$ $x_2 = t+v$ $x = (s^2-1)^{\frac{1}{2}}$ $y_1 = u+w$ $y_2 = v+w$ $y = (Zz)^{\frac{1}{2}}$ $a = \text{csch}\,\theta$ $c = \coth\theta$ $k = \epsilon^\theta$
			$k = \left[\frac{y_1 + 2z}{v - w}\right]$	$Z = z = (tu)^{\frac{1}{2}} = (vw)^{\frac{1}{2}}$	$u = v = dz$ $t = w = Dz$	$Z = z$ $u = v$ $t = w$ $s^2 = 1$ $d = \coth\frac{\theta}{2}$ $y = u+w$ $D = \tanh\frac{\theta}{2}$ $\theta = 0.115129 \times \text{No. (db)}$
 8	LATTICE	UNIT MATCHED IMAGE IMPEDANCES	$k = \left[\frac{\psi' + x_2' y_2'}{u'v' - t'w'}\right]$	$s^2 = \left[t'u'\frac{x_1' y_1'}{x_2' y_2'}\right]^{\frac{1}{2}}$ $1 = \left[t'u'\frac{x_2' y_2'}{x_1' y_1'}\right]^{\frac{1}{2}}$	$t' = [s(s+cx)/(c+as)]$ $u' = [s(s-cx)/(c-as)]$ $v' = [s(s+cx)/(c-as)]$ $w' = [s(s-cx)/(c+as)]$	$Z \geq z$ $s^2 = Z/z \geq 1$ $vw = tu$ $\psi' = (x_1' + y_1') = (x_2' + y_2') = (t'+u'+v'+w')$ $t' = t/z$ $v' = v/z$ $x_2' = t'+v'$ $u' = u/z$ $w' = w/z$ $y_1' = u'+w'$ $x_1' = t'+u'$ $y_2' = v'+w'$
			$k = \left[\frac{y_1' + 2}{v' - w'}\right]$	$1 = (t'u')^{\frac{1}{2}} = (v'w')^{\frac{1}{2}}$	$u' = v' = d$ $t' = w' = D$	$Z = z$ $s^2 = 1$ $t' = t/z$ $x_1' = y_1' = x_2' = y_2' = (u'+w')$ $u' = u/z$ $w' = w/z$ $v' = v/z$
 9	BRIDGED T	FULL MATCHED IMAGE IMPEDANCES	$k = \left[1 + \frac{z[v(s^2+1)+2s^2 z]}{w(v+2s^2 z)+s^4 z^2}\right]$	$z = \left[vs^2 z\frac{s^2 z + 2w}{v + 2s^2 z}\right]^{\frac{1}{2}}$	$v = 2zs^2/(ds^2-1)$ $w = z(d-s^2)/2$	$Z \geq z$ $s^2 = Z/z \geq 1$ $d = \coth\frac{\theta}{2}$
			$k = \left[1 + \frac{2z(v+z)}{w(v+2z)+z^2}\right]$	$z = \left[vz\frac{z+2w}{v+2z}\right]^{\frac{1}{2}}$	$v = Nz$ $w = nz$	$Z = z$ $s^2 = 1$ $k = \epsilon^\theta$ $n = 1/(k-1) = 1/(\epsilon^\theta - 1)$ $N = (k-1) = (\epsilon^\theta - 1)$
 10	BRIDGED T	UNIT MATCHED IMAGE IMPEDANCES	$k = \left[1 + \frac{v'(s^2+1)+2s^2}{w'(v'+2s^2)+s^4}\right]$	$1 = \left[v's^2\frac{s^2+2w'}{v'+2s^2}\right]^{\frac{1}{2}}$	$v' = 2s^2/(ds^2-1)$ $w' = (d-s^2)/2$	$Z \geq z$ $s^2 = Z/z \geq 1$ $z = 1^\omega$ $v' = v/z$ $w' = w/z$ d $\coth\frac{\theta}{2}$
			$k = \left[1 + \frac{2(v'+1)}{w(v'+2)+1}\right]$	$1 = \left[v'\frac{1+2w'}{v'+2}\right]^{\frac{1}{2}}$	$v' = N$ $w' = n$	$Z = z$ $s^2 = 1$ $z = 1^\omega$ $v' = v/z$ $w' = w/z$
 11	BRIDGED T	FULL MATCHED IMAGE IMPEDANCES	$k = \left[1 + \frac{v}{z}\right]$ $k = \left[1 + \frac{z}{w}\right]$ $k = \left[1 + (\frac{v}{w})^{\frac{1}{2}}\right]$	$z = (vw)^{\frac{1}{2}}$	$v = Nz$ $w = nz$	$Z = z$ $s^2 = 1$ $z^2 = vw$ $N = (k-1) = \epsilon^\theta - 1 = (\cosh\theta + \sinh\theta - 1)$ $n = 1/(k-1) = 1/(\epsilon^\theta - 1) = 1/(\cosh\theta + \sinh\theta - 1)$
 12	BRIDGED T	UNIT MATCHED IMAGE IMPEDANCES	$k = [1 + v']$ $k = \left[1 + \frac{1}{w'}\right]$ $k = \left[1 + (\frac{v'}{w'})^{\frac{1}{2}}\right]$	$1 = (v'w')^{\frac{1}{2}}$	$v' = N$ $w' = n$	$Z = z$ $s^2 = 1$ $v'w' = 1$ $N = (k-1) = (\epsilon^\theta - 1)$ $n = 1/(k-1) = 1/(\epsilon^\theta - 1)$ $v' = v/z$ $w' = w/z$ $\theta = 0.115129 \times \text{No. (db)}$

Figures 7 to 12

The power transmission losses and required element values for the *Lattice* and *Bridged-T* networks in symbolical notation, as shown by the headings of the *Tables of Hyperbolic Functions.*

from expressions 5 and 8, the transmission loss is

$$\text{db} = 20 \text{ Log}_{10} k = 20 \text{ Log}_{10}\left(s\frac{v' + w' + 1}{w'}\right) \quad (9)$$

Since,

$$v' = v/z, \; w' = w/z \text{ and } u' = u/z \quad (10)$$

the loss of the network in terms of the full impedance values is from *9* and *10*

$$\text{db} = 20 \text{ Log}_{10} k = 20 \text{ Log}_{10}(s(v+w+z)/w) \quad (11)$$

Solving equations *1* and *2* for u′ and equating, then simplifying, we obtain

$$(2v'w' + v'^2 - 1)s^2 = w'^2(1 - s^2) \quad (12)$$

From *9,* the factor

$$k = ((v' + w' + 1)s/w') \quad (13)$$

which solved for w′ becomes,

$$w' = s(v'+1)/(k-s) \quad (14)$$

Substituting this into *12* and solving for v′, the unit series impedance adjacent to the unit termination,

$$v' = (k^2 + 1 - 2ks)/(k^2 - 1) = \frac{k^2+1}{k^2-1} - s\frac{2k}{k^2-1} \quad (15a)$$

Using *6* in *15,*

$$v' = \frac{\varepsilon^{2\theta}+1}{\varepsilon^{2\theta}-1} - s\frac{2}{\varepsilon^{\theta}-\varepsilon^{-\theta}} \quad (16a)$$

$$v^1 = \coth\Theta - s\,\text{csch}\,\Theta \quad (17a)$$

$$= c - as = c - w' \quad (18a)$$

where: $k^2 = \varepsilon^{2\theta}$, $c = \coth\Theta$, $a = \text{csch}\,\Theta$, and $s^2 = Z/z$.

The full series impedance is obtained by multiplying each side of equation *15a* to *18a* inclusive, by *z,* getting

$$v = z\left(\frac{k^2+1}{k^2-1} - s\frac{2k}{k^2-1}\right) \quad (15b)$$

$$= z\left(\frac{\varepsilon^{2\theta}+1}{\varepsilon^{2\theta}-1} - s\frac{2}{\varepsilon^{\theta}-\varepsilon^{-\theta}}\right) \quad (16b)$$

$$= z(\coth\Theta - s\,\text{csch}\,\Theta) \quad (17b)$$

$$= z(c - as) = cz - ay = cz - w \quad (18b)$$

where: $y = (Zz)^{1/2}$.

From *13* and *15a,* eliminating v′, the unit shunt impedance is

$$w' = s\frac{2k}{k^2-1} = s\frac{2}{\varepsilon^{\theta}-\varepsilon^{-\theta}} = s\,\text{csch}\,\Theta = a \quad (19a)$$

Multiplying each side of equations *19* by *z,* the full shunt impedance is obtained as

$$w = zs\frac{2k}{k^2-1} = zs\frac{2}{\varepsilon^{\theta}-\varepsilon^{-\theta}}$$

$$= zs\,\text{csch}\,\Theta = asz = ay \quad (19b)$$

Substituting *15a* and *19a* into equation and solving for the unit impedance adjacent to the termination s^2,

$$u' = s^2\frac{k^2+1}{k^2-1} - \frac{2k}{k^2-1} \quad (20a)$$

$$= s^2\frac{\varepsilon^{2\theta}+1}{\varepsilon^{2\theta}-1} - \frac{2}{\varepsilon^{\theta}-\varepsilon^{-\theta}} \quad (21a)$$

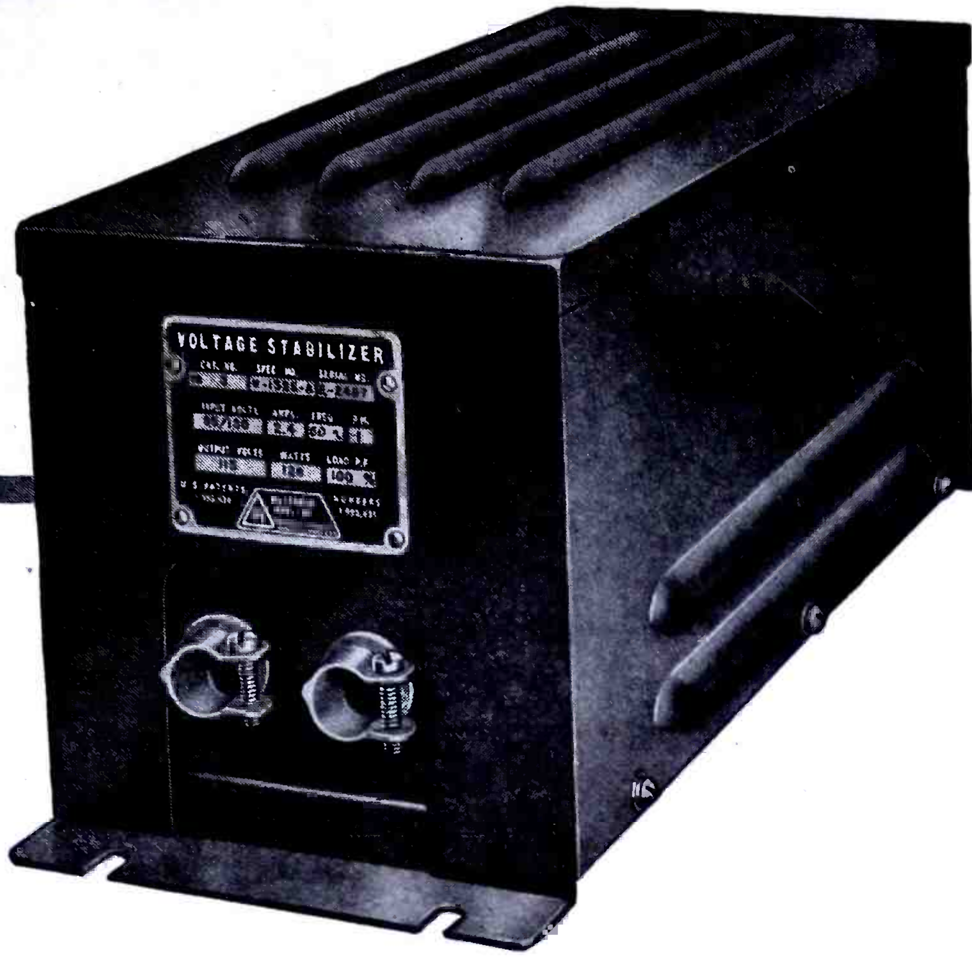
$$= s(s\coth\Theta - \text{csch}\,\Theta) \quad (22a)$$

$$= s(cs - a) = cs^2 - w' \quad (23a)$$

The full series impedance is found b

[*Text, continued on page 72; hyperbolic function tables appear on pages 57, 58 and 60.*]

RAYTHEON VOLTAGE STABILIZERS



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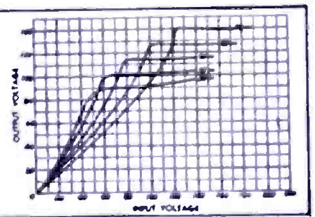
TYPE VR 2
INPUT VS OUTPUT VOLTAGE
FOR VARIOUS FREQUENCIES



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(Continued from page 54)

No (db) $20 \log_{10} \epsilon^{\theta}$ $20 \log_{10} k$	G Sinh 2θ $\frac{k^4-1}{2k^2}$	H $\mathrm{Tanh}^2\,\theta$ $\left(\frac{k^2-1}{k^2+1}\right)^2$	M $1-\epsilon^{-\theta}$ $\frac{k-1}{k}$	P $\mathrm{Sinh}^2\,\theta$ $\frac{(k^2-1)^2}{4k^2}$	Q Cosh 2θ $\frac{k^2+1}{2k^2}$	T $\mathrm{Tanh}^2\,\frac{\theta}{2}$ $\left(\frac{k-1}{k+1}\right)^2$	g Csch 2θ $\frac{2k^2}{k^4-1}$	h $\mathrm{Coth}^2\,\theta$ $\left(\frac{k^2+1}{k^2-1}\right)^2$	m $\frac{1}{1-\epsilon^{-\theta}}$ $\frac{k}{k-1}$	p $\mathrm{Csch}^2\,\theta$ $\frac{4k^2}{(k^2-1)^2}$	q Sech 2θ $\frac{2k^2}{k^2+1}$	t $\mathrm{Coth}^2\,\frac{\theta}{2}$ $\left(\frac{k+1}{k-1}\right)^2$	No (db) $20 \log_{10} \epsilon^{\theta}$ $20 \log_{10} k$
0.00	0.000000	0.00000000	0.000000	0.00000000	0.00000000	0.000000	∞	∞	∞	∞	∞	∞	0.00
.01	.002303	.00000132	.001151	.00000132	1.00000264	3.31776×10^{-7}	434.216	754830	870.565	754829	.9999974	3014083	.01
.02	.004605	.00000530	.002300	.00000530	1.00001060	1.32480×10^{-6}	217.155	188544	435.783	188543	.9999894	754830	.02
.03	.006908	.00001192	.003448	.00001192	1.00002384	2.98253×10^{-6}	144.760	83821.8	290.017	83820.8	.9999762	335286	.03
.04	.009211	.00002121	.004595	.00002120	1.00004240	5.30381×10^{-6}	108.566	47157.6	217.450	47156.6	.9999576	188544	.04
.05	.011513	.00003394	.005540	.00003314	1.00006628	8.28288×10^{-6}	86.8583	30176.0	174.310	30175.0	.9999372	120731	.05
.06	.013816	.00004772	.006884	.00004772	1.00009544	1.19301×10^{-5}	72.3798	20955.4	145.264	20955.3	.9999046	83821.8	.06
.07	.016119	.00006500	.008027	.0000650	1.0001300	1.62409×10^{-5}	62.0386	15397.1	124.580	15396.8	.9998700	61572.9	.07
.08	.018422	.00008478	.009368	.0000848	1.0001696	2.12060×10^{-5}	54.2829	11786.5	106.746	11786.4	.9998304	47156.5	.08
.09	.020725	.00010739	.010308	.0001074	1.0002148	2.68428×10^{-5}	48.2509	9315.32	97.0120	9313.49	.9997852	37253.9	.09
.10	.023028	.00011326	.011447	.0001326	1.0002652	3.31430×10^{-5}	43.4254	7544.50	87.3558	7543.50	.9997349	30176.0	.10
.11	.025331	.00016017	.012584	.0001604	1.0003208	4.00942×10^{-5}	39.9471	6234.54	79.4660	6233.54	.9996793	24941.3	.11
.12	.027635	.00019076	.013720	.0001908	1.0003816	4.77205×10^{-5}	36.1860	5239.85	72.8863	5238.85	.9996185	20955.4	.12
.13	.029938	.00025973	.014855	.0002240	1.0004480	5.60103×10^{-5}	33.4024	4464.99	67.3174	4463.99	.9995522	17853.9	.13
.14	.032242	.00020976	.015989	.0002598	1.0005196	6.49475×10^{-5}	31.0154	3849.78	62.5430	3849.78	.9994807	15397.1	.14
.15	.034546	.00029811	.017119	.0002982	1.0005964	7.45632×10^{-5}	28.9218	3353.86	58.4146	3352.86	.9994040	13411.4	.15
.16	.036850	.00033399	.018252	.0003394	1.0006788	8.48425×10^{-5}	29.1370	2947.63	54.7885	2946.63	.9993217	11786.5	.16
.17	.039154	.00038285	.019382	.0003830	1.0007660	9.57658×10^{-5}	25.5402	2611.27	51.5943	2610.27	.9992346	10442.1	.17
.18	.041459	.0004298	.020510	.0004296	1.0008592	1.07350×10^{-4}	24.1202	2329.15	48.7567	2328.15	.9991415	9315.32	.18
.19	.043763	.0004783	.021637	.0004785	1.0009570	1.19618×10^{-4}	22.8504	2090.60	46.2171	2089.60	.9990439	8359.94	.19
.20	.046068	.0005302	.02276	.0005305	1.0010610	1.32549×10^{-4}	21.7070	1886.08	43.9369	1885.08	.9989401	7544.38	0.20
.25	.057597	.0008283	.02893	.0008290	1.0016580	2.07130×10^{-4}	17.3620	1207.29	34.2466	1206.29	.9983447	4827.88	.25
.30	.069113	.0011917	.03395	.0011931	1.0023862	2.98184×10^{-4}	14.4649	839.138	29.4576	838.138	.9976195	3353.63	.30
.35	.080678	.0016225	.03949	.0016251	1.0032502	4.05821×10^{-4}	12.3950	616.333	25.3191	615.333	.9967603	2464.14	.35
.40	.092234	.0021174	.04501	.0021219	1.0042438	5.30012×10^{-4}	10.8420	472.277	22.2179	471.277	.9957741	1886.75	.40
.50	.11538	.0033065	.05594	.0033175	1.0066350	8.28001×10^{-4}	8.66671	302.435	17.8776	301.435	.9934087	1207.73	.50
.60	.13860	.0047570	.06675	.0047797	1.0095594	1.19198×10^{-3}	7.215007	210.217	14.9821	209.217	.9905311	838.940	.60
.70	.16188	.0064684	.07743	.0065105	1.0130210	1.62200×10^{-3}	6.177415	154.598	12.9147	153.598	.9871464	816.523	.70
.80	.18525	.0084351	.08799	.0085068	1.0170136	2.11784×10^{-3}	5.398111	118.552	11.3648	117.552	.9832710	472.179	.80
.90	.20872	.0106620	.09843	.0107769	1.0215538	2.67930×10^{-3}	4.791108	93.7910	10.1600	92.7910	.9789010	373.232	.90
1.00	.23230	.013139	.10875	.013314	1.026628	3.30636×10^{-3}	4.3048	76.1093	9.19538	75.109	.974063	302.447	1.00
1.10	.25600	.015868	.11895	.016124	1.032248	3.99892×10^{-3}	3.9062	63.0200	8.40686	62.020	.968759	250.068	1.10
1.20	.27984	.018849	.12904	.019211	1.038422	4.75658×10^{-3}	3.5734	53.0532	7.74992	52.053	.963000	210.235	1.20
1.30	.30383	.022068	.13901	.022566	1.045132	5.57785×10^{-3}	3.2914	45.3145	7.19387	44.314	.956817	179.281	1.30
1.40	.32797	.025541	.14886	.026210	1.052420	6.46689×10^{-3}	3.0490	39.1527	6.71755	38.153	.950191	154.634	1.40
1.50	.35230	.029242	.15861	.030123	1.060246	7.41907×10^{-3}	2.8384	34.1974	6.30504	33.197	.943177	134.788	1.50
1.60	.37681	.033191	.16824	.034330	1.068660	8.43532×10^{-3}	2.6538	30.1286	5.94389	29.129	.935751	118.549	1.60
1.70	.40151	.037341	.17776	.038789	1.077578	9.51581×10^{-3}	2.4906	26.7802	5.62577	25.780	.928007	105.088	1.70
1.80	.42643	.041745	.18717	.043564	1.087128	1.06601×10^{-2}	2.3450	23.9550	5.34273	22.955	.919855	93.8077	1.80
1.90	.45158	.046363	.19647	.048617	1.097234	1.18677×10^{-2}	2.2144	21.5689	5.08964	20.569	.911383	84.2623	1.90
2.00	.47696	.051200	.20567	.05396	1.10792	.013139	2.0965	19.5312	4.86205	18.5312	.902592	76.1119	2.00
2.10	.50260	.056247	.21476	.05960	1.11920	.014472	1.9897	17.7787	4.65631	16.7787	.893495	69.0989	2.10
2.20	.52851	.061504	.22375	.06554	1.13108	.015868	1.89211	16.2591	4.46921	15.2591	884111	63.0203	2.20
2.30	.55470	.066963	.23264	.07178	1.14356	.017326	1.80278	14.9336	4.29848	13.9336	.874462	57.7167	2.30
2.40	.58118	.072623	.24142	.07832	1.15664	.018849	1.72063	13.7697	4.14208	12.7697	.864573	53.0532	2.40
2.50	.60797	.078471	.25011	.08516	1.17032	.020428	1.64490	12.7436	3.99832	11.7436	.854474	48.9534	2.50
2.60	.63509	.084509	.25869	.09232	1.18464	.022068	1.57461	11.8331	3.86566	10.8331	.844138	45.3145	2.60
2.70	.66253	.090728	.26718	.09977	1.19954	.023773	1.50937	11.0220	3.74288	10.0220	.833653	42.0645	2.70
2.80	.69032	.097118	.27556	.10757	1.21514	.025541	1.44861	10.2967	3.62895	9.29675	.822950	39.1527	2.80
2.90	.71849	.103681	.28386	.11566	1.23132	.027358	1.39179	9.64497	3.52290	8.64497	.812136	36.5524	2.90
3.00	.74704	.110412	.29205	.12409	1.24818	.029242	1.33860	9.05699	3.42401	8.05699	.801134	34.1974	3.00
3.10	.77599	.117295	.30016	.13284	1.26568	.031181	1.28870	8.52551	3.33160	7.52551	.790689	32.0708	3.10
3.20	.80537	.124332	.30817	.14206	1.28412	.033191	1.24168	8.04298	3.24497	7.04298	.778743	30.1286	3.20
3.30	.83511	.131514	.31610	.15140	1.30280	.035234	1.19963	7.60375	3.16371	6.60375	.767577	28.3817	3.30
3.40	.86533	.138828	.32392	.16120	1.32240	.037341	1.15564	7.20316	3.08720	6.20316	.756201	26.7802	3.40

