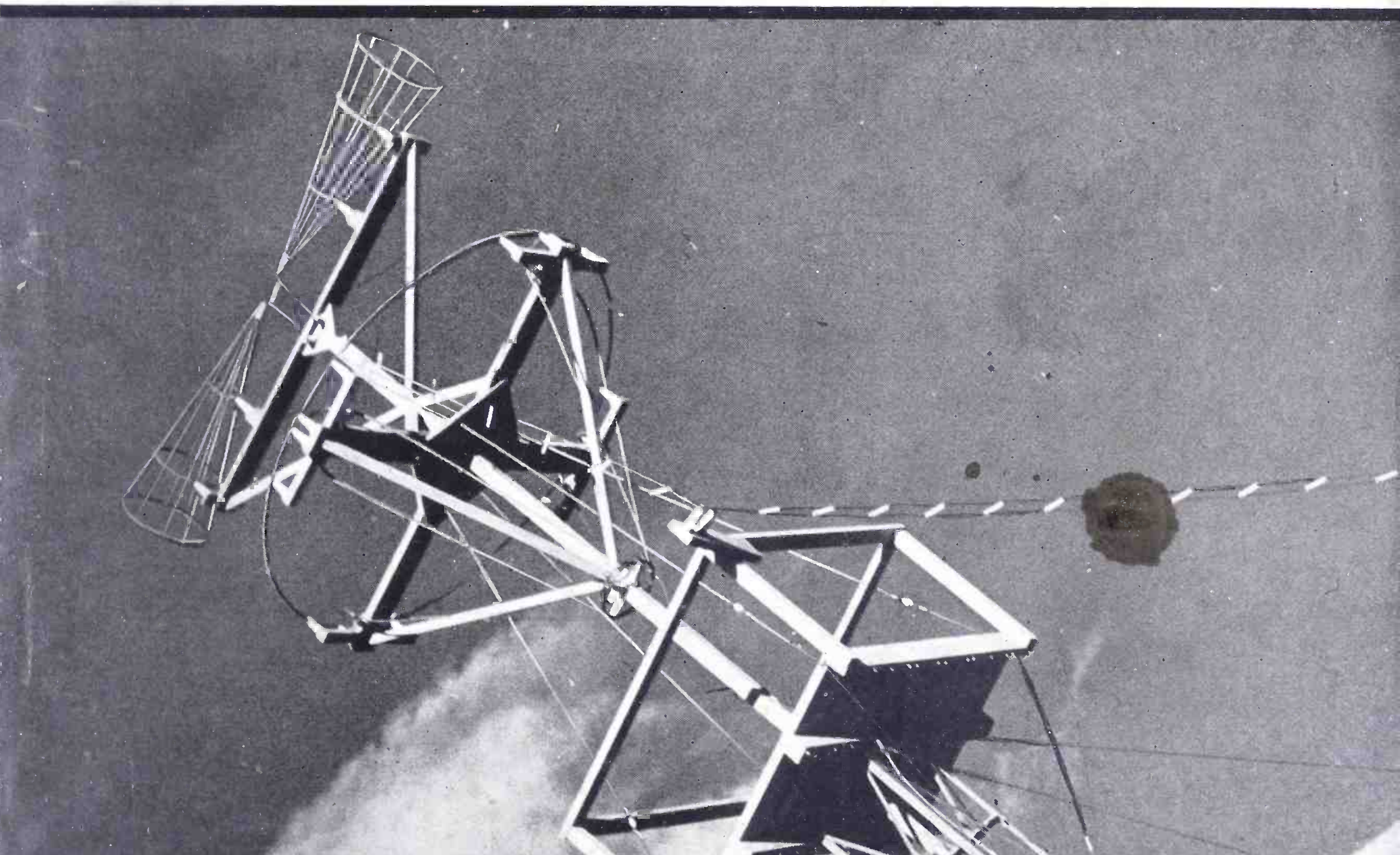
COMMUNICATIONS



JULY

★ RADIO ENGINEERING
★ U-H-F DIRECTIVE ANTENNAS
★ CATHODE-RAY TUBE DEVELOPMENTS
★ A-M/F-M TRANSMITTER SURVEY
★ MULTIVIBRATOR DESIGN
★ ELECTRICAL DIFFERENTIATION AND INTEGRATION

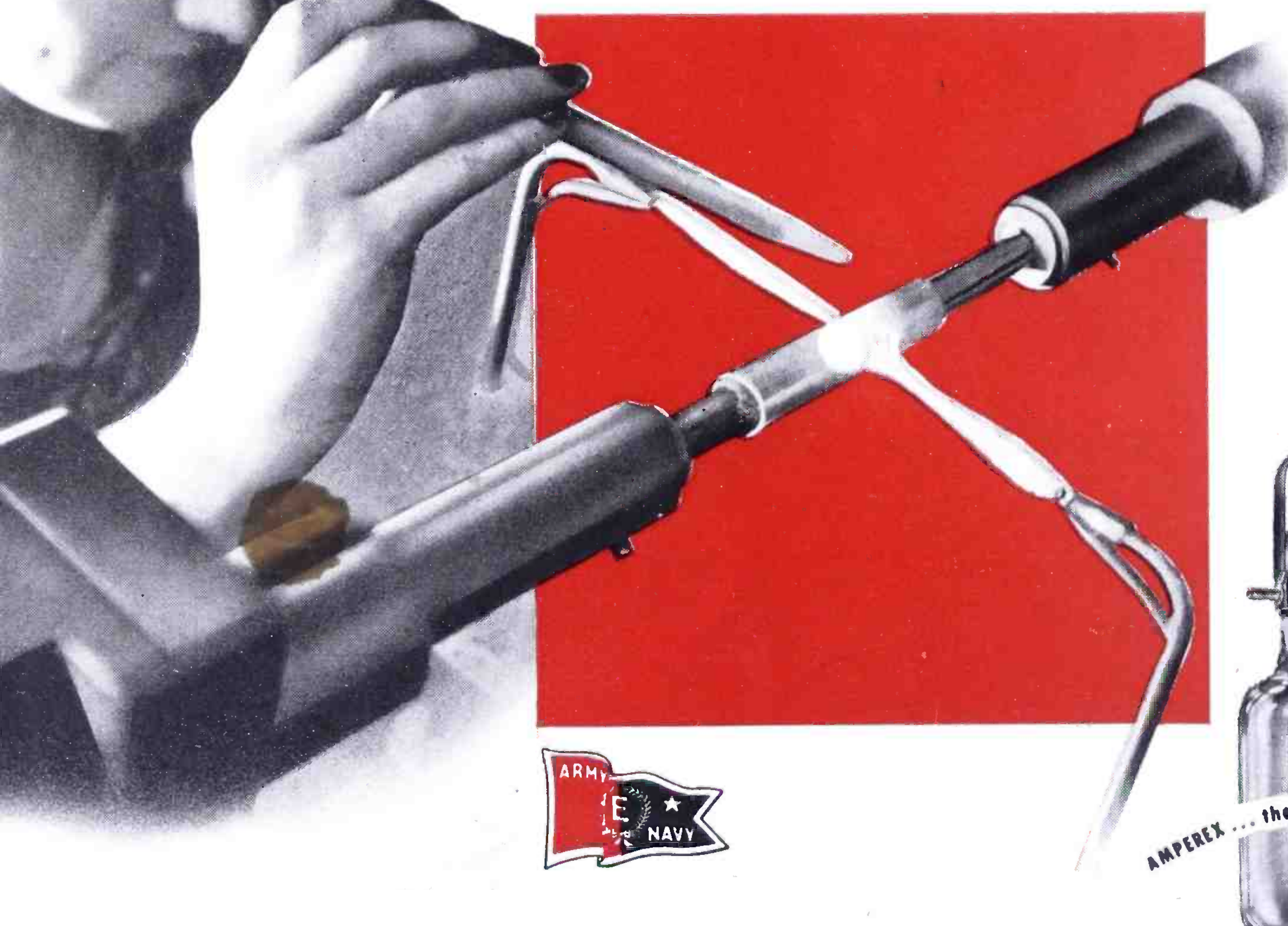
1944

Why AMPEREX

WATER AND AIR COOLED

TRANSMITTING and RECTIFYING TUBES

Singular care and precision are demanded in Amperex small glass lathe operations. Ever cautious, our engineers designed ingenious holders and fires which were developed in the Amperex Tool Shop. In the hands of finely trained technicians, these holders and fires are utilized to assure the high degree of satisfaction well known to Amperex tube users. In broadcasting and transmission applications, in industrial, electro-medical and military assignments such "Amperextras" substantially influence efficiency and economy of operation.



It doesn't hurt . . . it doesn't affect your health. Ask the man who's donated blood to the Red Cross.

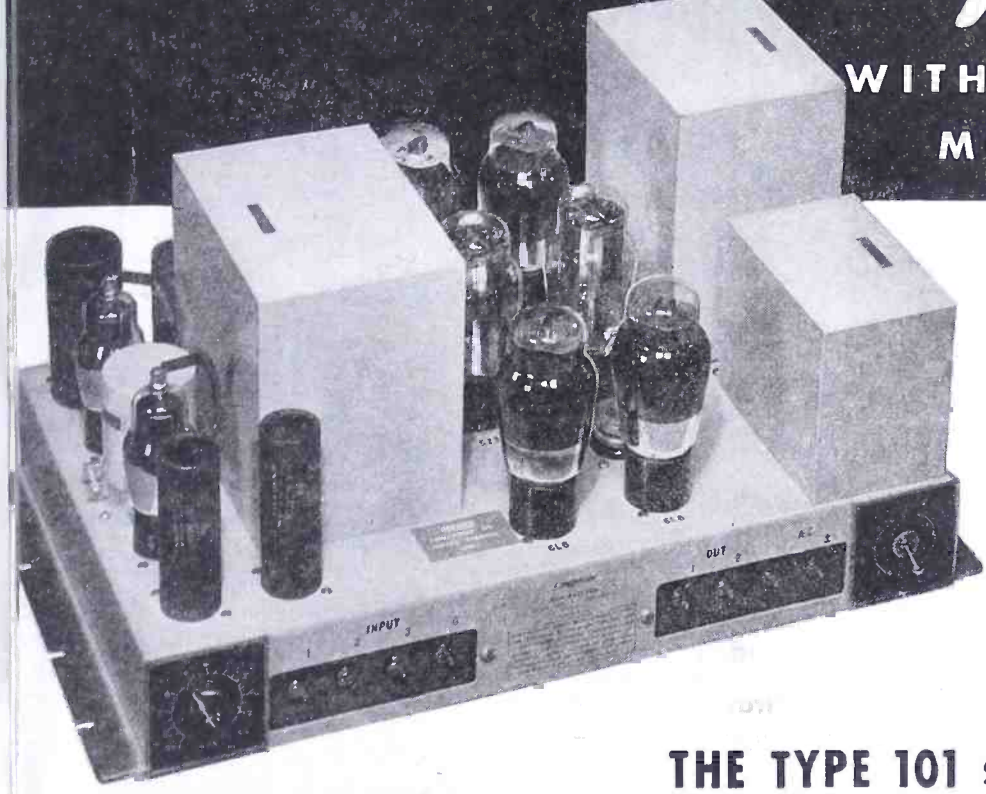
AMPEREX ELECTRONIC CORPORATION

79 WASHINGTON STREET BROOKLYN 1, N. Y.

EXPORT DIVISION: 13 EAST 40th ST., NEW YORK 16, N. Y., CABLES: "ARLAB"

101 SERIES *Amplifiers*

WITH RACK PANEL OR WALL MOUNTING ACCESSORIES



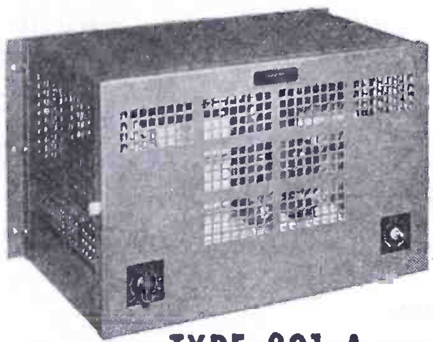
Input impedance 600 ohms and bridging. Gain 600 ohm input 61 db., bridging input 46 db. Frequency response 30 to 16,000 c.p.s. either input—600 ohm output ±.5 db., 30 ohm output ±1 db. Power output—production run average: +47 V.U. with less than 3% RMS harmonic content.

THE TYPE 101 Series Amplifiers are the results of twenty years' experience in the sound engineering field. They are identical with the exception of the output coil.

Type 101-A has output impedance adjustments to match loads from 1 to 1000 ohms and possesses excellent low frequency waveform at high output levels.

Type 101-B with a single nominal 6 ohm output is intended for use with wide range loudspeakers representing an 8 to 16 ohm load. Its output coil with a single secondary provides improved efficiency and even better waveform at high levels of low frequencies.

Type 101-C answers the demand for a good amplifier at lower cost. This lower cost is obtained by the use of a less expensive output coil with the only change being that the low frequency waveform is not as good as the A or B types but is equal to or better than any contemporary commercial amplifier. Output impedance is adjustable to loads of 1 to 1000 ohms.



TYPE 201-A Wall Mounting Cabinet permits universal installation of 101 Series Amplifiers to any flat surface. Well ventilated and designed for maximum accessibility for servicing and convenience of installation. Standard aluminum gray finish.

TYPE 7-A Modification Group permits 101 Series Amplifiers to mount on standard 19" telephone relay racks. Occupies 12¼" rack space. Allows servicing from front of rack. Standard aluminum gray finish.

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

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COMMUNICATIONS

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Member of Audit Bureau of Circulations.

JULY, 1944

VOLUME 24 NUMBER 7

COVER ILLUSTRATION

The video and audio antennas of W6XYZ. Television Productions, Inc., Hollywood, California.

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

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F. WALEN, Secretary
PAUL S. WEIL, General Manager
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We See...