$\theta = 0.115129 \times$ No (db), $k \geq 1$, $\epsilon = 2.718282$

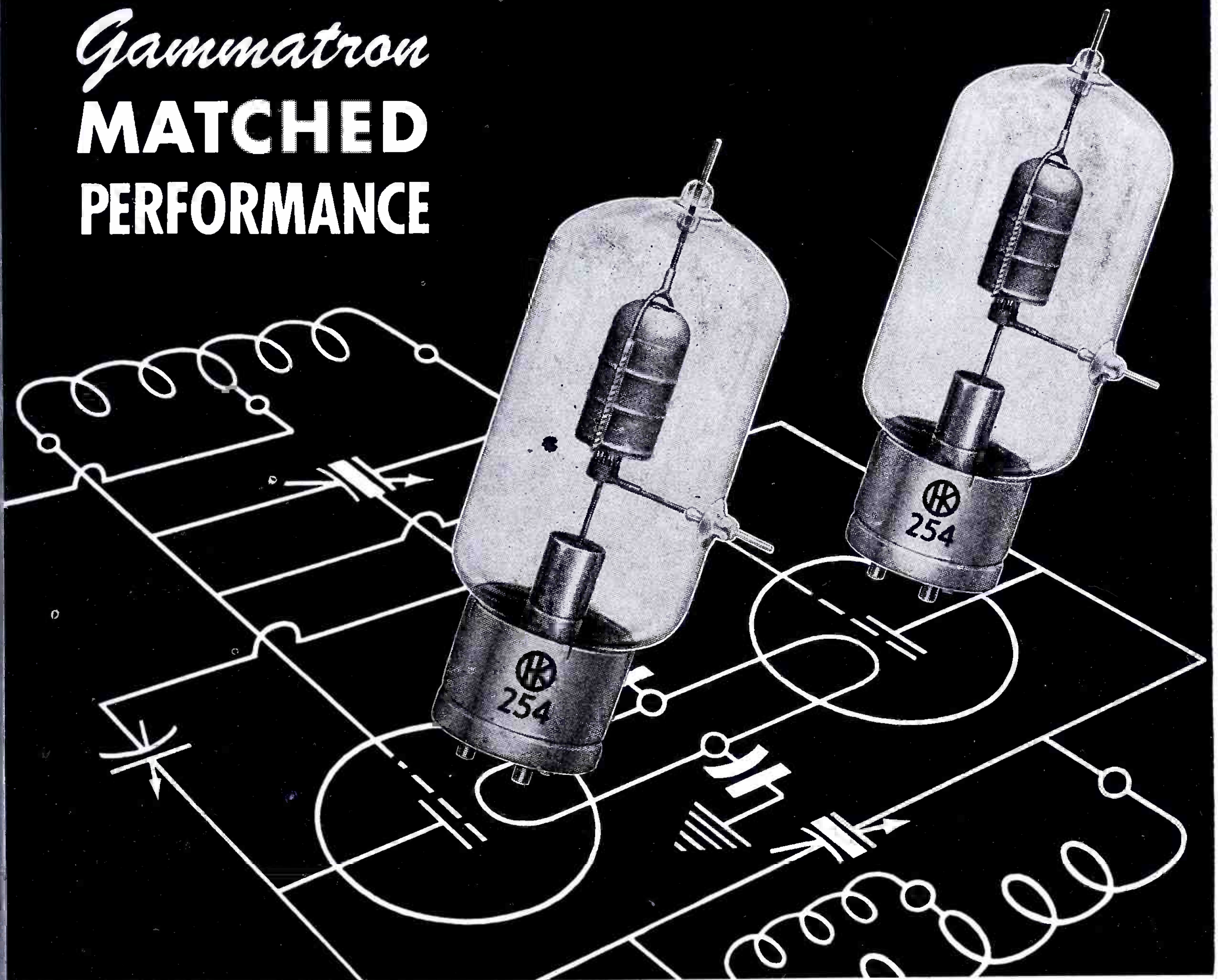
(Continued on page 58)

(Continued from page 57)

No (db) 20 $\log_{10}\epsilon^\theta$ 20 $\log_{10}k$	G Sinh 2θ $\frac{k^4-1}{2k^2}$	H $\tanh^2\theta$ $\left(\frac{k^2-1}{k^2+1}\right)^2$	M $1-\epsilon^{-\theta}$ $\frac{k-1}{k}$	P $\sinh^2\theta$ $\frac{(k^2-1)^2}{4k^2}$	Q Cosh 2θ $\frac{k^2+1}{2k^2}$	T $\tanh^2\frac{\theta}{2}$ $\left(\frac{k-1}{k+1}\right)^2$	g Csch 2θ $\frac{2k^2}{k^4-1}$	h $\coth^2\theta$ $\left(\frac{k^2+1}{k^2-1}\right)^2$	m $\frac{1}{1-\epsilon^{-\theta}}$ $\frac{k}{k-1}$	p $\mathrm{csch}^2\theta$ $\frac{4k^2}{(k^2-1)^2}$	q Sech 2θ $\frac{2k^2}{k^4+1}$	t $\coth^2\frac{\theta}{2}$ $\left(\frac{k+1}{k-1}\right)^2$	No (db) 20 $\log_{10}\epsilon^\theta$ 20 $\log_{10}k$
3.50	.89602	.146288	.33166	.17126	1.34252	.039519	1.11609	6.83583	3.015195	5.83583	.744768	25.3043	3.50
3.60	.92717	.153862	.33931	.18185	1.36370	.041745	1.07851	6.49933	2.94719	5.49933	.733299	23.9550	3.60
3.70	.95883	.161569	.34687	.19269	1.38538	.044026	1.04292	6.18931	2.88292	5.18931	.721824	22.7138	3.70
3.80	.99098	.169382	.35435	.20389	1.40778	.046363	1.00913	5.90381	2.82209	4.90381	.710338	21.5689	3.80
3.90	1.02366	.177305	.36173	.21551	1.43102	.048754	.97690	5.64000	2.76448	4.64000	.698802	20.5111	3.90
4.0	1.05689	.185335	.36904	.22750	1.45500	.051200	.94617	5.39568	2.70972	4.39568	.687287	19.5312	4.0
4.5	1.23178	.226782	.40434	.29329	1.58660	.064211	.81183	4.40952	2.47319	3.40952	.630282	15.5737	4.5
5.0	1.42303	.269876	.43766	.36963	1.73925	.078471	.70274	3.70541	2.28488	2.70541	.574957	12.7436	5.0
5.5	1.633146	.313890	.46912	.45750	1.914984	.093901	.61212	3.18583	2.13167	2.18583	.522197	10.6495	5.5
6.0	1.864943	.358178	.49881	.55808	2.116131	.110412	.53622	2.79191	2.00476	1.79191	.472561	9.05698	6.0
6.5	2.121482	.402156	.52685	.67268	2.345354	.127902	.47136	2.48660	1.89808	1.48660	.426375	7.81848	6.5
7.0	2.406174	.445323	.55332	.80284	2.605700	.146288	.41560	2.24556	1.80728	1.24556	.383774	6.83583	7.0
7.5	2.722782	.487257	.57830	.95030	2.900622	.165463	.36726	2.05230	1.72920	1.05230	.344757	6.04365	7.5
8.0	3.075539	.527634	.60189	1.11702	3.234026	.185335	.32515	1.89525	1.66142	.89525	.309214	5.39563	8.0
8.5	3.469103	.566192	.62416	1.30517	3.610357	.205806	.28826	1.76619	1.60215	.76619	.276983	4.85894	8.5
9.0	3.908691	.602741	.64519	1.51730	4.034583	.226782	.25584	1.65909	1.54994	.65909	.247862	4.40952	9.0
9.5	4.400154	.637176	.66503	1.75620	4.512356	.248168	.22726	1.56942	1.50368	.56942	.221616	4.02953	9.5
10.0	4.950000	.669428	.68377	2.02499	5.050000	.269876	.20202	1.49382	1.46247	.49382	.198015	3.70541	10.0
10.5	5.56553	.699458	.70146	2.32733	5.65466	.291808	.179682	1.42968	1.42559	.42968	.176846	3.42691	10.5
11.0	6.25491	.727310	.71816	2.66716	6.33434	.313890	.159870	1.37493	1.39244	.37493	.157870	3.18583	11.0
11.5	7.02729	.753028	.73393	3.04904	7.09808	.336038	.142246	1.32797	1.36253	.32797	.140883	2.97585	11.5
12.0	7.89282	.776686	.74881	3.47801	7.95592	.358178	.126696	1.28752	1.33545	.28752	.125691	2.79191	12.0
12.5	8.86328	.798378	.76286	3.95975	8.91951	.380239	.112826	1.25254	1.31085	.25254	.112113	2.62992	12.5
13.0	9.95125	.818205	.77613	4.50068	10.00137	.402156	.100492	1.22219	1.28845	.22219	.0999863	2.48660	13.0
13.5	11.17128	.836283	.78865	5.10797	11.21595	.423869	.089514	1.19577	1.26799	.19577	.0891587	2.35922	13.5
14.0	12.53953	.852717	.80047	5.78967	12.57934	.445323	.079748	1.17272	1.24926	.17272	.0794954	2.24556	14.0
14.5	14.07418	.867634	.81163	6.55482	14.10966	.466468	.071052	1.15256	1.23208	.15256	.0708734	2.14376	14.5
15.0	15.79558	.881141	.82217	7.41361	15.82720	.487257	.063309	1.13491	1.21629	.13491	.0631832	2.05230	15.0
15.5	17.72658	.893360	.83212	8.37738	17.75476	.507662	.056412	1.11936	1.20175	.11936	.0563229	1.96981	15.5
16.0	19.89281	.904390	.84151	9.45892	19.91793	.527634	.050269	1.10572	1.18834	.10572	.0502060	1.89525	16.0
16.5	22.32298	.914330	.85038	10.6727	22.34537	.547156	.044797	1.09370	1.17595	.09370	.0447520	1.82763	16.5
17.0	25.04940	.923281	.85875	12.0347	25.06935	.566192	.039921	1.083094	1.16449	.083094	.0398893	1.76619	17.0
17.5	28.10819	.931333	.86665	13.5630	28.12597	.584731	.035577	1.073729	1.15387	.073729	.035553	1.71018	17.5
18.0	31.53990	.938568	.87411	15.2779	31.55575	.602741	.031706	1.065453	1.14402	.065453	.0316899	1.65909	18.0
18.5	35.39017	.945062	.88115	17.2021	35.40442	.620233	.028256	1.058131	1.13488	.058131	.0282451	1.61229	18.5
19.0	39.71007	.950886	.887798	19.3611	39.72266	.637176	.025183	1.051650	1.12638	.051650	.0251745	1.56942	19.0
19.5	44.55694	.956108	.894075	21.7841	44.56816	.653575	.022443	1.045905	1.11847	.045905	.0224375	1.53004	19.5
20.0	49.99500	.960788	.900000	24.5025	50.00500	.669428	.020002	1.040812	1.111111	.040812	.0199980	1.49382	20.0
20.5	56.0965	.964976	.905594	27.5528	56.10535	.684715	.017826	1.036295	1.104248	.036295	.0178236	1.46047	20.5
21.0	62.9423	.968726	.910875	30.9752	62.95017	.699458	.015888	1.032282	1.097846	.032282	.0158856	1.42968	21.0
21.5	70.6233	.972080	.915861	34.8153	70.63044	.713650	.014160	1.028721	1.091869	.028721	.0141582	1.42967	21.5
22.0	79.2406	.975077	.920567	39.1239	79.24780	.727310	.012620	1.025561	1.086287	.025561	.0126186	1.37493	22.0
22.5	88.9112	.977757	.925011	43.9585	88.91676	.740431	.011247	1.022748	1.081069	.022748	.0112465	1.35057	22.5
23.0	99.7606	.980153	.929205	49.3827	99.76560	.753028	.010024	1.020247	1.076186	.020247	.0100235	1.32797	23.0
23.5	111.9339	.982293	.933166	55.4691	111.9384	.765111	.0089338	1.018027	1.071621	.018027	.0089335	1.30700	23.5
24.0	125.5923	.984201	.936904	62.2967	125.5963	.776686	.0079623	1.016053	1.067345	.016053	.0079620	1.28752	24.0
24.5	140.9174	.985910	.940434	69.9604	140.9209	.787773	.0070964	1.014291	1.063339	.014291	.0070962	1.26940	24.5
25.0	158.1123	.987432	.943766	78.5576	158.1155	.798378	.0063246	1.012728	1.059585	.012728	.0063245	1.25254	25.0
25.5	177.4051	.988788	.946911	88.2041	177.4079	.808505	.0056368	1.01133	1.056065	.011337	.0056367	1.23685	25.5
26.0	199.0524	.990001	.949881	99.0274	199.0549	.818205	.0050238	1.010100	1.052763	.010100	.0050237	1.22219	26.0
26.5	223.3408	.991084	.952685	111.1716	223.3428	.827445	.0044775	1.008996	1.049665	.008996	.0044774	1.20854	26.5
27.0	250.5927	.992050	.955332	124.7975	250.5947	.836283	.0039905	1.008014	1.046757	.008014	.0039905	1.19577	27.0
27.5	281.1699	.992913	.957830	140.0857	281.1717	.844704	.0035566	1.007138	1.044026	.007138	.0035565	1.18385	27.5
28.0	315.4775	.993680	.960189	157.2398	315.4790	.852717	.0031698	1.006360	1.041462	.006360	.0031698	1.17272	28.0
28.5	353.9722	.994366	.962416	176.4866	353.9737	.860351	.0028251	1.005666	1.039051	.005666	.0028251	1.16232	28.5

$\theta = 0.115129 \times$ No (db), $k \geq 1$, $\epsilon = 2.718282$

Gammatron MATCHED PERFORMANCE



Gammatron UNIFORMITY MEANS LONGER TUBE LIFE

Heintz and Kaufman engineers have continually developed closer electrical and physical tolerances for Gammatron tubes over the past 16 years, knowing that matched characteristics result in better operation and longer tube life.

Today the importance of tube uniformity, especially in the very high frequencies, is widely recognized; and many of the peacetime standards we have established for Gammatrons are now contained in the wartime specifications for all tubes of the Gammatron type . . . When you design a transmitter around a pair—or even a dozen—Gammatrons, you will get the full benefit of our years of experience in pioneering constantly higher standards of transmitting tube performance.

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

HK-254 *Matched* CHARACTERISTICS

MAXIMUM RATINGS

Power Output	500 Watts
Plate Dissipation	100 Watts
Amplification Factor	25
DC Plate Voltage	4000 Volts
DC Plate Current	225 M. A.
DC Grid Current	40 M. A
Max. Frequency	175 Mc

INTER-ELECTRODE CAP.:

C grid-plate	3.6 uuf
C grid-filament	3.3 uuf
C plate-filament	1.0 uuf
Filament Voltage	5 Volts
Filament Current	7.5 Amps.

ARMY E NAVY

KEEP IT UP . . . . . BUY WAR BONDS

(Continued from page 58)

No (db) $20 \log_{10} \epsilon^{\theta}$ $20 \log_{10} k$	G Sinh 2θ $\frac{k^4-1}{2k^2}$	H Tanh$^2\theta$ $\left(\frac{k^2-1}{k^2+1}\right)^2$	M $1-\epsilon^{-\theta}$ $\frac{k-1}{k}$	P Sinh$^2\theta$ $\frac{(k^2-1)^2}{4k^2}$	Q Cosh 2θ $\frac{k^4+1}{2k^2}$	T Tanh$^2\frac{\theta}{2}$ $\left(\frac{k-1}{k+1}\right)^2$	g Csch 2θ $\frac{2k^2}{k^4-1}$	h Coth$^2\theta$ $\left(\frac{k^2+1}{k^2-1}\right)^2$	m $\frac{1}{1-\epsilon^{-\theta}}$ $\frac{k}{k-1}$	p Csch$^2\theta$ $\frac{4k^2}{(k^2-1)^2}$	q Sech 2θ $\frac{2k^2}{k^4+1}$	t Coth$^2\frac{\theta}{2}$ $\left(\frac{k+1}{k-1}\right)^2$	No (db) $20 \log_{10} \epsilon^{\theta}$ $20 \log_{10} k$
29.0	397.16302	.994976	.964519	198.0825	397.16428	.867634	.00251786	1.005049	1.036787	.005049	.0025178	1.15256	29.0
29.5	445.62494	.995521	.966503	222.3313	445.62606	.874550	.00224404	1.004499	1.034657	.004499	.0022440	1.14345	29.5
30.0	499.99950	.996008	.968377	249.5003	500.00050	.881141	.00200000	1.004008	1.032655	.004008	.00200000	1.13491	30.0
31.0	629.43465	.996829	.971816	314.2315	629.46300	.893360	.00158873	1.003181	1.029001	.003181	.00158866	1.11936	31.0
32.0	792.44719	.997480	.974881	395.7239	792.44789	.904390	.00126191	1.002526	1.025766	.002526	.00126191	1.10572	32.0
33.0	997.63050	.997997	.977613	498.3156	995.63112	.914330	.00100238	1.002007	1.022900	.002007	.00100439	1.093697	33.0
34.0	1255.94435	.998409	.980047	627.4723	1255.9446	.923281	.000796214	1.001594	1.020359	.001594	.00079621	1.083094	34.0
35.0	1581.13884	.998736	.982217	790.0702	1581.1404	.931333	.000632456	1.001266	1.018105	.001266	.00063245	1.073729	35.0
36.0	1990.53040	.998996	.984151	994.7654	1990.5308	.938568	.000502379	1.001005	1.016104	.001005	.00050238	1.065453	36.0
37.0	2505.93688	.999202	.985875	1252.4730	2505.9460	.945062	.000399052	1.000799	1.014328	.000799	.00039905	1.058131	37.0
38.0	3154.77922	.999366	.9874107	1.5769×10^{3}	3154.7794	.950886	.000316979	1.000634	1.012866	.000634	.00031698	1.051650	38.0
39.0	3971.64166	.999496	.9887798	1.9853×10^{3}	3971.6418	.956108	.000251785	1.000504	1.011347	.000504	.00025178	1.045905	39.0
40.0	4999.99995	.999600	.9900000	2.4995×10^{3}	5000.0000	.960788	.000200000	1.000400	1.010101	.000400	2×10^{-4}	1.040812	40.0
41.0	6294.41998	.999682	.9910875	3.1468×10^{3}	6.2946×10^{3}	.964976	1.5887×10^{-4}	1.000318	1.008993	.000318	1.5887×10^{-4}	1.036295	41.0
42.0	7924.45697	.999750	.9920567	3.9617×10^{3}	7.9244×10^{3}	.968726	1.26192×10^{-4}	1.000250	1.008007	.000250	1.2619×10^{-4}	1.032282	42.0
43.0	9976.30951	.999800	.9929205	4.9876×10^{3}	9.9762×10^{3}	.972080	1.00237×10^{-4}	1.000200	1.007130	.000200	1.0024×10^{-4}	1.028721	43.0
44.0	12559.2864	.999840	.9936904	6.2791×10^{3}	1.2559×10^{4}	.975077	7.96224×10^{-5}	1.000160	1.006350	.000160	7.9624×10^{-5}	1.025561	44.0
45.0	15811.3917	.999874	.9943766	7.9052×10^{3}	1.5811×10^{4}	.977757	6.32456×10^{-5}	1.000126	1.005655	.000126	6.3247×10^{-5}	1.022748	45.0
46.0	19905.3522	.999900	.9949881	9.9521×10^{3}	1.9905×10^{4}	.980153	5.02377×10^{-5}	1.000100	1.005037	.000100	5.0238×10^{-5}	1.020247	46.0
47.0	25059.4033	.999918	.9955332	1.2529×10^{4}	2.5059×10^{4}	.982293	3.99052×10^{-5}	1.000082	1.004487	.000082	3.9906×10^{-5}	1.018027	47.0
48.0	31547.8564	.999936	.9960189	1.5773×10^{4}	3.1547×10^{4}	.984201	3.16979×10^{-5}	1.000064	1.003997	.000064	3.1699×10^{-5}	1.016053	48.0
49.0	39716.4137	.999950	.9964519	1.9858×10^{4}	3.9717×10^{4}	.985910	2.51785×10^{-5}	1.000050	1.003561	.000050	2.5178×10^{-5}	1.014291	49.0
50.0	50000.0107	.999960	.9968376	2.4999×10^{4}	4.9999×10^{4}	.987432	2.00000×10^{-5}	1.000040	1.003172	.000040	2×10^{-5}	1.012728	50.0
51.0	62946.1325	.999968	.9971816	3.1473×10^{4}	6.2947×10^{4}	.988788	1.58866×10^{-5}	1.000032	1.002826	.000032	1.5886×10^{-5}	1.011339	51.0
52.0	79244.7111	.999974	.9974881	3.9622×10^{4}	7.9245×10^{4}	.990001	1.26191×10^{-5}	1.000026	1.002518	.000026	1.2619×10^{-5}	1.010100	52.0
53.0	99763.1192	.9999820	.9977613	4.9881×10^{4}	9.9763×10^{4}	.991084	1.00237×10^{-5}	1.0000180	1.002244	.0000180	1.0024×10^{-5}	1.008996	53.0
54.0	125594.405	.9999840	.9980047	6.2796×10^{4}	1.25593×10^{5}	.992050	7.96214×10^{-6}	1.0000160	1.001999	.0000160	7.9622×10^{-6}	1.008014	54.0
55.0	155302.320	.9999872	.9982217	7.9056×10^{4}	1.58113×10^{5}	.992913	6.43905×10^{-6}	1.0000128	1.001781	.0000128	6.3246×10^{-6}	1.007138	55.0
56.0	199053.052	.9999904	.9985151	9.9526×10^{4}	1.99053×10^{5}	.993680	5.02379×10^{-6}	1.0000096	1.001587	.0000096	5.0238×10^{-6}	1.006360	56.0
57.0	250593.699	.9999916	.9985875	1.252962×10^{5}	2.50593×10^{5}	.994366	3.99052×10^{-6}	1.0000084	1.001415	.0000084	3.9905×10^{-6}	1.005666	57.0
58.0	315477.930	.9999936	.9987411	1.57738×10^{5}	3.15477×10^{5}	.994976	3.16979×10^{-6}	1.0000064	1.091261	.0000064	3.1698×10^{-6}	1.005049	58.0
59.0	397164.172	.9999950	.9988780	1.98582×10^{5}	3.97165×10^{5}	.995521	2.51785×10^{-6}	1.0000050	1.001123	.0000050	2.5178×10^{-6}	1.004499	59.0
60.0	5×10^{5}	.9999960	.9990000	2.49999×10^{5}	4.99999×10^{5}	.996008	2×10^{-6}	1.0000040	1.001001	.0000040	2×10^{-6}	1.004008	60.0
65.0	1.5811×10^{6}	.99999874	.99943766	7.90569×10^{5}	1.58114×10^{6}	.997751	6.32456×10^{-7}	1.00000126	1.000563	.00000126	6.3246×10^{-7}	1.002254	65.0
70.0	5×10^{6}	.99999960	.99968377	2.499999×10^{6}	5×10^{6}	.998736	2×10^{-7}	1.00000040	1.000316	.00000040	2×10^{-7}	1.001266	70.0
75.0	1.5811×10^{7}	.99999986	.99982217	7.905694×10^{6}	1.58114×10^{7}	.999288	6.32456×10^{-8}	1.00000014	1.0001778	.00000014	6.3246×10^{-8}	1.000713	75.0
80.0	5×10^{7}	.99999996	.99990000	2.4999999×10^{7}	5×10^{7}	.999600	2×10^{-8}	1.00000004	1.0001000	.00000004	2×10^{-8}	1.000400	80.0
85.0	1.5811×10^{8}	.99999998	.999943766	7.9056954×10^{7}	1.58114×10^{8}	.999774	6.32456×10^{-9}	1.00000002	1.0000562	.00000002	6.3246×10^{-9}	1.000226	85.0
90.0	5×10^{8}	1.00000000	.999968377	2.4999999×10^{8}	5×10^{8}	.999874	2×10^{-9}	1.00000000	1.0000316	.00000000	2×10^{-9}	1.000126	90.0
95.0	1.5811×10^{9}	1.00000000	.999982217	7.90569547×10^{8}	1.58114×10^{9}	.999928	6.32456×10^{-10}	1.00000000	1.0000188	.00000000	6.3246×10^{-10}	1.000072	95.0
100.0	5×10^{9}	1.00000000	.999990000	2.5×10^{9}	5×10^{9}	.999960	2×10^{-10}	1.00000000	1.0000100	.00000000	2×10^{-10}	1.000040	100.0
105.0	1.5811×10^{10}	1.00000000	.9999943766	7.90569548×10^{9}	1.58114×10^{10}	.999978	6.32456×10^{-11}	1.00000000	1.0000056	.00000000	6.3246×10^{-11}	1.000022	105.0
110.0	5×10^{10}	1.00000000	.9999968377	2.5×10^{10}	5×10^{10}	.9999872	2×10^{-11}	1.00000000	1.0000032	.00000000	2×10^{-11}	1.0000128	110.0
115.0	1.5811×10^{11}	1.00000000	.9999982217	$7.90569548 \times 10^{10}$	1.58114×10^{11}	.9999926	6.32456×10^{-12}	1.00000000	1.0000018	.00000000	6.3246×10^{-12}	1.0000074	115.0
120.0	5×10^{11}	1.00000000	.9999990000	2.5×10^{11}	5×10^{11}	.9999960	2×10^{-12}	1.00000000	1.0000010	.00000000	2×10^{-12}	1.0000040	120.0
125.0	1.5811×10^{12}	1.00000000	.9999994377	$7.90569548 \times 10^{11}$	1.58114×10^{12}	.9999974	6.32456×10^{-13}	1.00000000	1.00000056	.00000000	6.3246×10^{-13}	1.0000026	125.0
130.0	5×10^{12}	1.00000000	.9999996838	2.5×10^{12}	5×10^{12}	.99999874	2×10^{-13}	1.00000000	1.00000032	.00000000	2×10^{-13}	1.00000126	130.0
135.0	1.5811×10^{13}	1.00000000	.9999998222	$7.90569548 \times 10^{12}$	1.58114×10^{13}	.99999916	6.32456×10^{-14}	1.00000000	1.00000018	.00000000	6.3246×10^{-14}	1.00000084	135.0
140.0	5×10^{13}	1.00000000	.9999999000	2.5×10^{13}	5×10^{13}	.99999960	2×10^{-14}	1.00000000	1.00000010	.00000000	2×10^{-14}	1.00000040	140.0
150.0	5×10^{14}	1.00000000	.9999999684	2.5×10^{14}	5×10^{14}	.99999986	2×10^{-15}	1.00000000	1.00000003	.00000000	2×10^{-15}	1.00000014	150.0

$\theta = 0.115129 \times$ No (db), $k \geq 1$, $\epsilon = 2.718282$

(Continued on page 72)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CUMULATIVE INDEX

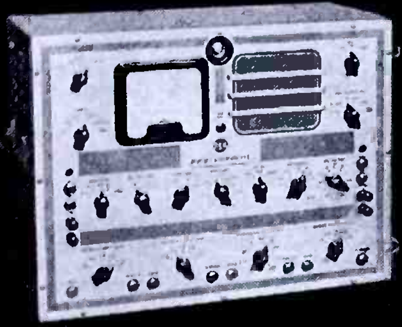
ALPHABETICALLY ARRANGED

FOR AUTHORS AND SUBJECTS

INDEX

RCA's New 170-A Audio Chanalyst

Tests Everything from Microphones to Multiple Speakers



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TABLES, CHARTS

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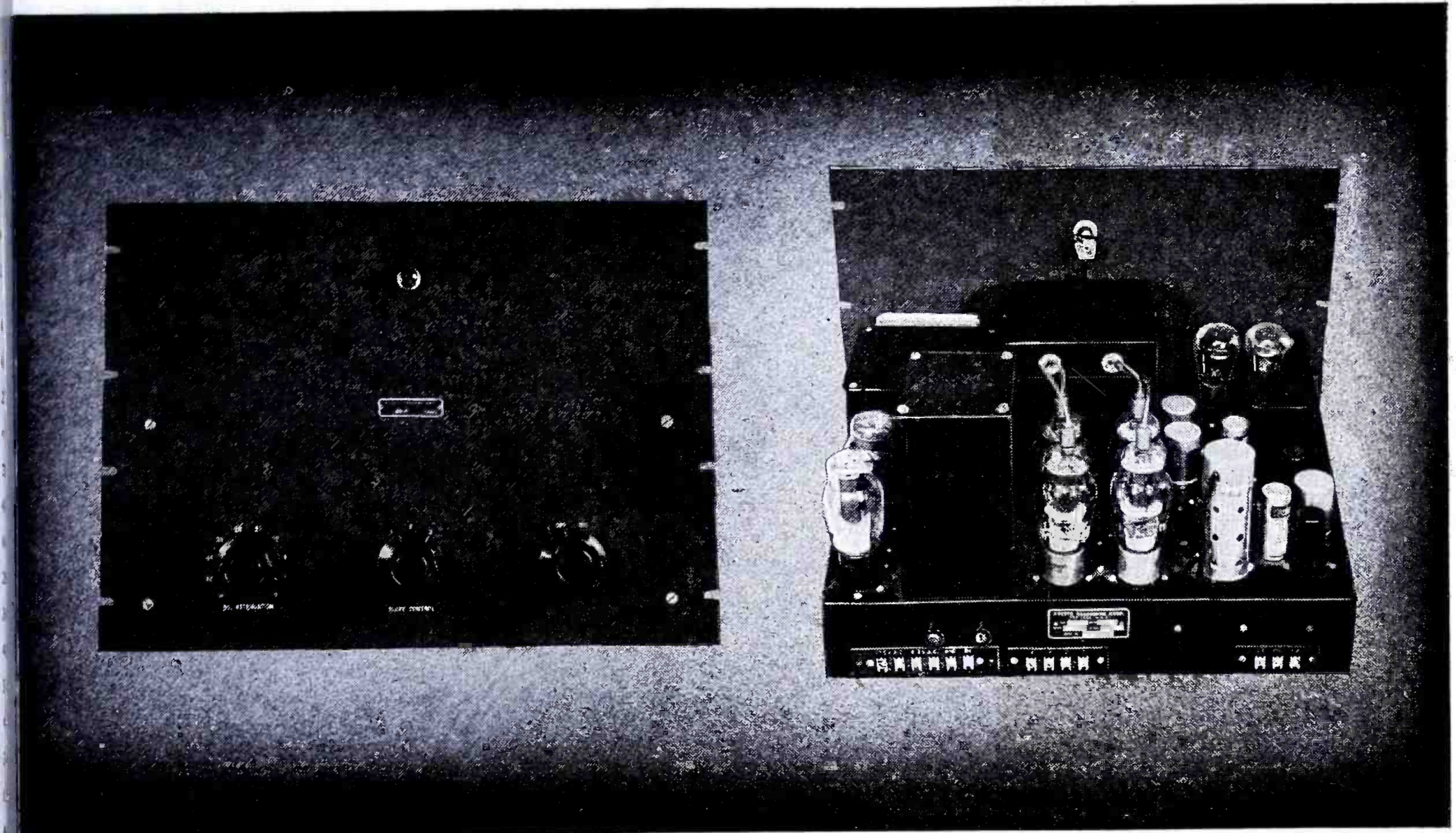

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COUPLED CIRCUIT DESIGN

(*Continued from page* 43)

$$(e')^2 = e_p^2 + \tfrac{1}{4}e_2^2 - e_p e_2 S_2/U_2 \qquad (37)$$

$$(e'')^2 = e_p^2 + \tfrac{1}{4}e_2^2 + e_p e_2 S_2/U_2 \qquad (38)$$

Assuming the diodes to be operating as peak rectifiers, the rectified voltages are

$$E' = 1.414e' \qquad E'' = 1.414e''$$

$$E = 1.414(e'' - e') \qquad (39)$$

For the moment suppose we let $(e')^2 = \alpha - \beta$ and $(e'')^2 = \alpha + \beta$ so that

$$E^2 = 2[(\alpha + \beta)^{1/2} - (\alpha - \beta)^{1/2}]^2$$

$$= [2\alpha - 2(\alpha^2 - \beta^2)^{1/2}]2$$

$$E = \pm 2[\alpha - (\alpha^2 - \beta^2)^{1/2}]^{1/2} \qquad (40)$$

From equations *37* and *38*, $\alpha = e_p^2 + \tfrac{1}{4}e_2^2$ and $\beta = e_p e_2 S_2/U_2$. Using equations *29* and *30* for e_p and e_2, the d-c output voltage may be written in terms of grid voltage at the driving tube. We are dealing now with scalar values only so the *j* is dropped. First using equation *31* the d-c voltage may be expressed in terms of secondary voltage

$$E = \pm 2e_2 \sqrt{(Z_{o1}/Z_{o2})(U_2/KQ_g)^2 + \tfrac{1}{4} - \sqrt{[(Z_{o1}/Z_{o2})(U_2/KQ_g)^2 - \tfrac{1}{4}]^2 + (Z_{o1}/Z_{o2})(1/KQ_g)^2}} \qquad (41)$$

A calculation constant is apparent here which is a function of coupling *Q*, and impedance ratio. Let us call it

$$B = (Z_{o1}/Z_{o2})(1/KQ_g)^2 \qquad (42)$$

From equation *30*, at resonance

$$A_o = e_2/e_g = g_m Z_{og}[KQ_g/(1 + K^2 Q_g^2)] \qquad (43)$$

and we may now write the discriminator equation in terms of two variables and two constants

$$E = \pm (2A_o e_g/U) \sqrt{BU_2^2 + \tfrac{1}{4} - \sqrt{(BU_2^2 - \tfrac{1}{4})^2 + B}} \qquad (44)$$

where

U_2 is the selectivity of a single circuit of Q_2

U is the selectivity of a coupled pair of $Q = Q_g^2/Q_a$

A_o is the grid-to-grid gain of the loaded transformer used as a coupled circuit amplifier (at resonance).

This reduces discriminator performance to a conveniently calculable formula.

Diode Loads

In the case of a discriminator or any diode-driving transformer, the diode load must be considered in arriving at an effective circuit Q[5]. We will assume that full peak rectification is obtained. Bypass capacitors will, in all usual designs, be sufficient to develop very nearly peak voltage. Where the diode load resistors are low in value, a loss of voltage due to internal diode resistance will need to be anticipated, and this internal diode resistance will also reduce the loading effect of the resistors. Neglecting the losses in the diode, the d-c power generated in the diode load must come from the i-f power supplied by the transformer since no external source of power is available. We can, therefore, equate the power the i-f would produce in a fictitious resistor to the power it does supply in d-c form across the diode load resistor. If we represent the i-f voltage driving the diode by an rms value *E*, then the peak d-c voltage developed will be 1.414E.

$$E^2/R' = 2E^2/R = E^2/(R/2) \qquad (45)$$

where R′ is the fictitious a-c load across the transformer, which is equal to ½R, *R* being the resistor in the diode load circuit. This applies to a circuit as shown in Figure 14. Another diode rectifier circuit often used is shown in Figure 15. With the same *R-C* time constant the performance will be the same as that of Figure 14 except for the appearance of i-f as well as the d-c voltage across *R*. The resulting power required of the transformer will be

$$E^2/R'' = 2E^2/R + E^2/R = E^2/(R/3) \qquad (46)$$

so that, in this case, the equivalent loading on the i-f circuit is (1/3)R.

The discriminator circuit, Figure 9, may be represented by a loaded i-f circuit, Figure 16, in which the effect of the diode loads is incorporated in the fictitious resistors ½*R*. The total power delivered to the diodes is

$$P = (e')^2/(R/2) + (e'')^2/(R/2) \qquad (47)$$

Using equation *37* and *38* this becomes

$$P = 4e_p^2/R + 4(e_2/2)^2/R$$
$$= e_p^2/(R/4) + e_2^2/R \qquad (48)$$

This means that the power required from the secondary (at any frequency) may be determined from a fictitious resistor of value *R* across the secondary circuit. The driving voltage for the diodes is partly provided by the primary, and from equation *48* it is apparent that the power required from the primary at any frequency may be accounted for by a fictitious resistor of value ¼*R* across the primary. *R* is the resistance in *one* diode load.

Let us now apply a sample calculation for Figure 9 with the following circuit constants: Diode load $R = 40{,}000$ ohms; Q_1 (coil only) $= 90$; $C_1 = 40$ mmf; Q_2 (coil only) $= 70$; $C_2 = 15$ mmf; $f_o = 4.0$ mc; $g_m = 3500$ μmho; and R_2 (a resistance load across C_2) $= 40{,}000$ ohms. The resistance load, R_2, is not shown in Figure 9.

First we must determine effective circuit *Q* and impedance.

Resonant impedance:

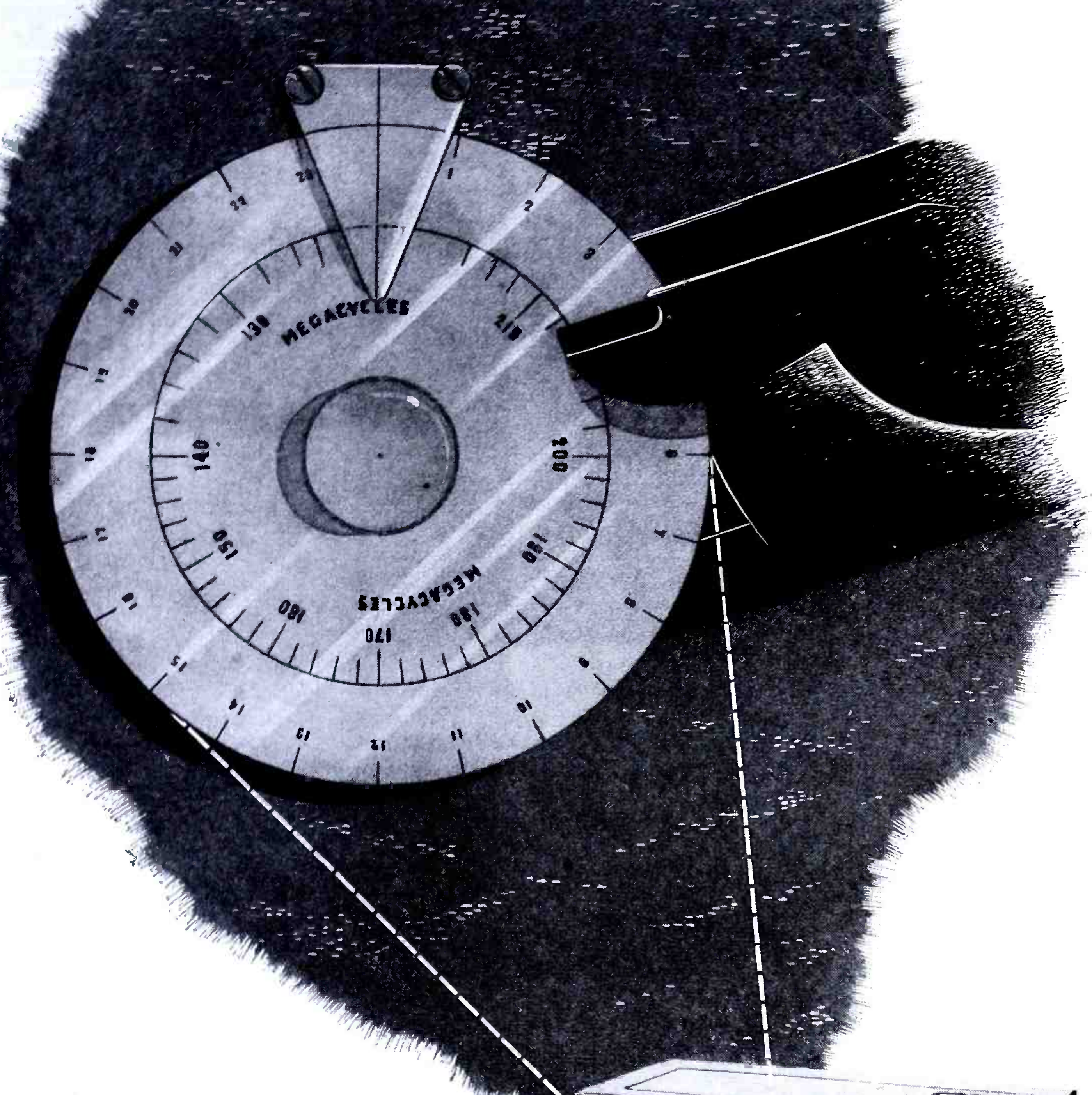
Primary alone $Z_1 = X_1 Q_1$
$= (1000)\ (90) = 90{,}000$ ohms

Secondary alone $Z_2 = X_2 Q_2$
$= (2667)(70) = 186{,}600$ ohms

The loading on the secondary is 40,000 ohms in parallel with a fictitious resistor

(*Continued on page* 74)

how high is very high?



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VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President — RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y. — GEORGE H. CLARK, Secretary

Personals

FROM Colonel Robert B. Woolverton, veteran of over forty years in the wireless art and inventor of the spark transmitter for which he was made a Fellow of the IRE in 1915, we've received an interesting note describing his early experiences. Col. Woolverton states that his experiments with the Slaby-Arco coherers appeared quite trivial when he began working with electrolytic detectors improvised from miniature lamp bulbs and pieces of Wolleston wire with a pair of headphones, way back in 1904. For the first time, he says, he heard signals! . . . Another real pioneer has also written in . . . Greenleaf W. Pickard. Mr. Pickard began sending out dots and dashes at Blue Hill in 1898-1899, and Providence in 1899. On the schooner *Maid of the Mist* he reported the 1901 yacht races using the *Pickard-Shoemaker* ten-second-dash code. Frequent unlicensed wireless communication went on between the Pickard station *HY* at Amesbury, Mass., and operator Charles C. Kolster (now, incidentally, the Inspector-in-Charge for the FCC in Boston) at the Stone *Isles of Shoals* station *S* off the coast of New Hampshire. Mr. Pickard received his first official license in 1913.

Commander Fred Muller has written in asking for letters. He says he "gets lonesome at times for home and my old pals." His address is USNR Navy No. 116, c/o Fleet P. O. New York, N. Y. . . . VWOA members H. H. Parker and Ladaveze sent in Christmas greetings. Thanks. HHP continues active up Westchester way with the lighting company and brother Ladaveze continues his technical duties at RCAC at Rocky Point.

Oldtimers

C. D. GUTHRIE informs us that one of the first men to aid Marconi in his early wireless experiments was, until recently, a resident of New York . . . Captain Arturo Hugo. Captain Hugo served aboard the American Shipping Board vessels in the 1920's. In 1896 he was a Chief Signalman in the Royal Italian Navy serving on the HIMS Carlo Alberta. Upon Marconi's arrival aboard the Alberta to carry on his experiments, Captain Hugo was assigned to assist Marconi, in view of his code knowledge. His work so pleased Marconi that a request to make him a permanent assistant was made. However, Captain Hugo had just passed his examination for a Third Mate's license to enter the Italian Merchant Marine. Later Captain Hugo came to America. Mr. Guthrie recalls meeting him often when he was master of various Shipping Board vessels back in the '20's. . . . William L. Lawson's thirteen-year professional radio record is most interesting. His assignments include service aboard the steamship Fluor Spar, airlines of the Eastern Air Transport, Tropical Radio, Eastern Air Lines, and Pan American Airways. He is now with the Civil Aeronautics Administration.

Jack Poppele, chief engineer of WOR, who was recently elected president of TBA. He will receive the Marconi Memoral Plaque for TBA at the 20th anniversary dinner-cruise in February.

Los Angeles

A LETTER from Leroy Bremer discloses that he had moved from Alaska down to the Solomon Islands during the year. He is now back in Alaska. Recalling his experiences since Pearl Harbor, he says that he has spent 29 months out of the last 33 outside of the continental United States and covered a half-million miles, plus plenty of action on all fronts.

Continuing, he says: "Of course I keep in touch with what's going on, and where the boys are, through the pages of COMMUNICATIONS which always gets to me no matter where I go. Keep up the good work, Bill."

Lieutenant Leroy Bremmer's address is: USMS, Communications Officer, Naneen, Alaska (Bristol Bay).

20th Anniversary

OUR twentieth anniversary dinner-cruise in the Belvedere Roof of the Hotel Astor on Saturday evening, Feb. 17, 1945, will feature the presentation of our Marconi Memorial Plaque to the Television Broadcasters Association, of which our own 'Jack' Poppele is the 1945 president. Many additional awards will be made. A full representation of the top ranking personnel of the various Armed services and some of the *communications* heroes of this war is also planned. . . . We'd like to hear from you regarding your reservations at the earliest possible moment.