A STRIKING VIEW OF THE EXTENSIVE USES of radio communication systems in emergency operations, appears in a special report just prepared by Herbert A. Friede, superintendent of fire alarms, Washington, D. C. According to Mr. Friede, approximately 128,000 fire-fighting units will use radio for mobile purposes, as soon as equipment can be made available. These units include ladder companies, chiefs, battalion chiefs, service cars, fuel wagons, squad cars, ambulances, utility trucks, boats and pumping companies. And this is a conservative estimate, says Mr. Friede. It is based on the 1940 census which shows that a thousand cities of ten thousand population and up have organized fire departments. There are, too, a large number of small communities who have a serious need for radio communication facilities, says Mr. Friede in this report. Practically all of these fire departments will also require fixed station facilities for standby and field service.

It appears that close to 130,000 units will probably require radio for fire fighting. And that's only the beginning!

RECENT SPECIAL MANEUVERS OF THE COMBINED Airborne-Troop Carrier Command disclosed the amazing scope of the communications network in invasion operations. We watched hundreds of paratroopers and equipment drop from rows of Douglas transports. And within minutes, a radio system was put into operation with significant signals of direction and organization pouring out from handi-talkies, walkie-talkies and field units. Although the equipment had been dropped from heights of a thousand to eight hundred feet and bounced around quite a bit, there wasn't a failure in operation reported. It was truly a magnificent performance . . . a performance we'll never forget!

WE ANNOUNCED A SHORT WHILE AGO the establishment of standardized symbols by the ASA. With this issue we begin the use of these standardized symbols. They appear in the majority of papers, which are correspondingly identified. As will be noted, all but one of the symbols are identical to our customary format of presentation. The change is in the fixed capacitor where adjacent straight and curved lines are used in place of two parallel lines. Two parallel lines now indicate an open contact of a relay. These *standard* symbols will be used in all drawings hereafter.—L. W.

TEAM BEHIND THE BOMBER TEAM

• Just as seven men fight as a team in a bomber, seven girls work as a team at a Sylvania Radio Tube assembly bench.

Thousands of fine precision radio tube parts are assembled into a finished product that must pass rigorous tests for ruggedness and sensitivity.

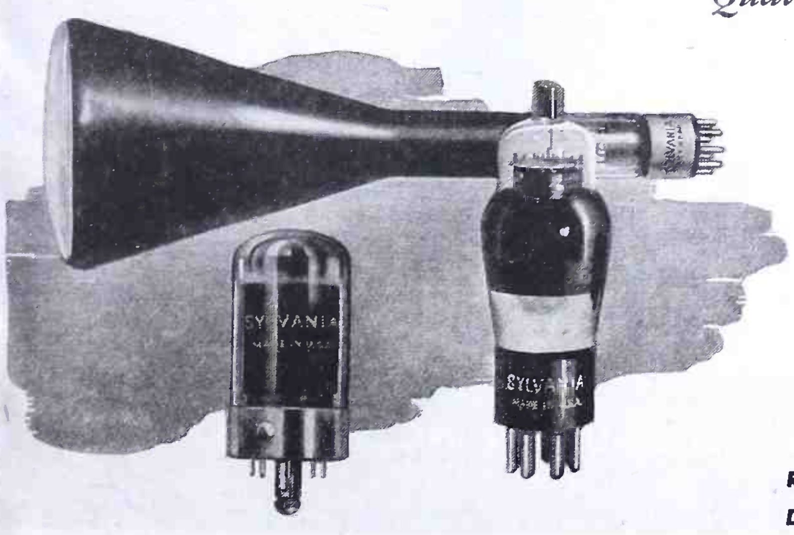
This is work that calls for the feminine touch, patience and sense of detail. Each girl "plays the position" on the team best suited to her ability.

Sylvania assembly teams compete with each other. But the champion in accuracy always takes precedence over the champion in speed.

This teamwork is just another example of how Sylvania maintains radio tube production at the highest standard of quality anywhere known.

You can sell Sylvania Radio Tubes with complete confidence.

Quality That Serves the War Shall Serve the Peace

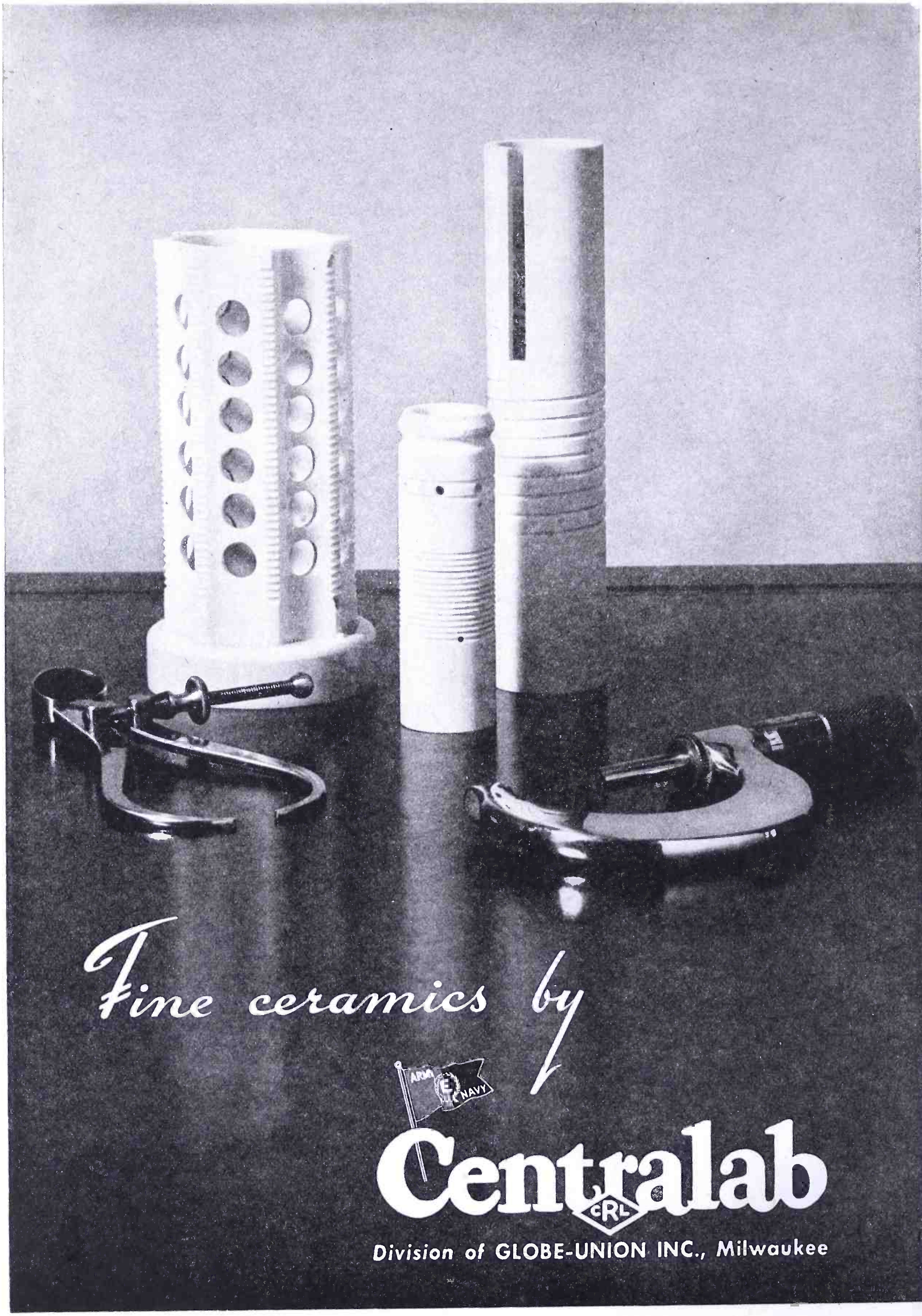


RADIO DIVISION EMPORIUM, PENNSYLVANIA

SYLVANIA

ELECTRIC PRODUCTS INC.

RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, INCANDESCENT LAMPS, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES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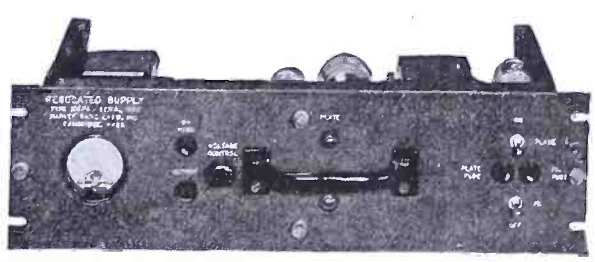
The HARVEY organization devotes itself entirely to the development and production of electronic and radio equipment and components.

The HARVEY organization has the engineering and creative resources to assure you a source of supply of the utmost reliability. This was true long before the present crisis and intensive war work of the highest importance has vastly increased our scope and facilities for present and postwar usefulness to you.

For radio-electronic apparatus you can depend on and for assistance on your present or projected plans remember—

HARVEY
"AMPLI-STRIP"
For I-F and AUDIO Amplification



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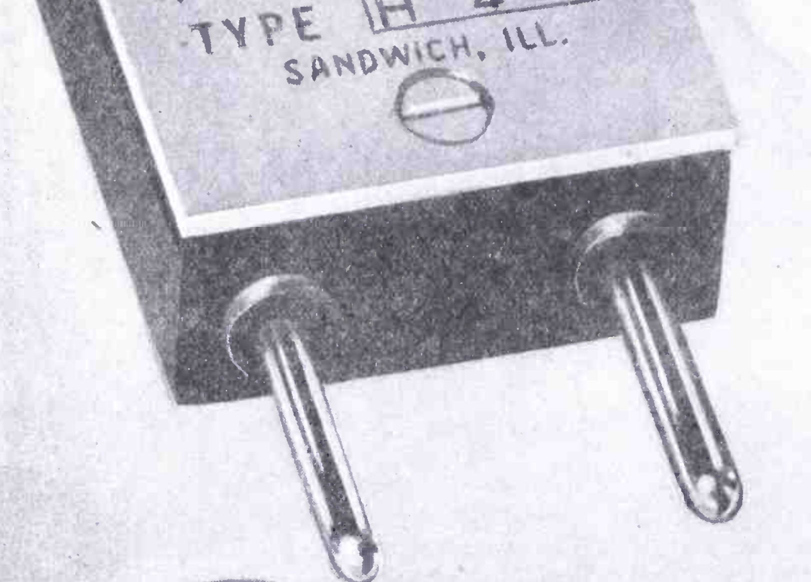

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In instance after instance, James Knights is called upon to supply precision quartz crystals to meet the intricate specifications of university experimental work. In many of these cases, research done in university laboratories with James Knights Crystals is contributing directly to war communication development. That James Knights Crystals are so often considered "first choice" with university scientists is proof of their superior qualifications under the most exacting conditions. Why not let the men of The James Knights Company help with your crystal problems!

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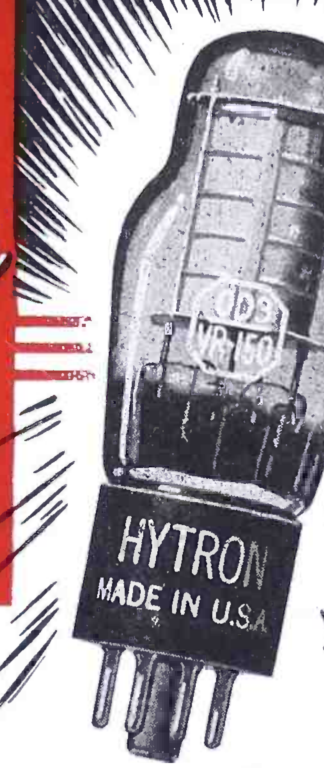
CRYSTALS

CRYSTALS FOR THE CRITICAL

"When we think of the OD3/VR-150, we think of HYTRON"



This enthusiastic comment by an expediter for one of the largest electronic equipment manufacturers, is typical. Engineers and purchasing agents everywhere are automatically associating Hytron with the OD3/VR-150. Since the tube was not originated by Hytron (Hytron was called upon to manufacture the tube to help satisfy a mushrooming demand), the reason must lie in Hytron's ability to do a better job.

WHY THE HYTRON OD3/VR-150 IS PREFERRED

1 CAREFUL ENGINEERING DESIGN — Hytron re-design, among other improvements, resulted in the addition of a new starting electrode which permits a uniformly lower starting voltage.

2 RIGID PRODUCTION CONTROL — Handling and dimensioning of internal parts during pre-processing and assembly are extremely painstaking.

3 TIGHTER FACTORY SPECIFICATIONS — For example, the minimum required starting voltage is 180 volts. Average starting voltage of the Hytron OD3/VR-150 is less than 160 volts.

4 CONTINUOUS ENGINEERING CONTROL OF QUALITY — In over 15 months, there have been no Government rejections of lots submitted for inspection.

5 MASS PRODUCTION — This apparently simple tube is in fact difficult to produce. Yet Hytron is manufacturing it at a rate sufficient to meet on schedule the growing demands of both new and old customers.

MORAL: You too should specify the Hytron OD3/VR-150 (and OC3/VR-105).

OD3/VR-150 AND VR-150-30 COMPARED

Frequently engineers ask how the OD3 and VR-150-30 differ. The maximum regulation limit for the VR-150-30 was 5.5 volts from 5 ma. to 30 ma. The OD3 has a maximum regulation limit of 4 volts from 5 ma. to 30 ma. Viewed another way, the current range is expanded to 40 ma., with the original maximum voltage regulation limit of 5.5 volts. The OD3/VR-150 is in short an improved replacement which supersedes the VR-150-30; it has the advantages of the increased 40 ma. max. rating.*

** The OC3/VR-105 also has ratings up to 40 ma. max.; it supersedes and is a replacement for the VR-105-30.*

OD3/VR-150 CHARACTERISTICS

Type	Glow Discharge Voltage Regulator
Maximum Overall Length	4-1/8"
Maximum Diameter	1-9/16"
Bulb	ST-12
Base	Small Shell Octal 6-Pin

Average Operating Conditions

Starting Supply Voltage	180 min. d.c. v.
Operating Voltage (approx.)	150 d.c. v.
Operating Current	5 min. d.c. ma. 40 max. d.c. ma.
Regulation = (E_{40}—E_5)	3.5 d.c. v.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION
ELECTRONIC AND RADIO TUBES
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HYTRON RADIO TUBES

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CLEARING all Wires!