Biographical Notes

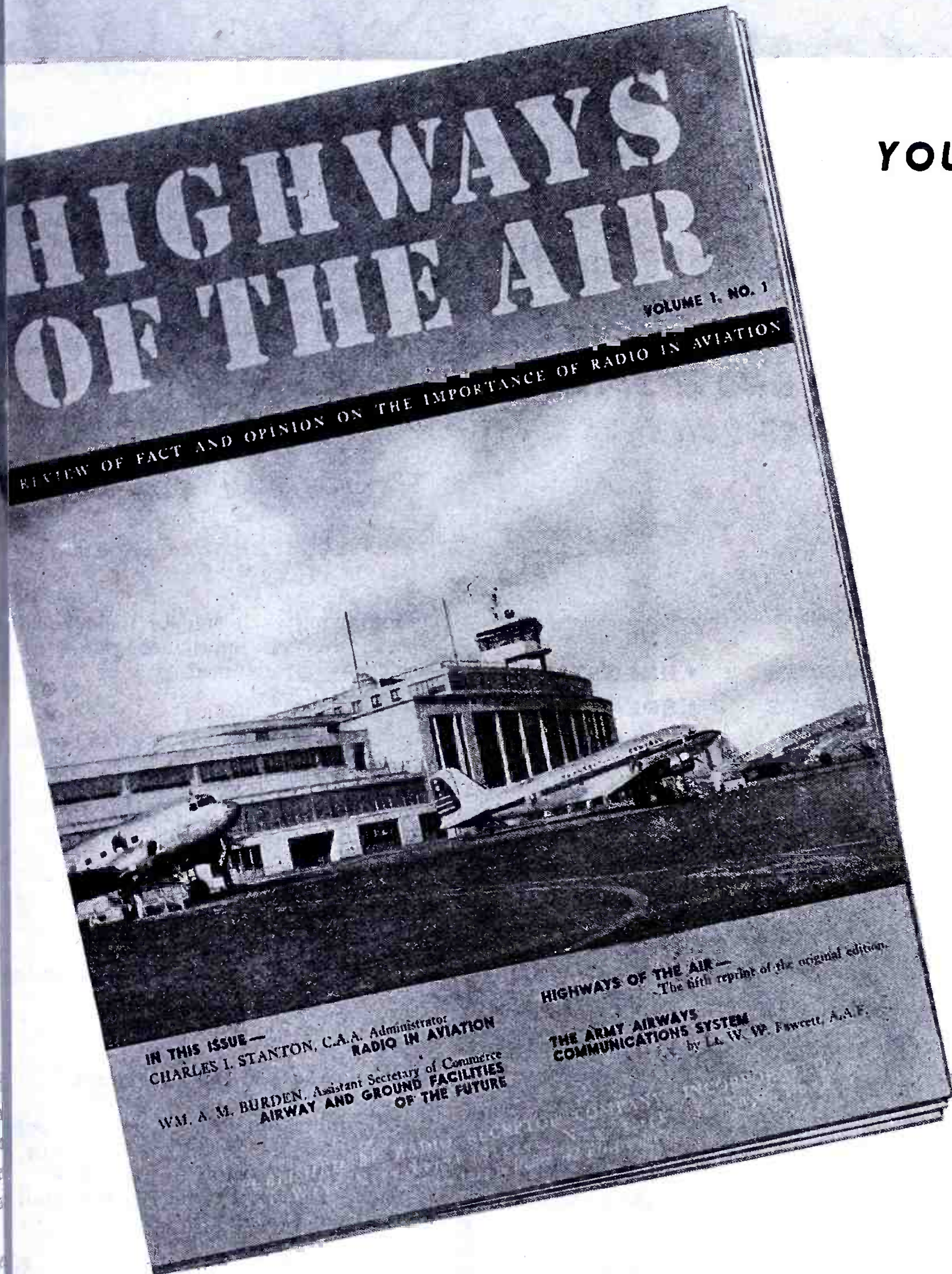
LIEUT. COL. THOMPSON H. MITCHELL who succeeded the late William A. Winterbottom as vice president and general manager of R. C. A. Communications, Inc., has had a varied wireless training.

He was Hawaiian general manager for RCAC from 1930 to 1935, and on the latter date was made manager of the Southern California District offices. He is a graduate of the U. S. Naval Academy at Annapolis (class of '25). He resigned from the Navy in 1927 to enter the communications field. In 1942, he accepted a commission as Major in the Office of the Chief Signal Officer of the Army, and in March, 1943, he was promoted to Lieutenant Colonel.

During his Los Angeles operations Colonel Mitchell was exceedingly active in VWOA activities. Now, he is with our New York chapter. Recently he was awarded the Legion of Merit by the War Department.

"HIGHWAYS OF THE AIR"

Important to everyone interested in airports and aviation



YOU SHOULD KNOW- - -

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

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

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

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

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

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

What is approach control. *See page 11*

These questions and dozens of others of vital import to all those interested in the development of radio in aviation for increased safety of human life and property are discussed in the pages of

"HIGHWAYS OF THE AIR"

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

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SINCE 1922 IN RADIO AND ELECTRONICS

RESISTIVE NETWORKS

(*Continued from page* 54)

multiplying each side of these equatio[ns] by *z*, obtaining,

$$u = z\left(s^2\frac{k^2+1}{k^2-1} - \frac{2k}{k^2-1}\right) \quad (20b)$$

$$= z\left(s^2\frac{\varepsilon^{2\theta}+1}{\varepsilon^{2\theta}-1} - \frac{2}{\varepsilon^{\theta}-\varepsilon^{-\theta}}\right) \quad (21b)$$

$$= sz\,(s\coth\Theta - \operatorname{csch}\Theta) \quad (22b)$$

$$= (cZ - y\operatorname{csch}\Theta) \quad (23b)$$

For the special, but most commo[n] case when the terminating impedanc[es] are equal, $Z = z$, or $s^2 = 1$, the unit im-pedances become

$$u' = \frac{k-1}{k+1} = \frac{\varepsilon^{\theta}-1}{\varepsilon^{\theta}+1} = \tanh\frac{\Theta}{2} = D \quad (24$$

$$v' = \frac{k-1}{k+1} = \frac{\varepsilon^{\theta}-1}{\varepsilon^{\theta}+1} = \tanh\frac{\Theta}{2} = D \quad (25$$

and

$$w' = \frac{2k}{k^2-1} = \frac{2\varepsilon^{\theta}}{\varepsilon^{2\theta}-1} = \operatorname{csch}\Theta = a \quad (26$$

Multiplying each side of these equatio[ns] by *z*, the full impedance values of th[e] elements are obtained as

$$u = z\frac{k-1}{k+1} = z\frac{\varepsilon^{\theta}-1}{\varepsilon^{\theta}+1} = z\tanh\frac{\Theta}{2} = D \quad (27$$

$$v = z\frac{k-1}{k+1} = z\frac{\varepsilon^{\theta}-1}{\varepsilon^{\theta}+1} = z\tanh\frac{\Theta}{2} = D \quad (28$$

$$w = z\frac{2k}{k^2-1} = z\frac{2}{\varepsilon^{\theta}-\varepsilon^{-\theta}} = z\operatorname{csch}\Theta = d \quad (29$$

Minimum Loss of the T Network

The minimum loss of this network [is] obtained as the series arm adjacent t[o the] smaller terminating impedance a[p]proaches zero. Passing to the limit [of] zero, from *17a* or *17b*

$$s\operatorname{csch}\Theta = \coth\Theta \quad (30$$

from which

$$s = \cosh\Theta = B \quad (31$$

or

$$s^2 = \cosh^2\Theta = E \quad (32$$

Hence, from either column *B* or *E* [of] the tables in part *II* of this series, th[e] minimum loss for a pad having a[ny] desired ratio of terminating impedanc[es] may be found by inspection. Instead [of] interpolating for any odd values not giv[en] explicitly, some engineers may prefer [to] use the relationship between the factor, [k] and the impedance ratios arising fro[m] equating equation *15a* or *15b*, to zero. [By] use of the quadratic formula, the result [is]

$$k = s + (s^2-1)^{1/2} \quad (33$$

By the use of equation *9*, *33* gives

$$_{\text{in. lons}} = 20\ \mathrm{Log}_{10}(s + (s^2-1)^{1/2}) \qquad (34)$$

...age Impedances of the T Network

...onsidering Figure 1, the square root ... the product of open- and short-...cuited impedances taken from the large ...pedance end is

$$= \left((u+w)\left(u + \frac{vw}{v+w}\right)\right)^{1/2} \qquad (35a)$$

$$= \left((uv + uw + vw)\frac{u+w}{v+w}\right)^{1/2} \qquad (35b)$$

$$= (\Phi\beta)^{1/2} \qquad (36)$$

...ere:

$$= uv + uw + vw \qquad (37)$$

$$= \frac{u+w}{v+w} \qquad (3\ \cdot)$$

... from the small impedance end, is

$$= \left((v+w)v + \frac{uw}{u+w}\right)^{1/2} \qquad (39a)$$

$$\left((uv + uw + vw)\frac{v+w}{u+w}\right)^{1/2} \qquad (39b)$$

$$= \left(\frac{\Phi}{\beta}\right)^{1/2} \qquad (40)$$

...e image impedances on a unit basis ... identical in form but with the primes ...ociated with each element, indicating ...ision by z the small terminating im...ance; the corresponding forms are ...wn in the chart with Figure 2.

...When the terminating impedances are ...al, *35b* and *39b* reduce to an identity, ...d become equal to

$$= z = (u(u+2w))^{1/2} \qquad (41)$$

...ince any generalized network may be ...olved to an equivalent *T*, (and as ...wn in part *1* of this series) the image ...pedances may be found by considera...n of the open and short circuited im...ances of the network, or

$$= (Z_{o1}Z_{s1})^{1/2} \qquad (42)$$

$$= (Z_{o2}Z_{s2})^{1/2} \qquad (43)$$

...ere the Z's have the meanings given ...part *I*.

APPENDIX I

...perbolic Functions

...The hyperbolic functions of a real vari...e which are being presented in this ...ies of articles (with parts *I*, *II* and ...) in tabulated form were obtained ...m the definitions of the sine and cosine ... a rectangular hyperbola. These are ...turn each defined by an infinite series

(*Continued on page* 82)

COUPLED CIRCUIT DESIGN

(*Continued from page* 68)

of 40,000 ohms representing diode load, so that the effective secondary impedance is 20,000 ohms in parallel with the circuit impedance.

$$Z_{o2} = (20{,}000)\,(186{,}600)/206{,}600 = 18{,}030 \text{ ohms}$$

The primary is loaded by a fictitious resistance of 10,000 ohms representing the diode load. It is also effectively shunted by the choke *L*, Figure 9, the losses of which would have to be accounted for by another parallel resistor if the primary were not so heavily loaded by the diode. With 10,000-ohms load we may neglect the losses in *L*. The effective primary impedance is therefore

$$Z_{o1} = (10{,}000)\ \ (90{,}000)/100{,}000 = 9000 \text{ ohms.}$$

$$Z_{og} = \sqrt{(9000)\,(18{,}030)} = 12{,}750 \text{ ohms.}$$

Effective Q as loaded:

$$Q_1 = Z_{o1}/X_1 = 9.0$$
$$Q_2 = Z_{o2}/X_2 = 6.76$$
$$Q_g = \sqrt{(9)\,(6.76)} = 7.8$$
$$Q_a = 15.76/2 = 7.88$$
$$Q = Q_g^2/Q_a = 60.8/7.88 = 7.72$$

For all practical purposes we could use Q_g in place of Q for this data, but for purposes of illustration that approximation will not be made. A somewhat overcoupled pair of circuits will give the closest approach to a linear discriminator characteristic; in this case we will use 25% overcoupling, C = 1.25. From equation *13* we find

$$1 + C^2 = (Q_g/Q_a)^2(1 + K^2Q_g^2) \qquad (49)$$

$$K^2Q_g^2 = (1 + C^2)\,(Q_a/Q_g)^2 - 1 = (2.563)\ (1.02) - 1 = 1.72 \qquad (50)$$

and from equations *42* and *43*

$$B = (9000/18{,}030)\,(1/1.72) = 0.29$$

$$A_o = (3500/10^6)\,(12{,}750)\,(\sqrt{1.72}/2.72) = 21.5$$

If we calculate the discriminator output for a constant input of $e_g = 1.0$ volt, equation *44* will be:

$$E = \pm\,(43/U)\,\sqrt{0.29U_2^2 + 1/4 - \sqrt{(0.29U_2^2 - 1/4)^2 + 0.29}}$$

U and U_2 are functions of frequency deviation from resonance. From equation *15*

$$U = (1/2.563)\sqrt{(2.563 - S^2)^2 + 4S^2}$$

$$S = (2\Delta f/f_o)\,Q = [2(7.72)/4000]\Delta f = 0.00386\Delta f \text{ in kc}$$

From equation *35*

$$U_2^2 = 1 + S_2^2$$

$$S_2 = (2\Delta f/f_o)\,Q_2 = [2(6.76)/4000]\Delta f = 0.00338\Delta f,\ \text{kc}$$

The complete discriminator curve may be calculated from these formulas; however, charts have been prepared to remove much of the labor and obtain rapid results with less chance of error. If we rewrite equation *44*

$$E = 2A_oe_g(D/U) \qquad (51)$$

or

$$E = 2A_fe_gD,$$

$$D = \sqrt{BU_2^2 + 1/4 - \sqrt{(BU_2^2 - 1/4)^2 + B}} \qquad (52)$$

it will be noted that the function D contains one variable, U_2, and one parameter, B. This suggests the possibility of producing a universal family of curves, D versus U_2 for specific values of B. This may be carried a step farther by using the variable S_2 instead of U_2. This has been done, assuming values of S_3 and B in their useful range. The resulting family of curves are plotted in the *discriminator chart*.

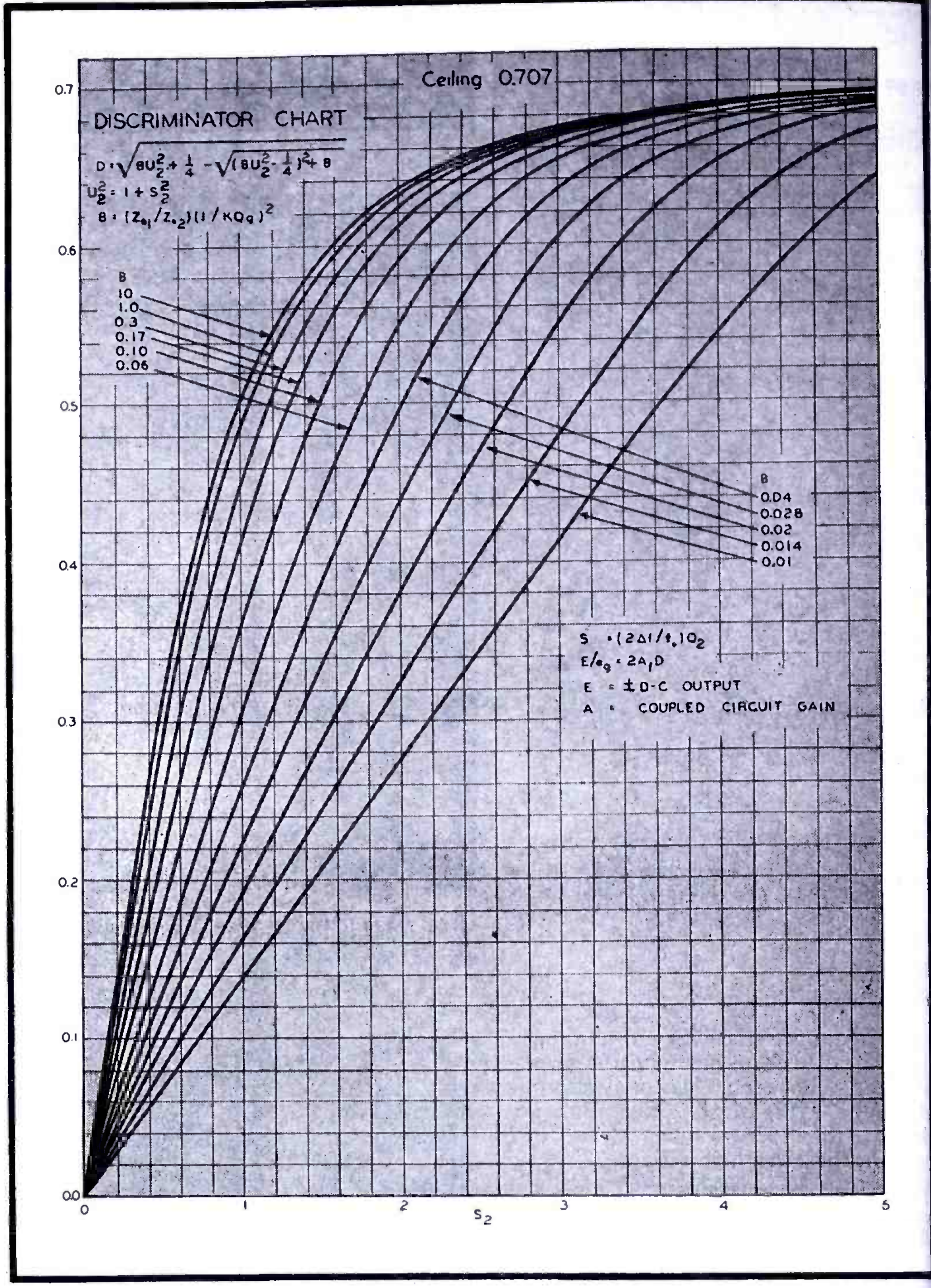

Figure 18
Discriminator chart.

For the example outlined, the solution for chart use will be

$$E = \pm\,43(D/U) \text{ volts, for } e_g = 1.0 \text{ volt}$$

where D is taken from the *discriminator chart* and U is obtained from a *universal*

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Tabulation of data from the charts and the resultant discriminator voltage. Measured data for the same circuit are also presented.

Δf kc	S .00386Δf	U	S₂ .00338Δf	D	± E	Measured + E	Measured − E
50	.193	1.0	.169	.088	3.77	3.3	3.5
100	.386	0.99	.338	.174	7.55	6.8	6.8
150	.579	0.98	.507	.254	11.10	10.1	10.2
200	.772	0.97	.676	.328	14.50	13.4	13.5
250	.965	0.99	.845	.396	17.20	16.1	16.2
300	1.158	1.01	1.014	.452	19.20	17.8	17.5
350	1.351	1.09	1.183	.498	19.60	18.2	16.8
400	1.544	1.20	1.352	.535	19.20	17.6	15.0

TBA CONFERENCE

(*Continued from page* 35)

ensely populated areas there is good ason to believe that a solution is in ght for television's severest handicap—e cost and difficulty of supplying the satiable appetite of the public for high-uality entertainment, stated Mr. Keister.

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ELAY SYSTEMS

THE relay and satellite problem was also discussed by Walter S. Lemmon. He said that at the present age of the art there appear to be only wo methods of transmitting television nages from city to city; the coaxial able which seems to require a very heavy ivestment and development for wide and service, and the chain of relay ations or automatic booster stations rung across the country.

The latter method is not inexpensive, e said, because to furnish a reliable relay ystem these booster stations will have be substantially constructed to with-tand all kinds of weather, and contain omplex control apparatus. And to be eco-omical they must simultaneously carry ther forms of communication from city city as *pay load* along with the precious eight of undistorted television images, e pointed out.

Therefore, said Mr. Lemmon, it is my pinion that the economical growth of elay television systems will depend on ie provision of some other form of *ay load* for some time to come, at least ntil television is fullgrown.

Describing this *pay load* activity, Mr. emmon said that IBM have recently re-eived construction permits from the FCC set up an experimental relay system etween New York and Washington and lso New York and Schenectady, and if ie initial experimental operation proves atisfactory, an extension of the system cross the country to Chicago and other oints West is planned.

Mr. Lemmon said that inter-city relay ystems for television should be designed accommodate more than one network t a time in order to best serve the ublic interest. These experimental relay ystems are being designed to carry simul-aneously at least two high-definition tele-ision images in each direction, explained Ir. Lemmon.

Mr. Lemmon indicated that the present elay system will carry bandwidths of 10 o 12 megacycles, which can be widened o 20 megacycles. F-m transmission will e used along this relay system.

The relay stations will be fully auto-natic, said Mr. Lemmon. Over average at terrain these automatic relay stations vill be located about every twenty-eight thirty miles, he said. And over moun-ainous territory it is probable that the istance between stations may be increased forty or fifty miles depending upon ie topography of the country.

In multiplexing, it should be possible carry television programs, several high-uality f-m broadcast programs, several acsimile channels for picture transmis-ion and a number of high speed circuits or transmitting the fast impulses of arious business machines, explained Mr. emmon. The IBM Radiotype, developed ust before the war, is already transmit-ng typewritten messages at speeds of

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one-hundred words per minute over ordinary radio circuits disclosed Mr. Lemmon. He expected an increase in this speed with the new methods planned.

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TBA Elections

J. R. POPPELE, secretary and chief engineer of WOR was elected TBA president at the annual meeting of the board of directors held at the conclusion of the conference. He succeeds Dr. Allen B. Du Mont. Mr. Poppele was also elected a member of the board of directors.

Robert L. Gibson, assistant to the vice president in charge of advertising and publicity at the General Electric Company, was elected vice president; Will Baltin was reelected secretary-treasurer and O. B. Hanson, vice president of the National Broadcasting Company, was elected assistant secretary-treasurer. Mr. Gibson succeeds Lewis Allen Weiss as vice president.

Three members of the TBA board, whose terms of office expired, were reelected. They are Dr. Du Mont, Curtis W. Mason of Earle C. Anthony, Inc., and F. J. Bingley of the Philco Radio and Television Corporation.

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AERONAUTICAL COMMUNICATIONS

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bands behaving in essentially quasi-optical manner, it became possible to duplicate them at relatively short geographical intervals with little or no possibility of serious interference. In addition, as technical skill advanced, the number of channels available in such a band would increase markedly over what at first seemed available. As the ability to increase usable receiver selectivity in terms of improved transmitter frequency stability developed, separation between channels could be decreased, thereby yielding additional usable channels in what at first had to be left as *guard bands* between adjacent channels.

About 1941 to 1942, fifteen frequencies between 129 and 131.8 mc were assigned, upon an approximately 500-mile duplication basis, to replace the single old 278 kc ground-to-plane communication frequency. Each channel was separated 200 kc. Thus between frequency separation, geographical separation and line-of-sight transmission range limitations the possibility of interference, so prevalent upon the old single 278-kc frequency, were virtually eliminated.

Under this plan an aircraft in flight would call and work ground upon a frequency of 140.1 mc. At the start, with a few aircraft in flight, this single frequency would probably serve adequately due to limited aircraft transmitter range, geographical separation and the rule that no aircraft should attempt to communicate with an airport control station until within 10 minutes flight (presumed to be approximately 30 miles) of the airport. With the inescapable tremendous expansion in civilian flying which now seems certain to follow the war, this single frequency will probably have to be expanded to many more, since it is quite conceivable that there may be many airports within some 30-mile areas, not to mention probable need of more than a

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POLICE COMMUNICATIONS

(*Continued from page* 33)

tential police radio licensees in this metropolitan region. The probable number of transmitters, fixed and mobile, might approach 10,000. Some of the local police radio engineers claim 500 potential police licensees within a fifty-mile radius of New York city. Additional channels would provide freedom from present interference.

In the Boston metropolitan area similar conditions prevail and similarly in the localities surrounding all large cities in the nation. There are, at present, 27 police radio systems within a 10-mile radius of Boston and 60 stations within a 20-mile radius. Thus it is evident that the actual allocation of frequencies in such an area is a problem for study by competent engineers familiar with the localities in question. In almost every instance these individuals will be found to be the radio engineers for the police departments operating in these areas.

The congested area problem has come about through no fault of the communications engineer. He has had to install police radio systems into an inflexible governmental and police system. The instrumentalities of government, their police, fire, water and sewer systems, their geography and their political and legal organizations are all the product of decades of growth. They are not flexible nor can they be changed to suit the needs of radio engineers. This condition is not defended here but is mentioned because it is a fact so basic in its implications that it is respected and no attempt to revise it is even suggested. The revision of the present governmental set-up is not a problem for the radio-communications engineer.

Wire Facilities Inadequate

Since police radio systems must be engineered to handle peak traffic load; and since their importance increases *with* the increase in traffic and becomes paramount during natural disasters, large conflagrations and serious civil disturbances, when wire communication generally fails, it is imperative that some other means of communication, other than that depending upon wire lines, be employed. Examples of such situations where ordinary wire facilities were of absolutely no use to the police and emergency organizations are: 1938 hurricane in New England; Cocoanut Grove fire in Boston; Detroit race riots; Port Chicago explosion in California and the recent circus fire in Hartford, Connecticut.

It is a well substantiated fact, supported by evidence in hundreds of cases, that commercial wire facilities cannot handle emergency police traffic within the time factors involved nor can they supply the area coverage necessary. The cost of a wired system producing results at all comparable to a radio-communications system is practically prohibitive to the majority of police departments. Furthermore, communication with moving vehicles at great distances is impossible by means of a wired system and lastly these wired-communication systems are subject to many faults and failures and are particularly vulnerable to weather, accident, sabotage, etc., to which, radio systems are, to a large extent, immune.

Throughout the midwest, south, south-

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west and western states, hundreds of police agencies not only make full use of radiotelephone systems for communication to their police cars but must depend, because of the inadequacy, as well as the expense of wired facilities, almost entirely on the radiotelegraph for point-to-point communications. These radiotelephone and radiotelegraph networks are highly developed and handle hundreds of thousands of messages yearly.

Cooperation Between Police

The modern criminal does not confine his activity to one community, to one city, or even to one state. As means of superhigh-speed transportation are developed it becomes more and more necessary that communication between police agencies be as fast, as dependable, and as immediately available, as the communication between the central station and the police cruiser is today.

The criminal recognizes no boundaries and, as a result, the police can operate within no rigid limits. Catching criminals in a radio network woven by instructions and information transmitted to radio-equipped police cars, has become a matter of minutes. Time is precious to the lawbreaker—it spells the difference between escape and capture to him. With the use of radio communication between patrol cars and headquarters the criminal is, many times, caught red-handed. Indisputable proof of guilt is frequently obtained, when only circumstantial evidence could otherwise be found.

In cases involving continuous pursuit by a police car in a metropolitan area it is usual to rebroadcast the transmissions from the car. Instructions change so rapidly, as the cars speed past corners and make turns, that no interruption of these communications can be tolerated. These pursuits sometimes last many minutes and happen frequently. Since continuous pursuits in metropolitan areas in many instances lead out into adjacent municipalities, it is well if that town or city can direct their own cars to help. This requires separate channels. Duplex operation is an urgent necessity in large cities for prosecuting fresh pursuit.

Speedy, reliable radio communication between law-enforcement agencies makes possible the direct apprehension of criminals; fast recovery of property; prevention of crime; quick release of innocent persons; prompt aid to the victims of criminal activity and intent; a greater degree of internal efficiency in the police departments and in general, a more effective protection of life and property is afforded the tax payer.

Present Status of Police Radio

At the present there are thirty-one frequencies allocated between 1600 kc and 2490 kc for use by municipal and state police radio stations. Assignment of these frequencies is made within specified geographical areas, to municipal and state police departments.

In the very-high frequencies the FCC rules allocate a total of twenty-nine channels for use by state and municipal police departments. The channels are separated into four groups as follows:

Group A

30700 kc	*31900 kc*	*33940 kc*	*37500 kc*	*39900 kc*
31100 kc	*33100 kc*	*35500 kc*	*39100 kc*	.....

Group B

31500 kc	35900 kc	37900 kc
33500 kc	37100 kc	39500 kc

Group C

)0580 kc	31780 kc	33780 kc	35220 kc	37780 kc
)0980 kc	33220 kc	35100 kc	37220 kc	39380 kc

Group D

5780 kc	37380 kc	39180 kc	39780 kc

Groups *A* and *B* are available for ssignment to land and portable munici-al and state police stations. Portable nd portable-mobile stations may be uthorized to operate on the same fre-uency as that assigned to the land sta-ion with which their communications re coordinated. Groups *C* and *D* are vailable for assignment to municipal and tate police mobile and portable-mobile tations, respectively.

There are at present three medium fre-uencies and six high frequencies allo-ated for use by zone and inter-zone olice stations:

804 kc	Calling	5195 kc	Calling
808 kc	Working	7480 kc	Day only
812 kc	Working	7805 kc	Day only
135 kc	Working	7935 kc	Day only
140 kc	Working		

There are also seven frequencies in e 116-to-119-megacycles band and one requency in the 158-megacycle band, llocated to the police service and avail-ble for assignment on an experimental asis only.

[*The new FCC reallocation proposals rovide for* 56 *channels in the* 30 *to* 44-*mc ands. The* 152-156-*m band was also as-igned to this service.*]

Up to June 30, 1944, the FCC had icensed 1906 municipal-police stations, 52 state-police stations, 88 zone-police tations, 31 interzone-police stations and 2 experimental Class 2 police stations. The number of transmitters licensed, up o the same date, including fixed, port-able and portable-mobile stations, were: Municipal police, 15,014; state police, ,844; zone police, 93; inter-zone police, 2; and experimental, 72.

Generally speaking, police departments hould operate a separate and distinct ommunication system and should be al-ocated specific channels for their ex-lusive use. This conclusion is predicated pon several important factors:

(*1*)—Peak loads occur in every one of he police services, whether in communi-ation with mobile units or in point-to-oint communication. Peak loads must be onsidered as an important factor in al-ocating frequencies to the police service. Other emergency services, such as fire epartments, transit companies and public tilities, frequently experience peak mes-age traffic conditions at the same time s the police departments, as say, a mul-iple alarm fire in a downtown district r a great natural disaster, hurricane, tc.

When such an emergency arises, *all* afety and police agencies must act romptly and efficiently. The police de-artment must control the traffic on the vay to, and at the scene of, the trouble. f a fire, the fire department must co-rdinate its forces for the prompt ex-inguishing of the conflagration, the lectric power company must get an mergency crew to the scene to disconnect ive wires and the transit company will robably wish to notify its vehicles of e-routing and schedule changes.

There is always congestion of vehicu-ar and pedestrian traffic at a fire and

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the police must relieve this situation at once or it will seriously hamper the response of the fire apparatus as well as contributing to heavy damage and possible loss of life.

Other conditions where peak message traffic occurs, not only in the police department but in other agencies as well, are large public gatherings outdoors, large parades, serious civil disturbances and natural disasters such as floods and tornadoes. In any of these emergency situations the number of messages required to be transmitted by each agency alone may seriously overload its facilities. Consequently, to attempt to transmit them all over one radio-communication system is obviously inadequate and futile.

(*2*)—The operating personnel of one service should not be required to give or receive orders from another service. The dissimilarity of operating methods and terminology are such that serious and vital errors are apt to be made. Radio operating personnel familiar with the procedure of their own service and accustomed to executing orders issued in a familiar manner will act as an efficient communication service, which cannot otherwise be achieved.

It should also be recognized that the fact that a police department has a police wire telephone system, if installed in a municipality, has nothing to do with the departments need for a radio-communication system.

Police departments are usually notified of an emergency by public telephone and upon receipt of such messages, they go into action and radio becomes immediately an important part of the police communication system. Mobile units on patrol often call in information of pertinent character with regard to suspiciously acting automobiles or persons and receive instructions at once as to the course of action they are to pursue.

There are some instances of small, isolated rural communities where the maximum peak message load may never reach the point where the radio communication system is overloaded. In these rare cases a coordinated communication system, comprising both police and fire departments may be desirable, both from an operating and an economic point of view. However, if the fire department in such a community is a part of an organized *mutual aid*[1] network, operating within a fire district, it should then, have its radio communications operating on the *fire department* frequency allocated to the district or it should cooperate with other small adjacent communities and operate the fire service on a common *fire frequency* with them.

Economic Factors

The extremely large investment by police agencies all over the country in radio transmitting and receiving equipment would render it highly uneconomica to initiate any large scale changes o frequency allocation.

While the general trend of police radi installation is toward the higher fre quencies there are some localities, whic because of geographical situation an peculiarity of terrain to be covered, re quire the use of low frequencies and thei attendant propagation characteristics t

[1] H. A. Friede, COMMUNICATIONS; Septembe 1944.

adequately service their area. Such localities are common in California, New Hampshire and other states having mountainous regions within which police radio communication must be maintained.

As present equipment becomes obsolete in the metropolitan areas and in municipalities it is expected that it will be replaced with veryhigh, or ultrahigh-frequency apparatus. Some municipal radio equipment is already operating very satisfactorily in the region near 118 megacycles.

Any proposal to move police and emergency services from their present location to parts of the radio spectrum where the propagation characteristics are radically different must be spaced over a long period of years and should be regarded as a *last ditch* expedient only.

Allocation Needs

Panel 13, of RTPB, requested that police agencies be allocated 31 channels, 8-kc wide, between 1601 and 2490 kc for radiotelephone use. These medium frequencies are, as previously noted, urgently needed in special cases of geographical location and over difficult terrain, where the propagation characteristics of these frequencies especially fit them for solving the communication problems at hand.

In the 30- to 40-megacycle region a total of 86 channels, 40-kc wide, were requested as the minimum number necessary to relieve the terrific congestion in the crowded metropolitan areas. A number of state wide police agencies are now using channels in this region for point-to-point service also.

In the higher portion of the radio spectrum, above 100 megacycles, the panel requested 122 channels, 50-kc wide, between 116 and 156 megacycles. This will permit many municipalities to move from the densely crowded lower frequencies and attain more favorable operating conditions with no loss of efficiency in servicing their areas. The possibility of *skip* interference at these frequencies has been found, in over eighteen months of observation, to be virtually non-existent.

A band of frequencies 10 megacycles wide, from 320 to 330 megacycles, was also requested for miscellaneous police use and experimental communication. It is not expected that this region will become immediately useful but it was thought advisable, in the light of certain restricted information, to reserve some channels in this region for police use.

Certain other channels near 600 mc; 1200 mc; 2400 mc; 4800 mc; and 9600 mc were requested. These requests are new proposals and were not in the RTPB's schedule of frequency assignments. The value of these channels will remain problematical for some time.

The proper perspective for viewing the needs of the law-enforcement agencies of the country for adequate radio-communication facilities can be attained by placing police radio services in their proper category as the nation's *most important* public service organization.

Police departments need *adequate communication facilities,* not just emergency facilities. This is necessary and essential to the operation of the police departments if they are to render adequate service to the public in police protection. In the final analysis, it is to the adequacy and efficiency of the radio-communication systems of the police departments to which we must look for the promotion of public safety and the protection of property.

RESISTIVE NETWORKS

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in terms of the mathematical base, ε. These series in terms of ε are

$$\varepsilon = + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \ldots \quad (1)$$

$$\varepsilon^{\theta} = 1 + \theta + \frac{\theta^2}{2!} + \frac{\theta^3}{3!} + \frac{\theta^4}{4!} + \ldots \quad (2)$$

$$\varepsilon^{-\theta} = 1 - \theta + \frac{\theta^2}{2!} - \frac{\theta^3}{3!} + \frac{\theta^4}{4!} - \ldots \quad (3)$$

The value of theta, θ, as used in this paper is found from the definition of the power ratio which is given in terms of a factor, k. This is

$$k^2 = W/w = \varepsilon^{2\theta} \quad (4)$$

The number of decibels gain or loss of any network on a power transmission loss basis is found by taking ten times the logarithm to the common base, *10*, of each side of the equalities in equation *4*; hence

$$db = 10 \, Log_{10} \, k^2 = 10 \, Log_{10} \, (W/w) = 10 \, Log_{10} \, \varepsilon^{2\theta} \quad (5a)$$

or

$$db = 20 \, Log_{10} \, k = 10 \, Log_{10} \, (W/w) = 20 \, \theta \, Log_{10} \, \varepsilon^{\theta} \quad (5b)$$

Where: W = power input to the network, and w = power delivered to the load.

The common logarithm of the mathematical base, $\varepsilon = 2.71828 \ldots$ is $0.43429 \ldots$, therefore *5b* may be written

$$db = 20 \, Log_{10} k = 10 \, Log_{10} (W/w) = 8.685889 \, \theta \quad (5c)$$

or

$$\theta = 0.115129 \times No(db) \quad (6a)$$

also from *5a*

$$\theta = Log_{\varepsilon} \, k \quad (6b)$$

Calculations of the functions ε^{θ} and $\varepsilon^{-\theta}$ given by equations *2* and *3* for wide ranges of the variable and for small increments of the angle, θ, were obtained by interpolation from *Tables of The Exponential Function*, ε^x, by the Federal WPA for the City of New York, sponsored by the National Bureau of Standards, Washington, D. C.

The hyperbolic sine and cosine functions (written, sinh and cosh to distinguish them from the well known trigonometric sine and cosine of circular fuctions which are usually written sin and cos), are defined in terms of equations *2* and *3* as

$$\sinh \theta = \frac{\varepsilon^{\theta} - \varepsilon^{-\theta}}{2} \quad (7a)$$

and

$$\cosh \theta = \frac{\varepsilon^{\theta} + \varepsilon^{-\theta}}{2} \quad (8b)$$

From these two equations, by addition and subtraction, there results

$$\cosh \theta + \sinh \theta = \varepsilon^{\theta} \quad (7b)$$

and

$$\cosh \theta - \sinh \theta = \varepsilon^{-\theta} \quad (8b)$$

The sinh and cosh functions of the tables in part *II* were calculated from equations and 8. The hyperbolic tangent, written tanh, was obtained from the relation

$$\tanh\Theta = \frac{\varepsilon^{\theta} - \varepsilon^{-\theta}}{\varepsilon^{\theta} + \varepsilon^{-\theta}} = \frac{\sinh\Theta}{\cosh\Theta} \qquad (9a)$$

From *7b*, *8b* and *9a*

$$\frac{\cosh\Theta + \sinh\Theta}{\cosh\Theta - \sinh\Theta} = \varepsilon^{2\theta}$$

$$= \frac{1 + \tanh\Theta}{1 - \tanh\Theta} = \frac{\coth\Theta + 1}{\coth\Theta - 1} \qquad (9b)$$

The double angle functions were obtained by change of the variable Θ to 2Θ and the definitions as given.

The half angle functions were found from the relationships existing between the sinh and cosh functions of a whole angle, namely,

$$\sinh\frac{\Theta}{2} = \sqrt{\frac{\cosh\Theta - 1}{2}} \qquad (10)$$

$$\cosh\frac{\Theta}{2} = \sqrt{\frac{\cosh\Theta + 1}{2}} \qquad (11)$$

$$\tanh\frac{\Theta}{2} = \sqrt{\frac{\cosh\Theta - 1}{\sinh\Theta}} \qquad (12a)$$

or

$$\tanh\frac{\Theta}{2} = \sqrt{\frac{\sinh\Theta}{\cosh\Theta + 1}} \qquad (12b)$$

The double angle functions used were:

$$\sinh 2\Theta = 2\sinh\Theta\cosh\Theta \qquad (13)$$

$$\cosh 2\Theta = \cosh^2\Theta + \sinh^2\Theta \qquad (14a)$$

or

$$\cosh 2\Theta = 2\cosh^2\Theta - 1 \qquad (14b)$$

or

$$\cosh 2\Theta = 1 + 2\sinh^2\Theta \qquad (14c)$$

$$\tanh 2\Theta = \frac{\sinh 2\Theta}{\cosh 2\Theta} \qquad (15a)$$

or

$$\tanh 2\Theta = \frac{2\tanh\Theta}{1 + \tanh^2\Theta} \qquad (15b)$$

The reciprocals of the various functions in equations *7* to *15* were taken, and these are defined as

hyperbolic cosecant,

$$\operatorname{csch}\Theta = \frac{1}{\sinh\Theta} = \frac{2}{\varepsilon^{\theta} - \varepsilon^{-\theta}} \qquad (16)$$

hyperbolic secant,

$$\operatorname{sech}\Theta = \frac{1}{\cosh\Theta} = \frac{2}{\varepsilon^{\theta} + \varepsilon^{-\theta}} \qquad (17)$$

hyperbolic cotangent,

$$\coth\Theta = \frac{1}{\tanh\Theta} = \frac{\varepsilon^{\theta} + \varepsilon^{-\theta}}{\varepsilon^{\theta} - \varepsilon^{-\theta}} \qquad (18)$$

The half- and double-angle reciprocal

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functions of equations *10* to *15* are written in similar manner.

The squared functions were obtained either directly by squaring the value of the function itself, or from derivations of the definitions, from which were found

$$\cosh^2\theta - \sinh^2\theta = 1 \qquad (19)$$

$$\text{sech}^2\theta + \tanh^2\theta = 1 \qquad (20)$$

and

$$\coth^2\theta - \text{csch}^2\theta = 1 \qquad (21)$$

Through the relationships given in *5a* and *5b* of

$$k^2 = \varepsilon^{2\theta} \qquad (22)$$

and

$$k = \varepsilon^{\theta} \qquad (23)$$

in conjunction with equations *5c* and *6b*, the complete interrelatedness between the network transmission power loss, the parameters or elements of the network, and the *Hyperbolic Functions of a Real Variable* was established.

A system or symbolical notation was then set up which would further compress the relationships between the parameters of the network and the terminating impedances. This notation makes use of the upper and lower case English letters only without either sub or superscripts. A choice was made arbitrarily for assignment of basic functions involving the full, double and half angles for both hyperbolic and exponential functions. These were denoted symbolically by upper case or *capital* English letters; for example $A = \sinh\theta$, $B = \cosh\theta$, $C = \tanh\theta$, etc. Their reciprocals were assigned the same letter in the lower case or *small* English letters; thus, $a = \text{csch}\,\theta$, $b = \text{sech}\,\theta$, $c = \coth\theta$, etc.

Identities between the symbolical, exponential, algebraic and hyperbolic forms are shown by the headings at the top of each column throughout the tables. Thus, with the multiple headings given, all of the transformations from one form to another for any function are given without reference to any text material. For those who prefer to deal with power ratios equal to or less than unity, an additional relationship may be written for each heading by substituting $k = 1/r$. For example, in the heading involving the hyperbolic sine of the angle, there results the identities, $A = \sinh\theta = (k^2 - 1)/2k = (1 - r^2)/2r = (\varepsilon^{2\theta} - 1)/2\varepsilon^{\theta}$.

APPENDIX II

Gudermannian Functions

Tables of the natural trigonometric functions are usually available from the pages of nearly every electrical, radio or mathematical handbook, whereas tables of the hyperbolic functions are seldom found except in special books or treatises rarely available to the average engineer. Most of the tables on hyperbolic functions have too large an interval for the argument of the angle and are not carried out to enough significant places to be of value for accurate work.

A relationship, well known to mathematicians, but unfamiliar to the average engineer, exists between the numerical values of the circular and the hyperbolic functions. These relationships are important, convenient and easily applied in practice.

If the angle or argument assumes values between zero and infinity, the hyperbolic sine, *sinh* Θ, assumes successive values between zero and plus infinity just as the circular tangent, *tan a*, does when *a* is varied from 0 to 90°. The hyperbolic cosine, *cosh* Θ, assumes values from one to plus infinity like the circular secant, *sec b*, and the hyperbolic tangent, *tanh* Θ, assumes values from zero to unity in the same manner as the circular sine, *sin c*.

Each of the hyperbolic functions give only singly periodic values, and therefore there must be some single value of the circular angles, *a*, *b*, and *c* which corresponds to a particular value of Θ, such that,

$$\sinh \Theta = \tan a \tag{1}$$

$$\cosh \Theta = \sec b \tag{2}$$

and

$$\tanh \Theta = \sin c \tag{3}$$

Squaring each side of equations *1* and *2*, and using *19* from *Appendix I*, we obtain,

$$\sec^2 b - \tan^2 a = 1 \tag{4}$$

remembzering that, $\sec b = 1/\cos b$ and $\tan a = \sin a/\cos a$, *4* becomes, after clearing of fractions,

$$\cos a = \cos b \quad \text{(b)}$$

or

$$a = b \tag{6}$$

In a like manner, using *2* and *3* with equation *20* from *Appendix I*, and remembering that $\cos^2 b + \sin^2 b = 1$, after simplifying, we have

$$\sin c = \sin b \tag{7}$$

or

$$c = b \tag{8}$$

hence, from *6* and *8*,

$$a = b = c = \varphi \tag{9}$$

The angle φ is called the *Gudermannian* of Θ, and is written

$$\varphi = \text{gd}\Theta \tag{10}$$

Therefore, the set of relationships may now be written for the circular and hyperbolic functions which show their inter-relatedness, as

$$\sinh \Theta = \tan \text{gd}\, \Theta = \tan \varphi \tag{11}$$

$$\cosh \Theta = \sec \text{gd}\, \Theta = \sec \varphi \tag{12}$$

$$\tanh \Theta = \sin \text{gd}\, \Theta = \sin \varphi \tag{13}$$

$$\text{csch}\, \Theta = \cot \text{gd}\, \Theta = \cot \varphi \tag{14}$$

$$\text{sech}\, \Theta = \cos \text{gd}\Theta = \cos \varphi \tag{15}$$

$$\coth \Theta = \csc \text{gd}\, \Theta = \csc \varphi \tag{16}$$

As an example of the application of these relationships, for 10 db, from table *1*, part *I*, $\Theta = 1.15129$; and from table *2*, part *II*, $\sinh \Theta = 1.42303$. From *11*, this equals the tangent of the Gudermannian. From a table of natural or circular trigonometric functions, $\varphi = 54.902°$. Using equations *12* to *16* inclusive successively, from the table of circular functions of a 54.902° angle, the hyperbolic functions of the circular angle $\Theta = 54.902°$ are found to be:

$$\cosh \Theta = \sec \varphi = 1.7392$$

$$\tanh \Theta = \sin \varphi = 0.81817$$

(*Continued on page* 86)

(Continued from page 85)

$\operatorname{csch}\theta = \cos\varphi = 0.70275$

$\operatorname{sech}\theta = \cos\varphi = 0.57497$

and

$\coth\theta = \csc\varphi = 1.22223$

These values were found by use of *Mathematical Tables* by H. B. Dwight. These tables are well suited for this purpose as the sin, cos, tan and their reciprocal functions are given directly in hundredths of a degree. This makes it possible to check the hyperbolic functions of the tables or those found elsewhere to an accuracy as great as that of the circular functions, which are usually carried to about five significant figures.