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Any current-carrying wire in an aircraft electrical system is a potential source of interference with radio communications unless properly shielded. Breeze Flexible Shielding Conduit, produced in a wide range of diameters, can be used in conjunction with Breeze Conduit Fittings and Multiple Electrical Connectors to meet practically any shielding requirement.

The custom design of complete radio ignition shielding harnesses is a Breeze specialty, based on years of pioneering experience in the field.

Breeze Flexible Shielding Conduit is in service today with fighting units of land, sea, and air, supplementing the many other well-known items of Breeze equipment that are helping the United Nations along the road to Victory.

Breeze Shielding guards communications against high frequency interference from spark plugs and ignition system circuits.

Breeze BREEZE MARK

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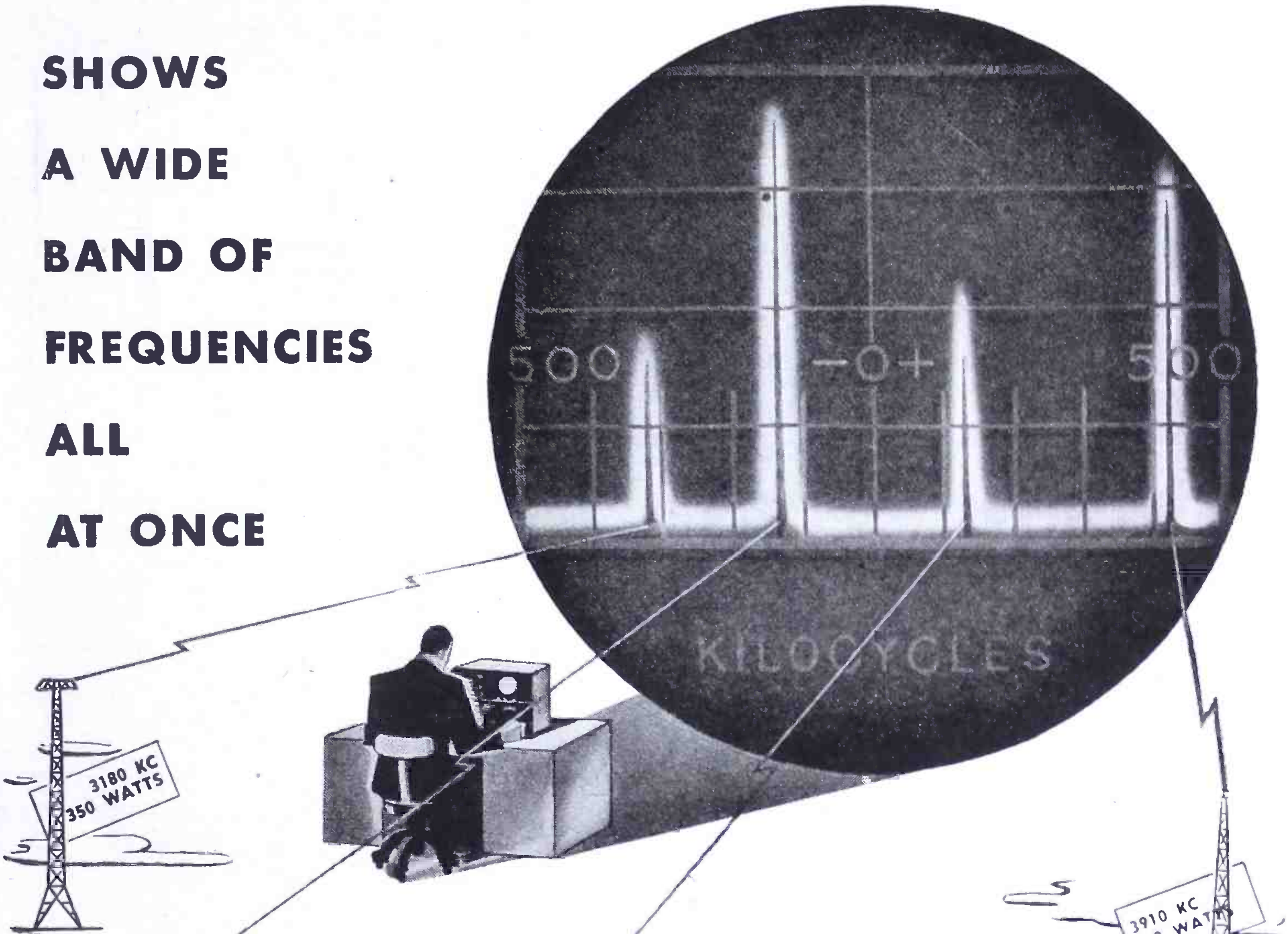
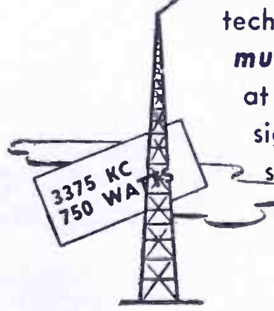
PRODUCTION FOR VICTORY • PRODUCTS FOR PEACE

PANORAMIC

SHOWS A WIDE BAND OF FREQUENCIES ALL AT ONCE

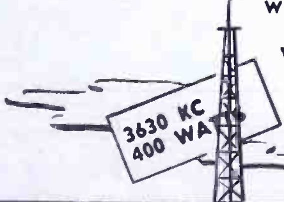


Panoramic reception is defined as the SIMULTANEOUS VISUAL reception of a multiplicity of radio signals over a broad band of frequencies. It is a technique that literally allows you to see what you are missing. In ***communications,*** for example, while ordinarily only one station may be received at one time, with Panoramic reception, the presence and characteristics — signal strength, frequency stability, modulation, etc. — of a number of stations may be seen concurrently.



In other applications, as well, Panoramic reception permits you to see what you're missing. In ***direction finding,*** signals too weak to give an aural indication can be made to give a satisfactory bearing with its use. In ***transmission,*** field strength and frequency of transmitter can be accurately compared with a standard signal. And in ***production,*** Panoramic reception may be utilized to compare components with a standard.

Why not let one of our engineers explain to you the principle of Panoramic technique, and how it may be used to your advantage.