The importance of the *Gudermannian* function is that given any single hyperbolic function of a real variable; all of the remaining hyperbolic functions may be obtained directly using the relationships shown in equations *11* to *16* from a common trigonometric table of circular functions.

Although, in this series of articles, all of the desired hyperbolic functions are given directly in the tables for relatively small increments of the variable, θ, there will be instances when the interpolation of some function will give greater accuracy than another one. In these cases, the *Gudermannian* is particularly useful. By this, it is implied that for any specified loss, if the incremental changes either side of that chosen loss are not approximately equal or linear for any desired function, it would be more advantageous to choose another function entirely which was more linear in the desired range of loss. Then, by use of the *Gudermannian Function*, the actual desired hyperbolic function can be found to a much greater degree of accuracy.

The inverse operation of finding the natural trigonometric functions from tables of hyperbolic functions can of course be done, but the occasion would seldom arise in network design to use the *Gudermannian Function* in this manner.

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APPENDIX III

[Data on L-taper networks, types 2 and 3, are presented in this appendix. Figures referred to appeared in Part II, October, Communications.]

•

L-Taper Network, Type 2

This is an impedance-transforming network matched by a terminating image impedance at the shunt end only and is shown in Figures 9 and 10, on a full and unit impedance basis, respectively.

Assuming a zero-impedance generator delivering unit current into the unit impedance through a unit external impedance, referring to Figure 10, the power ratio is

$$P_z/P_Z = \frac{v_1 + s^2}{s^4} s^2 \qquad (39)$$

where $w_1 = w/z$ and $s^2 = Z/z$. Since $k^2 = P_z/P_Z$,

$$k = \frac{v_1 + s^2}{s^2} s = s\left(1 + \frac{v}{Z}\right) \qquad (40)$$

From *40*, we may solve for the unit impedance and get

$$w_1 = v/z = s(k - s) \qquad (41)$$

from which, the full value impedance is

$$v = zs\,(k - s) \tag{42}$$

The matched input impedance from Figure 10 is

$$1 = \frac{w_1(v_1 + s^2)}{v_1 + w_1 + s^2} \tag{43}$$

Eliminating v_1 from equation *40* and *43*, the unit impedance is found to be

$$w_1 = w/z = ks/(ks - 1) = s/(s - r) \tag{44}$$

from which

$$w = zks/(ks - 1) = \sqrt{Zz}/(s - r) \tag{45}$$

The transmission loss of this type network is, from *40*,

$$db = 20\,\mathrm{Log}_{10}[s(1 + v/Z)] \tag{46}$$

When this network is matched on its shunt end and the terminating impedances are equal, $Z = z$, or $s = 1$. Then equations *40, 41, 42, 44, 45* and *46* become,

$$k = 1 + v/Z \tag{47}$$
$$v/z = k - 1 = N \tag{48}$$
$$v = z(k - 1) = Nz \tag{49}$$
$$w/z = k/(k - 1) = m \tag{50}$$
$$v = z\,(k - 1) = mz \tag{51}$$

and the transmission power loss is

$$db = 20\,\mathrm{Log}_{10}\,(1 + v/Z) \tag{52}$$

Minimum Loss for L-Taper Networks of Type 2

For a match of impedances to exist on the low impedance side and at the same time have minimum loss, this can only occur if the series arm equals zero; hence from equation *42*,

$$v = zs\,(k - s) = 0 \tag{53}$$

from which, we obtain the condition for minimum transmission power loss that

$$k = s. \tag{35}$$

This is the same condition for L-taper networks of Type 1 to have minimum loss. Only in this case, the network has degenerated into a simple shunt-impedance having a value of

$$w = zk/(k - 1) = akz/2 \tag{54}$$

where $a = \mathrm{Csch}\,\theta = 2k/(k - 1)$.

L-Taper Network, Type 3

This type of network is commonly referred to as an impedance matching pad, and is used to transform impedances on a matched basis so that no reflections take place at either of the junctions of the terminating impedances and the network. It is matched on an impedance basis at both ends by the terminations, and is shown on both a full and a unit impedance basis in Figures 11 and 12, respectively. From Figure 12, we may write for the image impedances,

$$s^2 = \frac{v_1\,(w_1 + 1)}{v_1 + w_1 + 1} \tag{55}$$

and

$$1 = \frac{w_1(v_1 + s^2)}{v_1 + w_1 + s^2} \tag{56}$$

(*Continued on page* 88)

(*Continued from page 87*)

where $v_1 = v/z$ and $w_1 = w/z$.

Eliminating w_1 from this pair of equations, and solving the resultant for the series impedance,

$$v_1 = v/z = s\sqrt{(s^2-1)} = \sqrt{s^2(s^2-1)} \quad (57)$$

or

$$v = zs\sqrt{(s^2-1)} = \sqrt{Z(Z-z)} \quad (58)$$

Eliminating v_1 from equations *55* and *56*, and solving the resultant equation for the shunt impedance, we obtain,

$$w_1 = w/z = s/\sqrt{(s^2-1)} = Z/v = Z/\sqrt{Z(Z-z)} \quad (59)$$

or

$$w = zs^2/\sqrt{s^2(s^2-1)} = Zz/v = Zz/\sqrt{Z(Z-z)} \quad (60)$$

Thus, it may be seen that the element values in this type network are a function of the terminations only.

This network is a special case of a so-called minimum loss *T-network*. When the *T-network* fulfills this condition, it has been degenerated into a *L-taper* network of *type 3*, and is accomplished by allowing the element adjacent to the smaller impedance to be reduced to zero. This element may conveniently be represented by hyperbolic functions, and is

$$u = z\,(\mathrm{Coth}\,\theta - s\,\mathrm{Csch}\,\theta) = 0 \quad (61a)$$

$$= cz - asz = 0 \quad (61b)$$

when the minimum transmission loss condition is applied. From *61*, a most useful relationship is obtained, that is

$$s = \mathrm{Cosh}\,\theta = B, \text{ or} \quad (61c)$$

$$s^2 = \mathrm{Cosh}^2\,\theta = E \quad (61d)$$

and

$$\theta = \mathrm{Cosh}^{-1}s \quad (61e)$$

where

$$a = \mathrm{Csch}\,\theta = 2k/(k^2-1) = 1/\mathrm{Sinh}\,\theta;$$

$$c = \mathrm{Coth}\,\theta = (k^2-1)/(k^2+1);$$

$$s^2 = Z/z = \mathrm{Cosh}^2\,\theta = E,$$

and

$$s = \mathrm{Cosh}\,\theta = B = (k^2+1)/2k.$$

Substituting *61d* into equations *57, 58, 59* and *60* respectively, we find

the unit series impedance, $v_1 = \frac{1}{2}\,\mathrm{Sinh}\,2\theta$

$$= \frac{1}{2}\,G = \sqrt{Z/z}\,\mathrm{Sinh}\,\theta = As \quad (62)$$

the full series impedance, $v = \frac{z}{2}\,\mathrm{Sinh}\,2\theta$

$$= \frac{z}{2}\,G = \sqrt{Zz}\,\mathrm{Sinh}\,\theta = A\sqrt{Zz} \quad (63)$$

the unit shunt impedance, $w_1 = 2\frac{Z}{z}\,\mathrm{Csch}\,2\theta$

$$= 2s^2g = \sqrt{Z/z}\,\mathrm{Csch}\,\theta = as \quad (64)$$

(*Continued on page 89*)

NEWS BRIEFS

RE CHAPTER FORMED IN EDAR RAPIDS

he IRE has approved a Cedar Rapids, Iowa, ection. About 100 will be members of the ew section. Temporary officers of the section re: Chairman, T. A. Hunter, Collins Radio o., and secretary-treasurer, John A. Green, ollins Radio Co. The area in the section in- ludes thirty counties in Iowa and two coun- ies in Illinois.

* * *

W. L. NELSON JOINS ANDREW

Vilbur L. Nelson has become mechanical de- ign engineer of the Andrew Company, Chicago 9. Mr. Nelson was formerly with Western lectric.

* * *

BURLINGTON R.R. TO EMPLOY RADIO

he Chicago, Burlington and Quincy Railroad s preparing to install a radio communications ystem to direct switching operations in its hicago and other large yard terminals, as oon as the FCC assigns frequencies. U-h-f quipment made by the radio division of Ben- ix Aviation Corporation will be used.

* * *

FARADAY ELECTRIC BUYS HOLTZER-CABOT SIGNALS UNIT

he Holtzer-Cabot Electric Company, Boston, as sold its signal systems department to the araday Electric Corporation, Chicago.

Included in the sale, which involves no sale r exchange of capital stock, are the company's atents on signal systems, its signal-systems nventories and movable tools used in the manufacture of this equipment.

The Holtzer-Cabot Company will continue to manufacture fractional-horsepower motors, and motor generators. In August, 1942, the com- pany became a wholly-owned subsidiary of Commercial Investment Trust Corporation, of New York.

* * *

IRAQ AWAITS TELEVISION SAYS RCA DISTRIBUTOR

Sayid Hafidh of Hafidh Al-Kadi, RCA Victor distributor in Iraq, reported recently that tele- vision is one of the developments of modern science in which the people of Iraq are most keenly interested.

Mr. Hafidh stated that the Iraq government which provides programs over three stations, one of which is the powerful Baghdad trans- mitter, well-known throughout the Middle East, is keenly interested in television.

* * *

PEERLESS CATALOG

A 20-page catalog, 431, containing photographs and illustrations, diagrams, full construction details, and prices on transformers, windings, and reactors, has been published by the Peer- less Electrical Products Co., 6920 McKinley Avenue, Los Angeles 1, California.

Industrial personnel may secure a free copy by requesting on company letterhead.

* * *

BENDIX RADIO APPOINTS CLAUDE LEACH

Claude Leach, Jr., has been named sales-pro- motion manager for the home radio division of Bendix.

* * *

CELANESE CELLULOID CORPORATION CHANGES NAME

Celanese Celluloid Corporation has changed its name to Celanese Plastics Corporation.

* * *

MYKROY BULLETIN

A bulletin, 102, discussing the 19¼" x 29¾"

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RESISTIVE NETWORKS

(Continued from page 88)

the full shunt impedance, $w = 2Z \operatorname{Csch} 2\theta$

$$2Zg = \sqrt{Zz} \operatorname{Csch} \theta = a\sqrt{Zz} \quad (65)$$

where $A = \operatorname{Sinh} \theta = (k^2 - 1)/2k$;

$a = 2k/(k^2 - 1)$;

$G = (k^4 - 1)/2k^2$,

and $g = 2k^2/(k^4 - 1)$

$$\text{Since } s = \operatorname{Cosh} \theta = (k^2 + 1)/2k \quad (66)$$

we may express k in terms of s by solving 66 by means of the quadratic formula and taking the positive sign of the square root since $k \geq 1$, and get

$$k = s + \sqrt{s^2 - 1} \quad (67)$$

The minimum attenuation for this network to match both of its terminations is, therefore,

$$db = 20 \operatorname{Log}_{10} (s + \sqrt{s^2 - 1}) \quad (68)$$

If the ratio of the terminating impedances is given, the minimum-loss pad that must be used for the network to provide a perfect match with no reflections, can be found by inspection from the column headed E which is symbolical notation for $\operatorname{Cosh}^2 \theta$. After locating the ratio in this column, the number of decibels loss may be read from the table either at the right hand or left hand margin. Conversely, if the maximum loss that can be permitted is known, the reverse procedure will give immediately the maximum impedance ratio that may be matched and not exceed the given loss.

BACK THE INVASION—BUY MORE BONDS NOW!

AERONAUTICAL COMMUNICATIONS

(*Continued from page 76*)

single *party-line* to control the number of aircraft which will desire to take off from and land at some of the larger airports alone during rush hours.

The allocation of frequencies within this new u-h-f aviation radio band is well depicted in Figure 1. This figure has been abstracted from the *CAA Technical Development Report No.* 28, May, 1941. The famous *checker-board* pattern of assignment of radio-range frequencies is shown here. It is based upon dividing the continental United States up into 100-mile squares, with one radio-range station located within each square, then grouping twenty-five such 100-mile squares into one major 500-mile square for purposes of frequency assignment. Upon the seemingly sound theory that each of the twenty-five frequencies which would suffice for the 500-mile square may be duplicated 500 miles away, it became possible to divide the country up into 500-mile major squares, with each such square using identical but discreetly spaced frequencies. A study of this map will reveal that not only has this been accomplished, but that, most adroitly, frequencies individually spaced 200 kc have not been assigned to adjacent squares, but within the 500-mile major square have been juggled so as to give an average separation in frequency between adjacent 100-mile squares the country over of nearly 2500 kc. In no case are adjacent 100-mile-square frequencies closer than 400 kc. This operates effectively to minimize interference, although it is stated that with frequencies repeated only at 500-mile intervals, interference is not anticipated below altitudes of 29,000′, which few civilian planes may be expected to reach very soon. Eleven auxiliary frequencies all between 119 and 126 mc, are held in reserve to supplement or replace the twenty-five basic frequencies charted.

So much for a brief glance at the postwar civilian aviation frequency assignment plan as it existed before Pearl Harbor. Since then the frequencies involved have been occupied by war services, and there may be some question as to whether they will ever be returned to their originally intended service after V-Day. Should they not be so returned, some other spot in the u-h-f spectrum will probably have to be found which will accommodate an equivalent frequency assignment plan. Whether such a step will be necessary it is too early to guess. If needed, it today seems reasonable to assume that the assignments will probably be lifted up to somewhere between 300 and 600 mc.

[*The FCC reallocation proposal provides for the following new assignments*: 108-118 *mc* (*air navigation*); 118-132 *mc* (*aeronautical mobile service*); 420-450 *mc* (*amateurs and air navigation*); 450-460 *mc* (*air navigation, temporarily*); 1450-1500 *mc* (*air navigation*); *and* 1550-1650 *mc* (*experimental aeronautical mobile services*).]

It appears inescapable that a practically certain tremendous increase in civilian aircraft in use in the United States is to be anticipated beginning after V-Day. And the vital importance of radio communications to safety of life in the air is believed to be apparent. There appear to be substantial reasons that an expansion in civilian aircraft will occur. Ignoring completely the popularity of aircraft and flying, significant part air power is playing in the war, complete catching of popular fancy, interest of demobilized military flyers, and strong appeal to

American youth, there seem to be two aramount reasons for anticipating such xpansion, an expansion that will open p on a significant scale, a major new ield for radio-equipment engineering, production and sale.

Possibly the first, and most immeiately compelling reason is that aircraft roduction is today America's *No.* 1 inustry. During the war, this is probably s it should be, but after cessation of ostilities a few years hence and with robable rapidly dwindling demand for nilitary aircraft, what does America's *Vo. 1 industry* then do to fully utilize its roductive plant? What does it do to ontribute to national welfare through ontinuing its employment of the large umber of employable Americans today ngaged in aircraft production? A glance t aircraft figures as of Pearl Harbor, Dec. 7, 1941 is suggestive. As of Dec. 1, 1941, inquiry has revealed that there vere but approximately 486 commercial ir transports and 26,500 civilian itinerant nd other non-military aircraft in the Jnited States. Presumed correct, these igures provide food for thought. With overnment *borrowing* of significant umbers of commercial aircraft to aid the var effort, they suggest that the first postwar demand upon the aircraft industry will be for commercial transport and argo planes. Approximately 15,000 transport or like aircraft now utilized by the government may offset the possible proluction which this initial demand could reate. In event of release of these airraft to commercial users in an orderly nanner, their number would go far to satisfy initial demand. Conversion of hese aircraft to be suitable for commerial use could create a new and temporary business in competition with the original producers, who might advantageously devote some of their productive capacity nitially to such conversion.

Such demand alone cannot preserve current activity-rate in the aircraft industry after V-Day, even without the threat represented by 15,000 governmentheld transport craft. Heavy as the initial, and continuing commercial demand may be, in character it is unsuited to support plants specializing in smaller types of aircraft which may find it not feasible to convert rapidly to production of large transport cargo aircraft. It is reasonably certain, in any event, that the demand, domestic and export, for large aircraft cannot keep the entire industry operating at anywhere near its present rate indefinitely in terms of number of aircraft produced and number of workers employed. The search for survival alone by the many plants producing smaller aircraft will force intensive cultivation of the civilian market. The average American is ready for such cultivation in terms of conventional aircraft, seems to anxiously await the practical helicopter, and industry need can find long-time relief only in civilian volume-sale possibilities.

If, for unfavorable reasons of cost and convenience which may be envisaged, the private plane market should prove unable over time to support the expanded industry, the second reason comes to its aid. This takes the form of a combination of heavier, probable annual military aircraft procurement than before the war, and the opportunity inherent in developing government-sponsored *flying clubs*. So great is the romance of flying that

American youth will dream of being able to fly for years to come, a dream in most cases not to be satisfied for economic reasons. Uncle Sam may require trained pilots; the pilot material is ready and waiting for training. At some future date, the capacity to produce small trainer planes may even be begging for business. *Flying clubs* all over the country sponsored by the government appears to offer a possible solution. It supports an industry which it must preserve against future need in purchasing the required planes, preliminarily trains at nominal cost to them the pilots it must also have in reserve, and simultaneously provides outlets for the air-enthusiasm of its youth.

Twice now the allocation of radio frequencies to amateur investigation and employment has stood Uncle Sam in good stead, when as a result the government has found ready and waiting a substantial body of technically skilled radio amateurs in its hours of need—1917-18 and 1941-?. The numerous benefits of government *flying clubs* should be as potentially, maybe even more, valuable.

It is believed that consideration of the foregoing will indicate conclusively the inseparability of aircraft and radio in all the aspects of the former after V-Day. In the face of a steadily increasing number of aircraft going into service, communication (which may satisfactorily be only by radio to an aircraft in flight) becomes even more essential to safety of life in the air—yes, on the ground too—than is the motor of an aircraft. Just one glider out of control-contact can be a

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AERONAUTICAL COMMUNICATIONS

(*Continued from page 91*)

lethal weapon indeed in a crowded air.

The following proposition is therefore respectfully propounded; in civilian aircraft, radio communication equipment is the first and primary requisite. This may appear to be a bold statement, but a little contemplation of possible confusion at a major airport on a Sunday afternoon with but *one* aircraft bereft of contact with the control tower makes it almost inescapable.

On the assumption that it has been indicated that civilian aircraft expansion after V-Day will be on a major scale, and that the need of radio communication equipment in operative condition is the essential prerequisite to civilian flight, it may be concluded that the radio industry is in the position of being given a new and sizable outlet for its skill.

What the radio and aeronautical industries and the government do with this opportunity is the acute concern of radio engineers, for in this expanded field, life itself is the price of inadequate radio equipment. The primary justification here for radio communication is neither pleasure nor convenience, but the preservation of life itself. It is unthinkable that quality may ever be allowed to fall, engineering or production-wise, into the classification of broadcast receivers. Yet, the makers of broadcast receivers are the seemingly logical producers of aeronautical radio equipment in terms of the probable considerable output which will be required.

There is something of a limit, fortunately, upon the sales expansion possible for aeronautical radio receivers, transmitters, direction finders, positioning equipment, etc., as the reward for reduced selling price, bringing, as price reduction seems almost invariably to do, deterioration of quality. At least two limits exist: One, little more equipment can be profitably sold than there are aircraft made to use them; second, the equipment must be such quality that it is in operative condition when, properly inevitably, government inspection of aircraft and accessories takes place at frequent periodic intervals.

Only engineering refinement, increased production skill, diminished distribution costs would seem to be the proper devices to be employed to reduce selling price. If these alone be given free reign, the essential of preservation of human life in the air will be better served.

The writer feels that we should have government regulation now, rather than later, after abuses have made it inescapable and punitive in possible effect, to insure maintenance in all airborne radio equipment of a minimum standard of quality and serviceability. It would seem this may be accomplished through modification of the present *CAA Approved Type Certificate* plan. Under the *ATC* plan the manufacturer may submit his product to CAA for test, and when and if it is found suitable for air-borne use, an *Approved Type Certificate* is issued indicating its suitability for use by commercial air lines, and civilians, should they be interested.

The writer is convinced that if it may be made mandatory by Federal law that no aircraft, powered or glider, may take off without radio equipment in operative condition, and that such equipment must have previously measured up to rational minimum standards of technical excellence, that a significant service will have been rendered to the American people and the radio industry.

It would seem wise to establish from within the radio industry an aeronautical radio advisory committee to collaborate with the responsible government agency in the formulation and interpretation of technical standards governing engineering and production best calculated to serve the flying public, and through it the radio industry itself.

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COUPLED CIRCUIT DESIGN

(*Continued from page 74*)

selectivity chart.[6] Data from the charts and the resultant discriminator voltage are tabulated on page 74, with measured data for the same circuit.

Calculated data are, of course, symmetrical about f_o. The data in the tabulation are plotted in Figure 17.

References:

[1]J. E. Maynard, *Tuned Transformers,* General Electric Review, Part I, pp. 559-561; October, 1943: Part II, pp. 606-609; November, 1943.

[2]Terman, *Radio Engineering*; p. 93.

[3]D. E. Foster and S. W. Seeley, *Automatic Tuning, Simplified Circuits and Design Practice,* Proc. IRE, vol. 25, pp. 289-313; March, 1937.

[4]J. E. Maynard, U. S. Patents 2,338,-526, 2,338,527.

[5]H. Roder, *Theory of the Discriminator Circuit for Automatic Frequency Control,* Proc. IRE vol. 26, pp. 590-611; May, 1938.

[6]Paul C. Gardiner and J. E. Maynard, *Aids in the Design of Intermediate Frequency Systems;* Proc. IRE vol. 32, pp. 674-678; Nov., 1944.

NEWS BRIEFS

(*Continued from page 89*)

ts of glass-bonded mica ceramic insulation, wn as Mykroy, has been published by Elecic Mechanics, Inc., 70 Clifton Boulevard, on, New Jersey.
e new sheets are made in thicknesses rangfrom 1/8" to 1 1/2".