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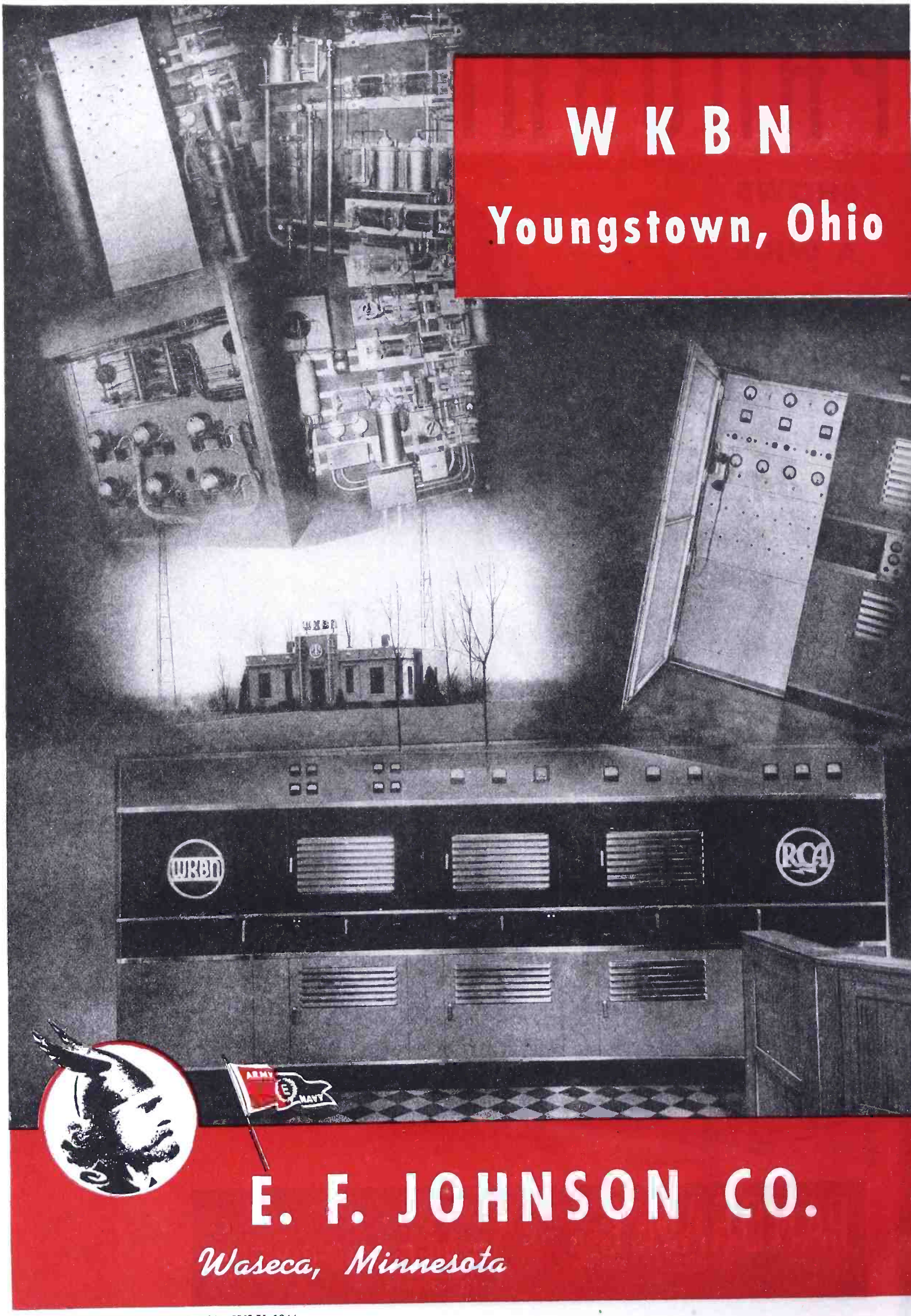
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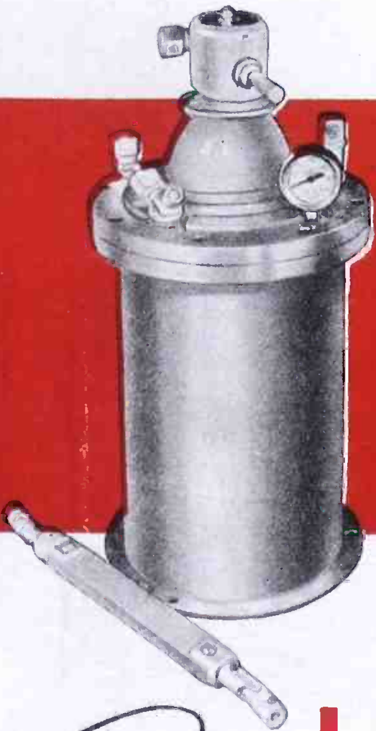

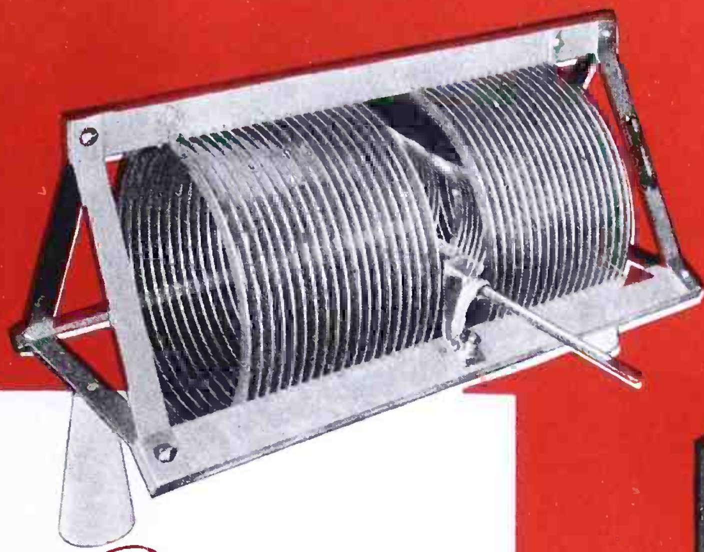

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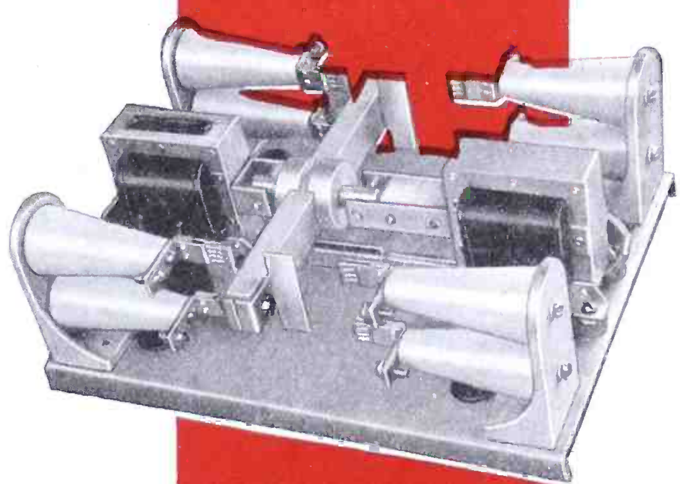
Broadcast Components

Widely used by discriminating broadcast engineers. Typical is the Phasing Equipment installation by WKBN, Youngstown, Ohio. Variable air condensers, fixed air condensers, gas pressure condensers (for higher voltages), inductors (all kinds), chokes, remote motor driven tuning controls and other components.