* * *

PERIMENTAL TELEVISION LICENSE FARNSWORTH

icense to erect an experimental television on has been granted to the Farnsworth vision & Radio Corporation by the FCC. e station will be used solely for experitation and research.

* * *

EL-MC CULLOUGH ADVANCES NDERLICH, PIERRI AND BROWN

ge F. Wunderlich has been named general ager of Eitel-McCullough, Inc., of San no, Calif., and Salt Lake City, Utah.
uis Pierri, manager of the Salt Lake City t, has become production manager of the plant at San Bruno. Hewitt V. Wilson, tant manager of the Salt Lake City plant, named manager there.
rbert C. Becker, liaison engineer, has red to his post as field representative.
rin H. Brown, industrial relations and onnel director for the past two years, has me head of the sales engineering deament.
n V. Young, assistant to O. H. Brown, been assigned to the sales engineering dement to handle public relations. He will work with Leigh Norton, of the labora research division, in the publication of a company industrial magazine to appear tly.

Herbert Becker G. F. Wunderlich

* * *

PHENOL A-N INSERT CHART

hart of molded A-N insert arrangements electrical connectors has been published by rican Phenolic Corporation, Chicago 50, ois.
serts are grouped by total number of con in vertical columns, in numerical order, ing from top to bottom and left to right. l standard inserts from one contact to hundred contacts are shown full size. et or pin arrangements are indicated toer with wire sizes. Also included are ial cable connections and grounded or ted inserts. Mechanical spacing of cons and alternative positioning of the ins with new position numbers are given in case. Chart is 50" x 38".
copy will be sent on receipt of a request ompany letterhead.

* * *

I.C. PRICE LIST DATA

price-list bulletin, 1460, covering twentyn carbon, dynamic and velocity types in , stand, throat, lip, hand and cartridge es, has been issued by Universal Microhe Co., Inglewood, Cal.

* * *

LE PRODUCTIONS FILES 8 PLICATIONS

vision Productions, Inc., a subsidiary of amount Pictures, has filed eight applicas with the Federal Communications Comsion for permission to erect a series of exmental television relay stations in the east, west and far west.
annels 13, 14, 15 and 16 were sought in the York City; Buffalo; Peru, Vt.; and De, Mich., areas, and channels 9, 10, 11 and were requested in the El Paso, Texas; Des nes, Iowa; Chicago, Ill.; and Los Angeles. f., areas.

* * *

RRY MINTER AN R.C. OF A. SPEAKER

io distortion was the subject of a paper

(*Continued on page 94*)

NEWS BRIEFS

(*Continued from page 93*)

by Jerry B. Minter, chief engineer of Measurements Corporation, Boonton, N. J., presented at a recent meeting of the Radio Club of America.

This paper analyzed amplitude versus frequency characteristics and harmonic distortion. Practical methods of measurement were suggested and data on several practical systems were offered.

* * *

G. E. BUYS KEN-RAD RADIO TUBE INTERESTS

The General Electric Company has purchased the radio tube manufacturing and plant facilities of the Ken-Rad Tube and Lamp Corporation at Owensboro, Kentucky, and at Huntington and Rock Port, Indiana, and will take over operation of government-owned plants at Tell City, Indiana, and Bowling Green, Kentucky.

The sale does not include the Ken-Rad electric lamp manufacturing business.

Carl J. Hollatz, formerly executive vice president of Ken-Rad, will manage the new G. E. operation, which will be known as the Ken-Rad division of the electronics department of G. E.

* * *

RMA ISSUES 1944-45 DIRECTORY

The new annual 1944-45 RMA membership and trade directory, with data on personnel, products, etc., was issued recently. The RMA membership now totals 227.

* * *

A. M. WIGGINS NOW WITH ELECTRO-VOICE

A. M. Wiggins has been appointed chief research engineer of the Electro-Voice Corporation, South Bend, Indiana.

Mr. Wiggins was formerly with RCA Laboratories in Princeton, New Jersey.

• • •

CONCORD PARTS SUPPLEMENT

A 16-page supplement 97, with data on meters, resistors, switches, speakers, relays, volume controls, test accessories, transformers, rheostats, etc., has been issued by the Concord Radio Corp., 901 West Jackson Blvd., Chicago 7, Illinois.

* * *

"E" AWARDS

The United Transformer Company, 150 Varick Street, New York City, and the Hoffman

H. L. Hoffman of Hoffman Radio with the "E" flag.

F. D. Bliley (right) of Bliley Electric and the three-starred "E" flag.

lio Corporation, 3430 South Hill Street, Los geles, California, were recently awarded the ny-Navy "E."

second white star for the "E" flag has n won by United Electronics Company, wark, N. J. The Sprague Electric Company, th Adams, Mass., and the Bliley Electric npany, Erie, Pa., received their third white for the "E" flag.

* * *

RASCH JOINS SHERRON ECTRONIC

es V. Barasch has become chief engineer Sherron Electronics Company, 1201 Flushing enue, Brooklyn, New York.

Ir. Barasch was formerly with Western ctric in charge of the cathode-ray and elecnic tube equipment design section.

* * *

E. PROMOTES PRINCE AND SUITS

rid C. Prince, vice president of General ctric has been appointed head of the genl engineering laboratory.

r. C. G. Suits, assistant to the director of research laboratory, has been elected a president and head of the research labora-y.

r. W. D. Coolidge, vice president and dicor of the research laboratory, since 1940, retired.

* * *

AL BEAR NOW RADIART S-M

l Bear has been appointed distributor sales nager of The Radiart Corporation, Cleveland, o.

Ir. Bear has been with Radiart for seven rs. Recently he has been acting as operais manager.

* * *

B. SINCLAIR IN NEW G.R. POST

Donald B. Sinclair is now assistant chief ineer in charge of circuit development at neral Radio Company, 275 Massachusetts enue, Cambridge 39, Mass.

Prior to joining the General Radio engineerstaff in 1936, Dr. Sinclair was a research istant at MIT from 1932 to 1935, and a rerch associate in 1935 and 1936.

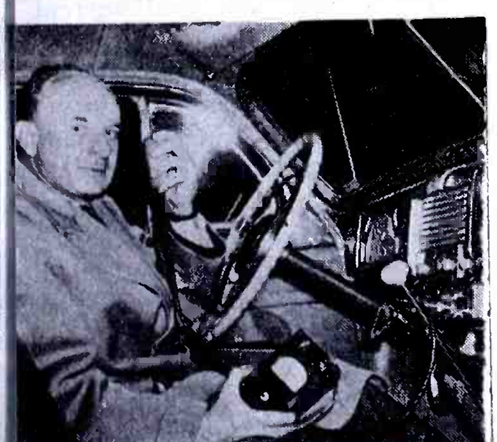
* * *

RESS WIRELESS SCHOOL TRAINING AVY STUDENTS

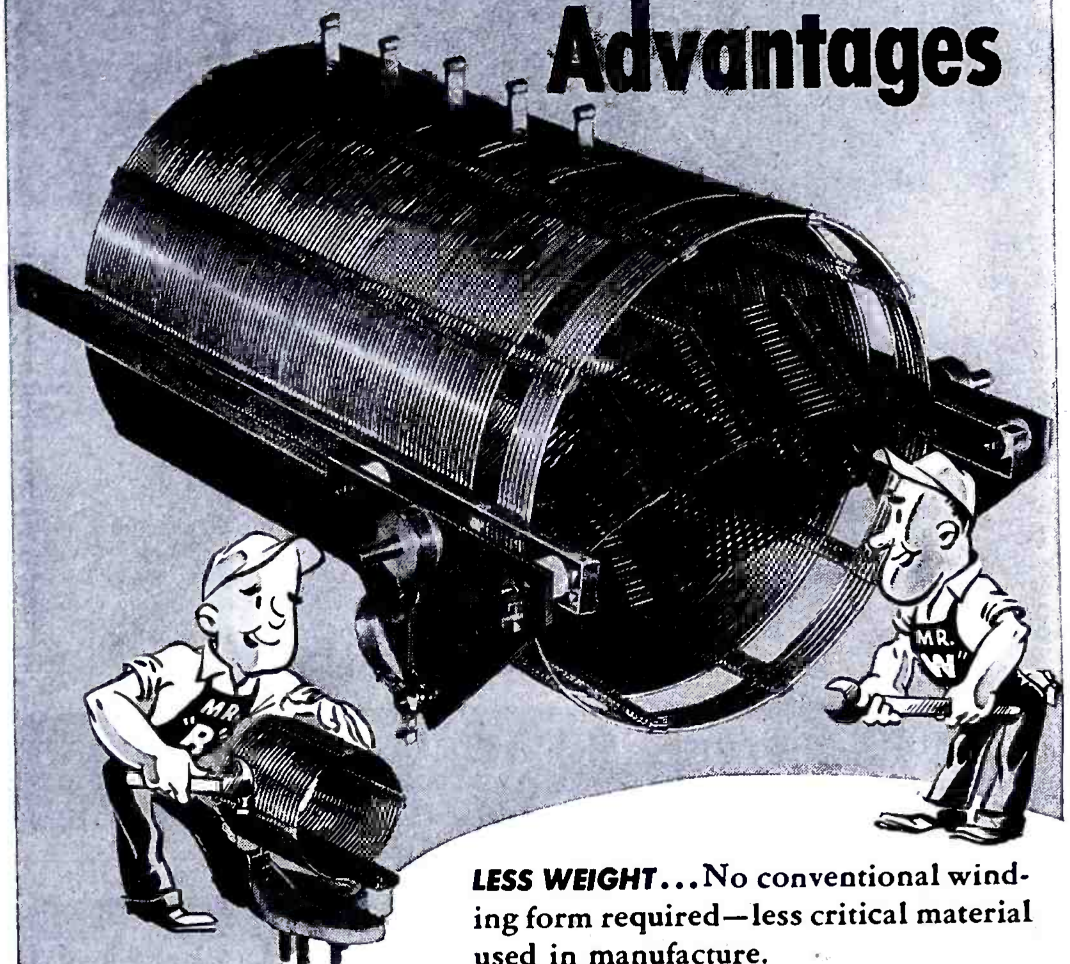
e Press Wireless-Signal Corps radio school

(*Continued on page 97*)

UNDERLICH RUNS 118-MC TESTS



orman B. Wunderlich, of the Motorola comunications division, conducting 118-mc mobile ets in Chicago recently. Mr. Wunderlich reorted that 118-mc was better than 30 to 40 mc.



U-H-F POWER SUPPLY

BY IREDELL EACHUS, JR.

Formerly ESMT Communications Instructor, Moore School of Electrical Engineering, University of Pennsylvania; now on leave.

This paper is based on work carried on by the author at the Moore School

PART II

[*In the first installment* (*December*, 1944, Communications), *Mr. Eachus described the design and construction of a power supply for a general purpose r-f source operating on approximately* 3000 *mc. In this, the concluding installment, Mr. Eachus describes some of the characteristics of the klystron, which is used in the u-h-f r-f system.*]

THE klystron oscillator is similar to most other electronic apparatus in that its ruggedness is electrical, *not mechanical.* The most easily disturbed part of a klystron is the resonator which is made pliable to facilitate adjustment. It is to this that the concentric lines are attached and by which the tube itself is supported. It is therefore necessary to exercise continuous care in avoiding any strain on the tuner by pulling on the coaxial connectors or by jarring the tube. Short flexible leads fastened to rigid connectors must be used to make the external r-f connections to the tube. Strains on the tuner will not only cause the tube to go out of oscillation but will, if repeated too often, break one of the several glass-to-metal seals, rendering the tube completely useless.

Electrical damage to the klystron may be prevented if but one rule is observed; at no time should the accelerating grid current exceed its rated value. The Sperry *S*-410 klystron has an accelerating grid rated at a maximum current of 15 milliamperes.

There are several values of accelerating voltage and grid current at which the klystron will operate. A typical group of settings, chosen for maximum power output shows that values of accelerating grid current from 2 to 3 milliamperes is optimum.

Much the same as a gas engine will stall when fed too rich a mixture, the klystron will fail to operate on too high a beam current; therefore, when bringing a klystron into operation low values of grid current should be tried for the best results. The klystron may often be made to operate with the control grid negative although, as the output is reduced, it is not usually operated in this condition.

NEWS BRIEFS

(Continued from page 95)

icksville, Long Island, which has given uction to Army men during the past two one-half years, has begun courses for s of U. S. Navy seamen.

school will hereafter be known as the Wireless Institute, a division of Press less, Inc.

Army curriculum will be followed, spe- emphasis being placed on high power mitter work, antenna technique, "trouble ing" and other practical courses directed d utility and service in the field.

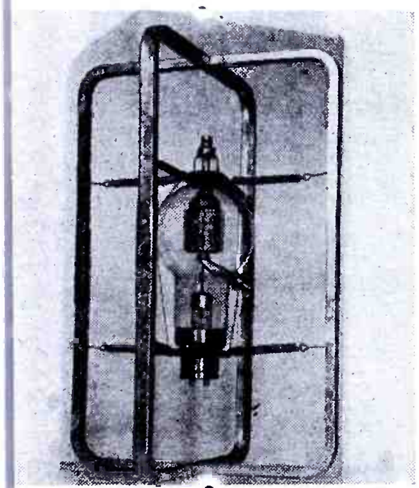
* * *

AC TUBE PACKAGING METHOD

ethod of packaging large electronic power for overseas shipments has been de- led by Eitel-McCullough, Inc., at its San io, Calif., plant. It is said to have been oved by the Signal Corps and the Navy e specification standard for all shipments, estic and foreign, of certain tube types.

e original package was designed for ship- the Eimac 450-T.

package consists of a set of interlocked less-steel springs suspended in a gal- ized steel X-frame which fits diagonally corrugated cardboard box.



X MARKELL JOINS RCA

E. Markell, for the past four years chief e vacuum tube section of the U. S. Signal s at Camp Evans, has joined the RCA and equipment division as a specialist on strial tube applications.

Markell will work under the direction of Thees, manager of the equipment tube on at Harrison, New Jersey.

* * *

C BECOMES AIREON MANUFAC- RING CORPORATION

Aircraft Accessories Corporation will after be known as the Aireon Manufac- g Corporation.

ne Franke has been appointed director of rtising and public relations. His head- ters for the present will be in Kansas Kansas.

* * *

NERAL ELECTRONICS CATALOG

atalog, 101, covering d-c voltmeters, am- ters, milliammeters, microammeters and o-frequency ammeters of the a-c thermo- ple type, has been published by the General tronics Manufacturing Company, 6014 West hington Boulevard, Culver City, California.

* * *

NDIX-MARINE LAB SHIP

0-foot ocean-going marine laboratory to aid he development of instruments and controls nder construction by Bendix-Marine.

mong the equipment to be tested in this lab will be radio direction finders, hydraulic equipment, weather forecasting equipment, etc.

The 60-foot floating laboratory will have a beam of 16′, a 7′ 6″ draft, and weigh 59 tons. Its cruising speed will be 10 knots and cruising range, 1,600 miles.

* * *

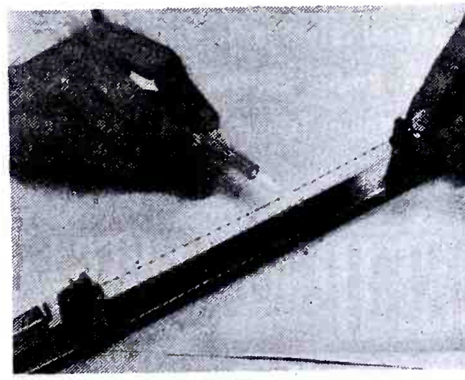
M.I.T. TO OFFER ELECTRONICS COURSES

Plans for a professional course in electronics at M. I. T., emphasizing applications to television and highly developed production methods in which Philco will cooperate, were announced recently by Dr. Karl T. Compton, M. I. T. president.

Under the new cooperative course, which follows a plan established at the Institute many years ago, leading to the master of science degree, students in the department of electrical engineering will spend alternate terms at the Institute and at Philco. Plant experience is

(Continued on page 98)

THERMISTORS



(Courtesy Western Electric)

Drying metallic oxide beads for thermistors.

NEWS BRIEFS

(*Continued from page 97*)

thoroughly integrated with professional theoretical instruction.

The new course is established as an option the department of electrical engineering, which has conducted parallel courses for more than 25 years in conjunction with the General Electric Company, the American Telephone and Telegraph Company, the Boston Edison Company, the Boston Elevated Railway, and the General Radio Company.

* * *

KEN BURCAW BECOMES S-M AT C-D

K. C. Burcaw has been appointed sales manager of the jobber division, Cornell-Dubilier Electric Corporation.

Mr. Burcaw was formerly sales manager of Radiart.

* * *

MONACK NOW MYCALEX V-P

A. J. Monack has been elected vice president, in charge of engineering, of the Mycalex Corporation of America. Mr. Monack has been chief engineer since February of 1942. He has also served with the Radio Corporation of America and the Western Electric Company.

* * *

ED CONTENT DEVELOPS ACOUSTICAL METHOD FOR WOR

A new method of compensation for acoustical defects in large auditoriums has been developed by Edward J. Content, assistant chief engineer of WOR.

Mr. Content's method provides for the rejuvenation of overtones.

* * *

R. M. WISE IN NEW SYLVANIA POST

Roger M. Wise has been appointed to a newly created post of vice president in charge of engineering of Sylvania Electric Products, Inc.

Sylvania's director of engineering for the past two years, Mr. Wise previously served as the company's chief radio engineer for ten years.

* * *

WHITE NOW JENSEN RADIO PRESIDENT

Thomas A. White has been elected president and general manager of Jensen Radio Manufacturing Company. He succeeds W. E. Maxson, who has retired.

Mr. Maxson will remain on the board of directors.

* * *

HAVENS BECOMES S-M OF NOMA CONDENSER DIV.

B. H. Havens has been appointed sales manager of the condenser division of Noma Electric Corporation, 55 W. 13 Street, N. Y. 11, N. Y.

Mr. Havens will direct merchandising of Noma condensers through sales representatives and parts jobbers in key cities throughout the United States.

HE INDUSTRY FFERS . . . —

ED COMPARISON BRIDGE

mparison bridge for measurement of re-s, capacitors and inductors by compari-with a standard has been developed by Gurevics of Freed Transformer Com-72 Spring St., New York, N. Y. An acy of .5% to 20% is said to be available. rument consists of an a-c bridge, phase-oscillator and vacuum-tube voltmeter. A ndicator in conjunction with a calibrated ndicates percentage of difference between nknown and the standard. The compari-bridge is supplied with 3 frequencies: 60 s, 1,000 cycles, 10,000 cycles. Resistors, tors and condensers being compared to a ar standard range are: capacitors from 25 to 20 mfd; inductors 5 microhenries to enries; resistors from 10 ohms to 5 me-s.

e unit measures 10"x7½"x8¼". For a-c, 25 volts, 50-60 cycles.

* * *

PACITRON ELECTROLYTICS

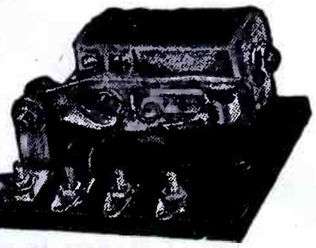
trolytic capacitors are scheduled for pro-tion by The Capacitron Company, 849 North zie Avenue, Chicago 51, Illinois.

* * *

RUTHERS-DUNN RELAYS

w snap-action relays and vacuum switching ing relays have been announced by Struth-Dunn, Inc., 1321 Arch St., Philadelphia 7. he snap-action relay, 79 XAX, employs an nature that is said to almost complete its vel in either direction before the contacts p into the new position. This feature is said permit its use for vacuum-tube circuits, rcurrent protection, pulsing circuits, etc. he standard adjustment using 60-ampere ns in the coil at approximately .02 watt re-ts in contact pressures of 5 grams with tacts rated 5 amperes, 115 volts a-c; or 0.5 pere, 115 volts d-c, noninductive. Contact ings up to 10 amperes, 115 volts a-c may be ained with 100 or more ampere turns and orresponding increase in power. A sensitiv-of 0.005 watt with 30 ampere turns is also ainable with reduced contact pressures and ings.

The vacuum-switch keying relay, 78CCA100 s seven poles, including one double-throw le which handles high-voltage r-f currents by eans of a vacuum switch. All high-voltage rts are rounded to reduce corona.



79 XAX Relay

* * *

TR CENTER CONTACT RECTIFIERS

enter contact, a patented plate construction in etal-plate rectifiers, which is said to allow

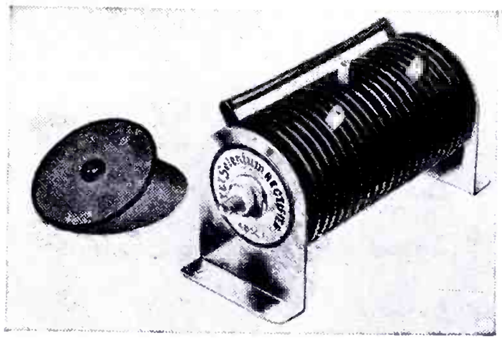
(*Continued on page* 100)

THE INDUSTRY OFFERS . . . —

(*Continued from page* 99)

coating protection against destructive atmospheres, is available in units now being manufactured by Selenium Rectifier Products, Federal Telephone and Radio Corporation, Newark, New Jersey.

The center-contact construction is available in the same range of sizes and capacities as the standard petal-type contact.

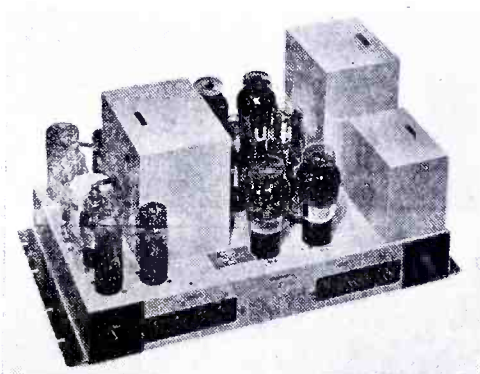


* * *

LANGEVIN 101 AMPLIFIERS

Amplifiers, 101 types, for medium gain, high-power bridging applications, have been designed by The Langevin Company, Inc., of 37 West 65th Street, New York.

All models are said to deliver 50 watts to a nominal load impedance with less than 3% rms harmonic distortion at 400 cycles. The gain control provides adjustment over a 40 db range and bridging connections. Chassis is 16-gauge welded steel, zinc plated, and bonderized. Weight approximately 45 pounds.



* * *

G.R. U-H-F OSCILLATOR

A 100 to 500-mc oscillator, type 857-A, has been announced by General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Mass. Maximum output is said to be ½ watt or better over the entire frequency range.