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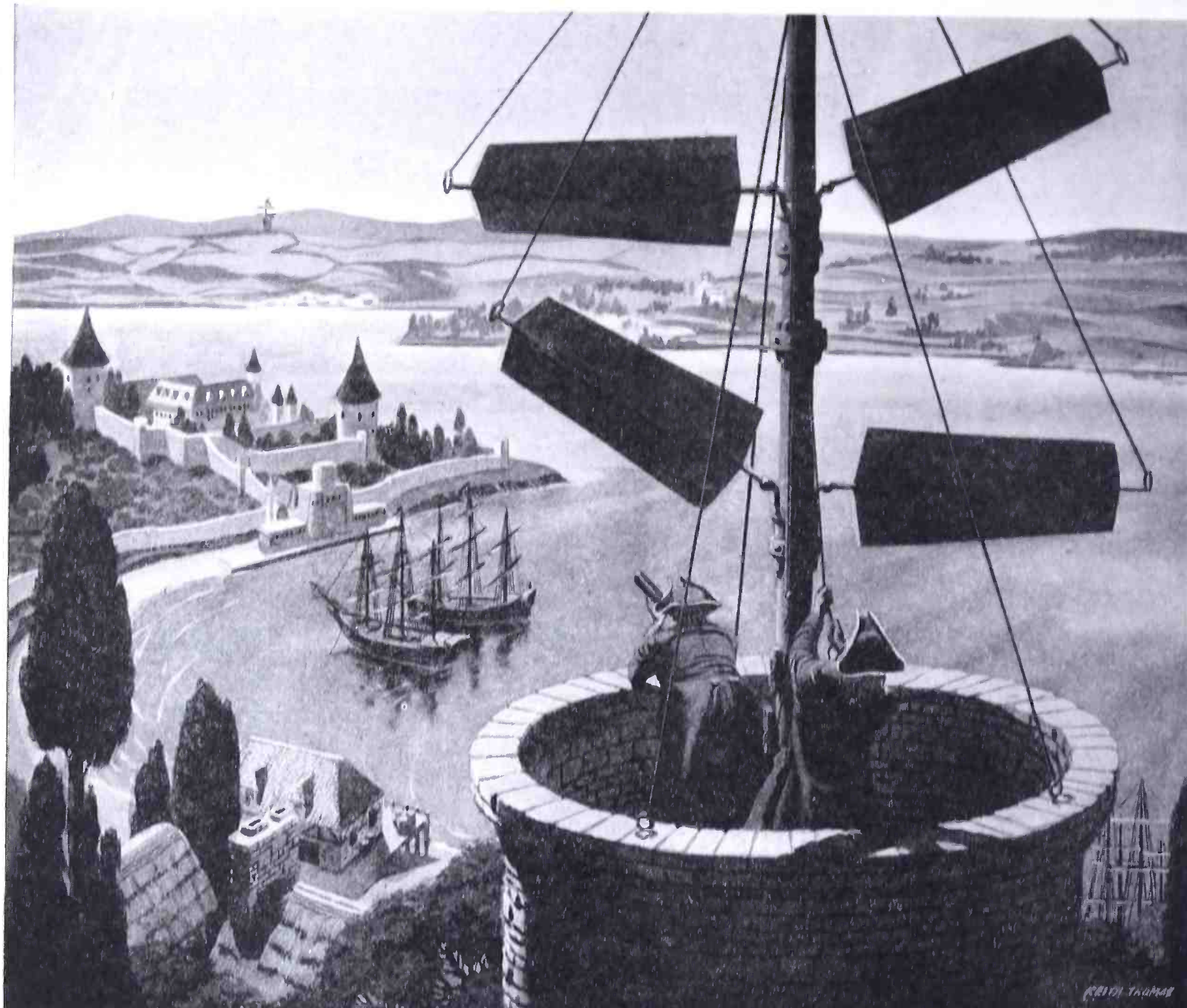
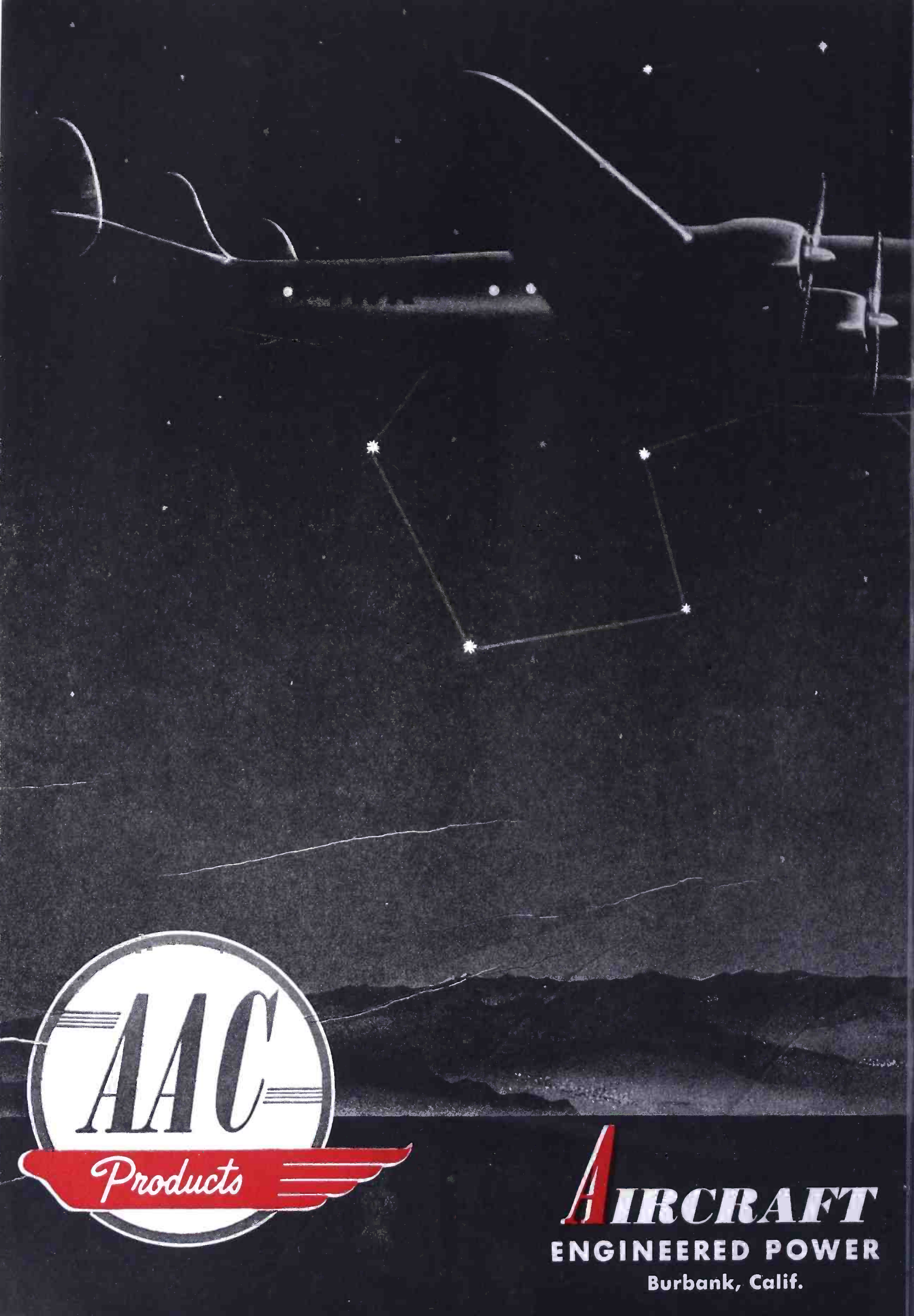


History of Communications Number Six of a Serie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(P-74)