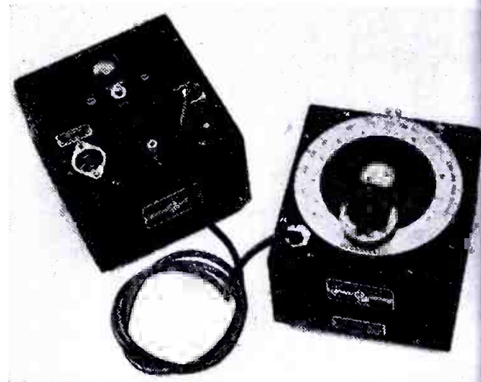
The frequency-determining element in this oscillator is a "butterfly," a tuned-circuit developed by General Radio. In the butterfly, inductance and capacitance are varied simultaneously with a single control and no electrical contact to the moving element is said to be necessary.

The dial is said to read directly in frequency with an accuracy of ±1%. A slow-motion drive is provided.

The output circuit is inductively coupled to the oscillator and the output is controlled by varying the coupling. Otput terminal is a coaxial jack.

Type 857-P1 power supply, supplied with the oscillator, furnishes filament and plate power and operates from a 115- or 230-volt a-c line, 42 to 60 cycles. An electron-ray tube is used to indicate oscillation.

Oscillator is 6⅛" x 7⅝" x 7¼" overall and weighs 6¼ pounds. Dimensions of the power supply unit are 5½" x 6⅝" x 7⅝"; weight, 9½ pounds.



* * *

WESTINGHOUSE THIN HIPERSIL

Ultra-thin thicknesses of grain-oriented Hipersil have been produced by the engineers of American Rolling Mill and Westinghouse.

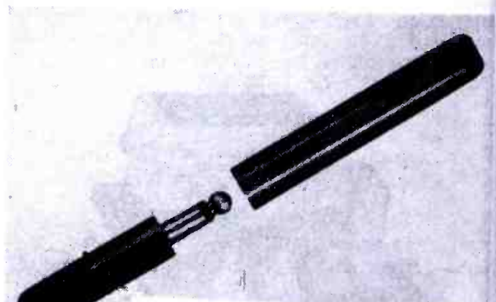
Prewar standard Hipersil laminations were 29 gauge, or about 14-mils thick. This was followed by 7-mil Hipersil, used for 400-cycle aircraft transforming equipment. A 5-mil thick sheet was then developed. Recently 2-mil and 1-mil thick Hipersil for h-f transformers have been developed.

* * *

AMALGAMATED RADIO TELEVISION PLUGS AND JACKS

Plugs and jacks are now being produced by the Amalgamated Radio Television Corp., 476 Broadway, New York, N. Y.

Jack types are JK-48, JK-26, JK-55; plug types are PL-54, PL-55, PL-204, PL-291, and PL-291A.



Left, PL-54; right, JK-26.

AVERY MASKING PROCESS

Die-cut masking stickers have been announced by Avery Adhesives, 451-453 East Third

Street, Los Angeles 13, California.

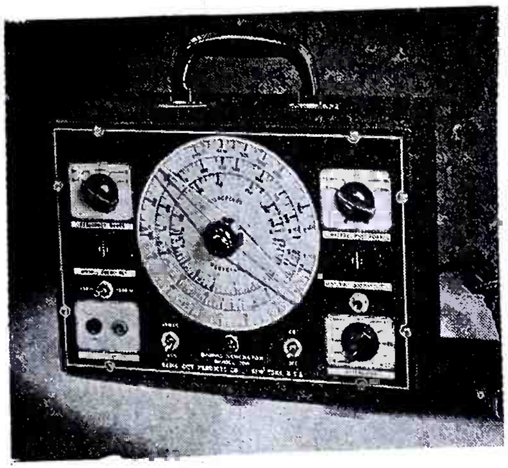
The masking stickers can be applied without moistening.

* * *

RADIO CITY PRODUCTS SIGNAL GENERATOR

A signal generator, model 704, covering from 95 kilocycles to 100 megacycles, has been produced by Radio City Products Company, 127 West 26th Street, New York 1, N. Y. Fundamental frequencies are said to be continuously variable from 95 kilocycles to 25 megacycles in 5 bands. Calibration is said to be accurate to 2% per band up to the broadcast band and within 3% for high-frequency bands.

Model has a planetary-drive condenser with direct reading calibration. Output can be modulated or unmodulated.



* * *

G.E.M. METERS

Meters featuring linear scales and unit construction have been announced by General Electronics Manufacturing Company, Culver City, California.

Unit construction is said to consist of jewel bearings, armature and core assembled as a unit construction that maintains accurate alignment and permits almost instant removal. Alnico magnet and pole piece used are said to be brazed together. Meter weighs .5 pound.

Standard meters include d-c voltmeters, ammeters, milliammeters, microammeters, and radio-frequency ammeters of the a-c thermocouple type.

* * *

THREAD PROTECTORS

Internal and external safeguards for threaded and machined parts, fittings, etc., have been developed by Precision Paper Tube Company, 2033 West Charleston St., Chicago 47, Illinois.

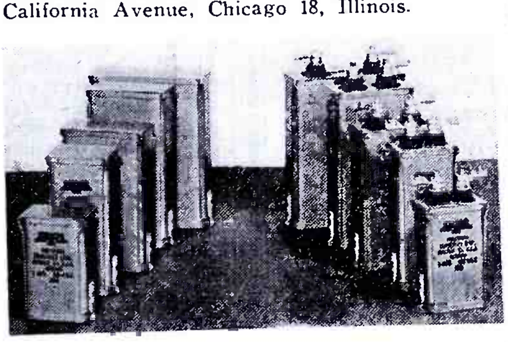
They are made of spiral-wound fibre, kraft paper, or cellulose acetate, under heat-treated compression.

Protectors are cylindrical, square, rectangular or tapered, crimped, flared or perforated. Tolerances are said to be ±.003″.

* * *

I.C.C. CONDENSER MOUNTING

Brackets, M type, designed to permit the mounting of oil capacitors in either vertical or inverted position, have been developed by Industrial Condenser Corporation, 3243-65 North California Avenue, Chicago 18, Illinois.



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G. E. DELTABESTON FLAMENOL LEAD WIRE

A new deltabeston flamenol thermoplastic in-

(Continued on page 103)

E INDUSTRY OFFERS . . . —

(*Continued from page* 101)

ted lead wire for use in all types of rescent lamp ballasts has been announced by E.

he insulation of this new wire is said to be eraging and resistant to flame, oils, acids alkalies. The wire is available in solid and nded conductors, sizes 16 and 18 AWG in y colors, including black, white, red and n.

* * *

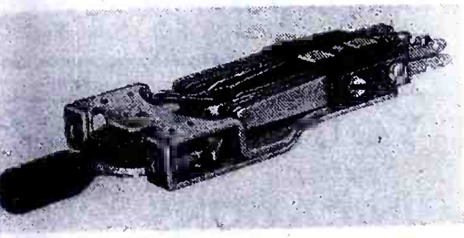
R NARROW LEVER KEY

/16" wide lever key, FTR-810, is now being duced by Federal Telephone and Radio Corration, Newark, New Jersey.

aid to have 18-spring capacity. Designed one or two way, locking or non-locking ration. Entire key assembly is said to be d together by a single screw. The spring -up mounts on one side of the two-piece ssed steel frame, with all front position ngs in one group and all back position ngs in another.

ontact springs are of nickel silver with adium cross-bar contacts, and brass backsprings are provided for tension adjustnt. Non-click buffer springs are supplied use in circuits where spring backlash is be avoided. All springs are interchangee and the pile-ups may be rearranged.

an be supplied fungus and moisture proofed ording to Signal Corps specifications.



* * *

ELECHRON RADIO PRESELECTOR

semi-automatic radio clock preselector, that orks on the alarm clock principle, for installation in radio receivers, has been developed by e Warren Telechron Company (Ashland, ass.).

The telechron alarm clock provides the basic echanism for the new device. It is operated a two-watt telechron a-c synchronous motor d can be furnished for 115-volt or 220-volt eration in any standard commercial frequency.

* * *

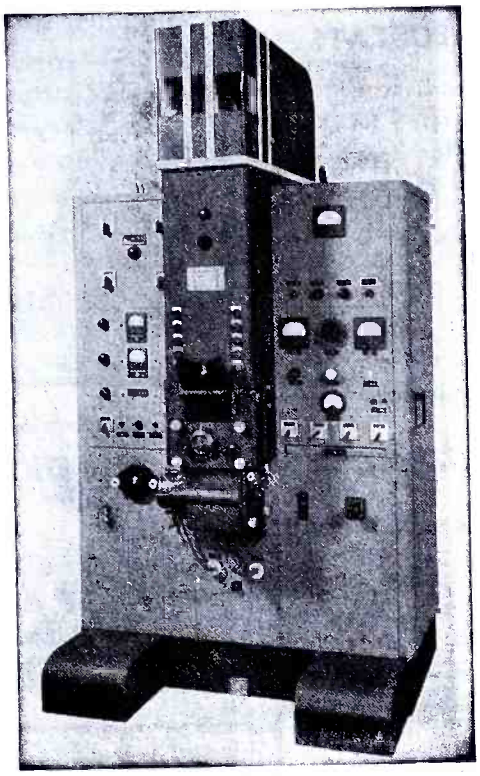
ESTINGHOUSE OSCILLOGRAPH

self-contained electronic oscillograph has en developed by Westinghouse Electric and anufacturing Company, P. O. Box 868, Pittsrgh, Pa.

Cathodes of the tubes are energized from a -kv d-c rectifier.

Unit consists of the oscillograph proper in ont of the cabinet and the cabinet proper which houses all energizing and control circuits.

In addition to fluorescent screen for direct observation, the instrument contains a stationary film holder taking a standard film for recording 1/1000 of a second or less. May be operated with a rotating film drum for use from 1/1000 to 1/10 of a second.



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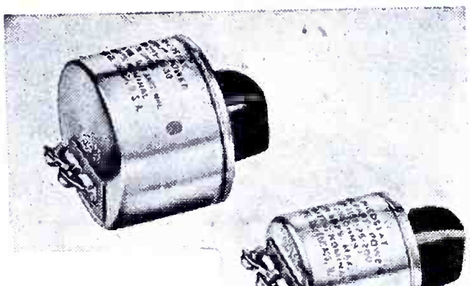
OHMITE ARMY-NAVY AIRCRAFT RHEOSTATS

Two approved power rheostats for aircraft made in accordance with the latest Army-Navy Aeronautical Specifications AN-R-14a, have been announced by Ohmite Manufacturing Co., 4835 Flournoy St., Chicago 44, Ill.

The rheostats are light weight. Two sizes are available: model "J" 50-watt and model "H" 25-watt; linear or taper wire-wound, in various resistances, with "off" position, as required.



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CLARK LEVER-LOCK BORING BAR

Lever-lock boring bars, available in sets of four . . . 3/16"x5", ¼"x6", ⅜"x7" and ½"x8", have been announced by Robert H. Clark Company, 9330 Santa Monica Boulevard, Beverly Hills, California.

These bars are said to be designed for use without bushings or adaptors.

One precision ground high-speed threading bit and one boring bit are provided, with each bar. The lever-lock holds the tool bit at a right angle on one end and at a 15° angle on the opposite end.

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INDEX

(*Continued from page* 66)

EXTERNAL ANODE TRIODES

(*Continued from page 46*)

tween the anode and the cooling mechanism, which is normally at ground potential. Porcelain or rubber tubing is used to insolate the jacket from the rest of the cooling system electrically. Provision must be made also for controlling electrolysis. This is usually accomplished by providing a metallic electrolysis target which can be replaced after it has been disintegrated. The necessity for pure water in the system is obvious, since impurities lead to increased conductivity, increased electrolysis, and increased deposits which are formed on the anode of the tube.

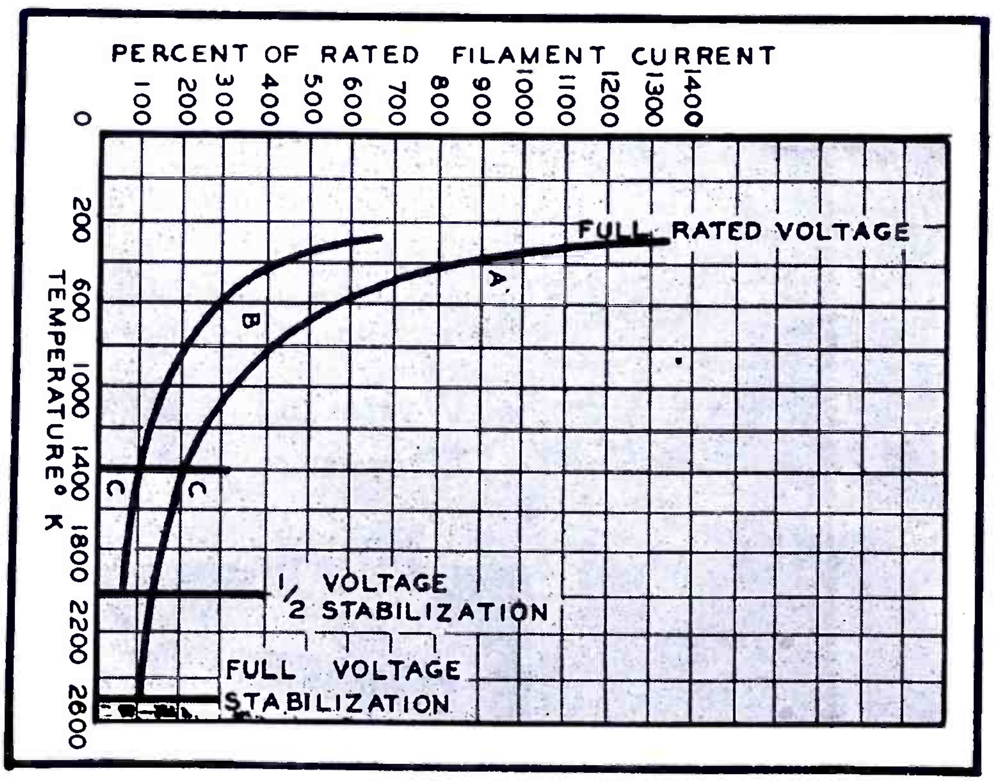


Figure 5

Variation of current with temperature for tungsten filament for half (*B*) and full (*A*) applied voltage. Normal operating temperature equals 2500° K. (*Courtesy FTR*).

In forced-air cooled tubes the heat is conducted away from the anode by a copper-fin structure that is soldered to the anode. The heat in the fins is in turn dissipated into the air which is forced through the fin structure. Such a tube is set in an insulated socket which provides a duct for the air flow from the blowers. It is important that the air be clean so that no dust collects in the various parts of the circulating system. Such dust may reduce the efficiency of the cooling apparatus to a dangerous point.

The other seals of the tube which provide for connection through the glass envelope to the filament strands and the grid are made by using a metal with essentially the same expansion coefficient as that of glass. Care must be taken that the temperature of these seals is kept below the danger point. In certain tubes air-blast cooling of the seals may be necessary. Too much cooling, however, may set up strains in the glass, which is a poor conductor of heat.

Although the filament of an external-anode vacuum tube is little more than a strand of tungsten arranged so that it can be heated to inncandescence, its operational characteristics have furnished material for many pages of discussion. The resistance of a tungsten filament at 2500° K is thirteen times as great as the resistance of the same filament at room temperature. When it is realized that many of these filaments draw up to 100 amperes at normal operating temperature, the difficulties in designing a starting

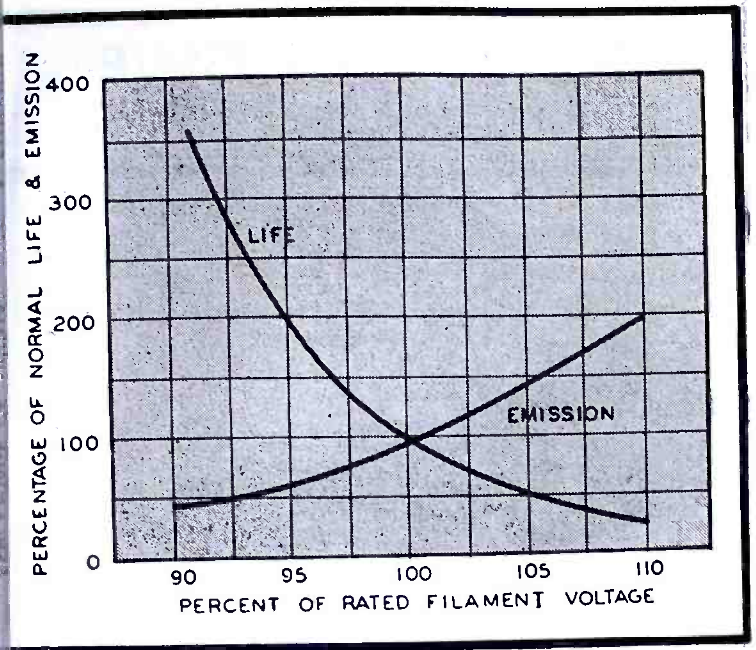


Figure 6

Relationship between tungsten filament temperature and length of life.

rcuit to bring these tubes to this tem-erature become apparent. The problem two-fold. First, the cold filament is in fect a direct short on the supply; there-ore, some means for current limitation ust be supplied. Second, shock to the lament caused by such a high current ansient must be prevented.

Figure 5 shows how the current of tungsten filament varies with tempera-ure for full and half voltage. It has been nown[5] that such a set of curves can upply the information necessary to de-gn the usual filament starting circuit. 'he two factors to be considered in such esign are first, a means of limiting the urrent surges to twice the ra+ed current; nd second, the total time necessary to ring the filament to operating tempera-ure. Since there is very little call for apid-start circuits using external anode ubes, the first design requirement is most nportant. It may be seen from Figure 5 hat if the series starting resistance is horted out at point *C*, the current surge vill be within the requirements. The esistance necessary to give half voltage t this temperature, 1400°, is given by

$$R = \frac{E_F}{2 I_F} \quad (1)$$

where E_F is the rated filament voltage, and

I_F is the rated filament current

Since this resistance is usually inserted n series with the primary of the filament eating transformer, the above relation must be modified to give the necessary rimary resistance:

$$R = \frac{E_L^2}{2 E_F I_F} \quad (2)$$

where E_L is the primary voltage

This resistor also limits to a safe value the starting current when the filament is cold. The total current through the cold filament must be less than 200% normal, since the resistance determined in *1* is half the operating resistance. High reactance transformers may also be used to limit starting current.

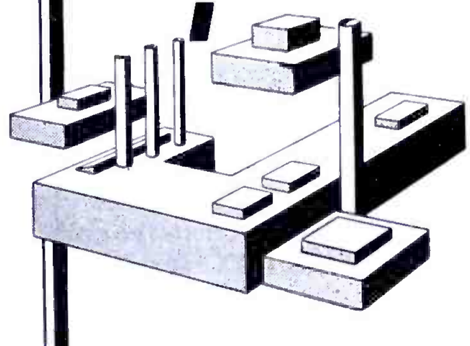
The time necessary for the filament to come to the 1400° temperature with the starting resistance determined from *1* or *2* is difficult to determine because of the number of thermal factors involved.

Jones and Langmuir[6] have derived an expression for the heating time for tungsten filaments which is accurate where small temperature changes are involved. Experimental determination of the actual heating time for each filament is generally necessary, however. It is interesting to note that, in general, the heating time varies with the square of the strand diameter and with the first power of the length. Since there is no reason for hurrying the process, it is possible to make the first part of the heating cycle long enough to bring the filament to a stable temperature, a condition which can be visually noted by the operator.

To obtain maximum life from a tungsten emitter the operating temperature shuld be kept as low as possible. Figure 6 shows graphically this relationship between temperature and length of life. The extent to which the filament voltage may be reduced is limited by the available emission. In the fundamental design of the tube a compromise is made between the life expectancy on the one hand and filament heating power required on the other. Although tubes with a life of 50,000 hours are within the realms of possibility, they would be very uneconomical because of the increased filament heating capacity necessary, the increased power consumption, and the increased filament heat dissipation.

It is apparent from Figure 6 that the filament life of an external-anode vacuum tube depends not only on the tube design itself, but also on the design of the equipment into which it is installed. This fact is illustrated by the long life obtained from the tubes used in high-level modulated broadcast transmitters where the design has been very generous. Because the external anode tubes are expensive items it is important that the designer consider this life factor in equipment design and balance it against increased costs of conservative operation.

[To be continued]



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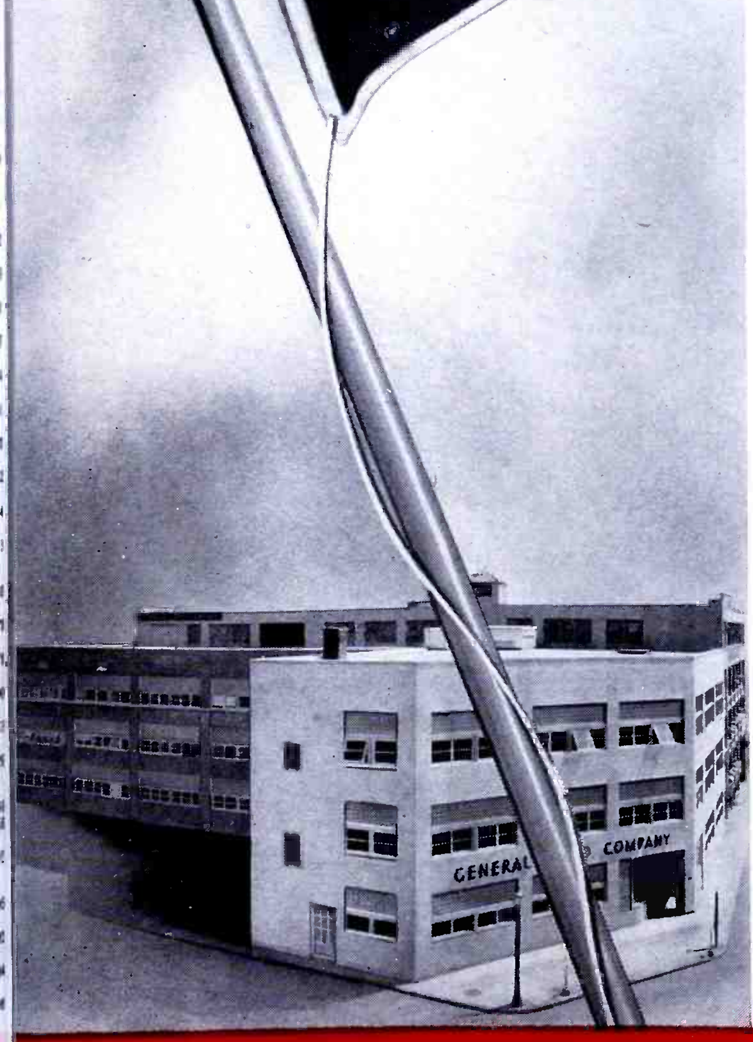

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