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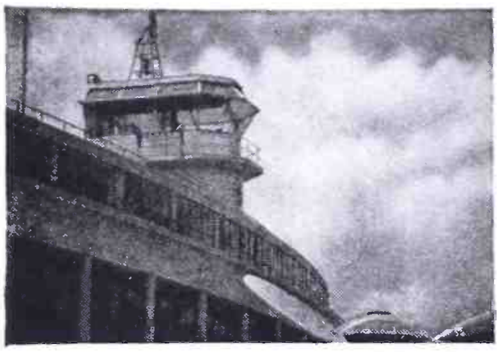

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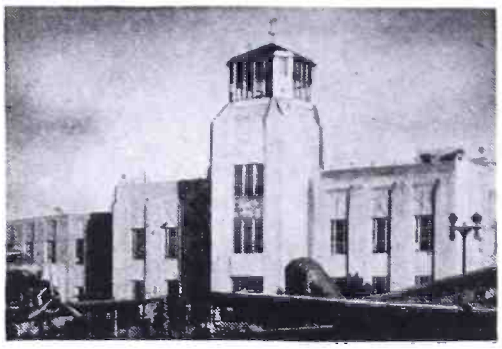
WASHINGTON NATIONAL AIRPORT

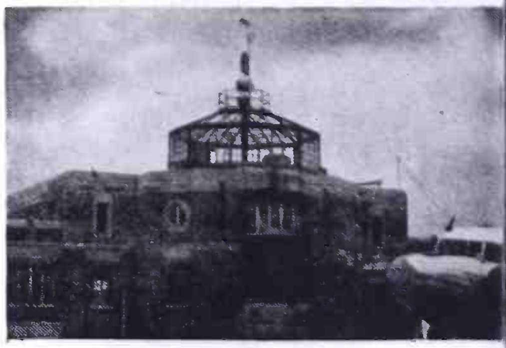
The nation's own, at the Capital City—Operated by CAA.



Delta Airlines Photo

NEW ORLEANS AIRPORT

Modern airport terminal at the Crescent City—an architectural gem.



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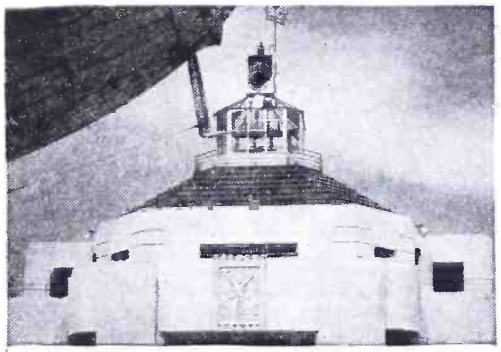
LOUISVILLE'S BOWMAN FIELD

Pride of the Blue Grass State.



Braniff Airways Photo

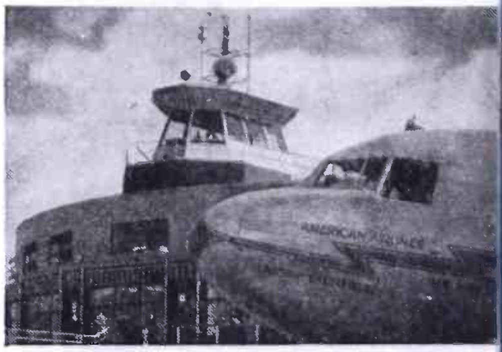
HOUSTON MUNICIPAL AIRPORT

Gateway to Mexico and Central America.

Delta Air Lines Photo

ATLANTA MUNICIPAL AIRPORT

Serving the metropolis of Southeastern U.S.



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LA GUARDIA AIRPORT, NEW YORK

One of the world's largest and busiest airports.

Sentinels of the Sky • • • **the control towers of the nation's airports that stand guard night and day. Each safe arrival and departure at these busy terminals rests on the vigilance of their skilled staffs and the reliability of their radio equipment. Each must function with never failing dependability—in peace as in war.**

Radio Receptor airport traffic control radio equipment, examples of which are to be found throughout the nation in leading civil airports, and around the world in army airfields, is noted for its rugged construction and reliability in operation.

Specify **Radio Receptor** radio equipment for your airport and you may rest assured that your equipment will be equal to the best.

It is not too early to plan for that postwar airport for your municipality. Let **Radio Receptor** aid you. Send for our Airport Radio Questionnaire — no obligation.

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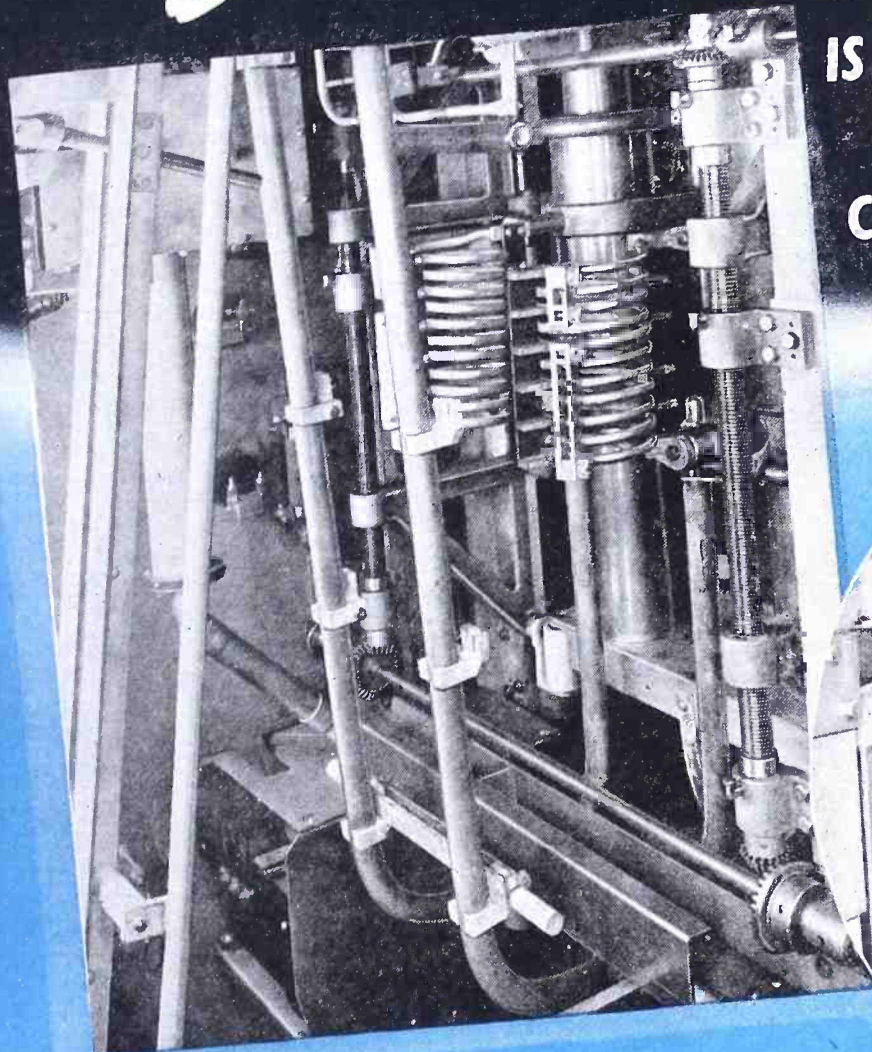
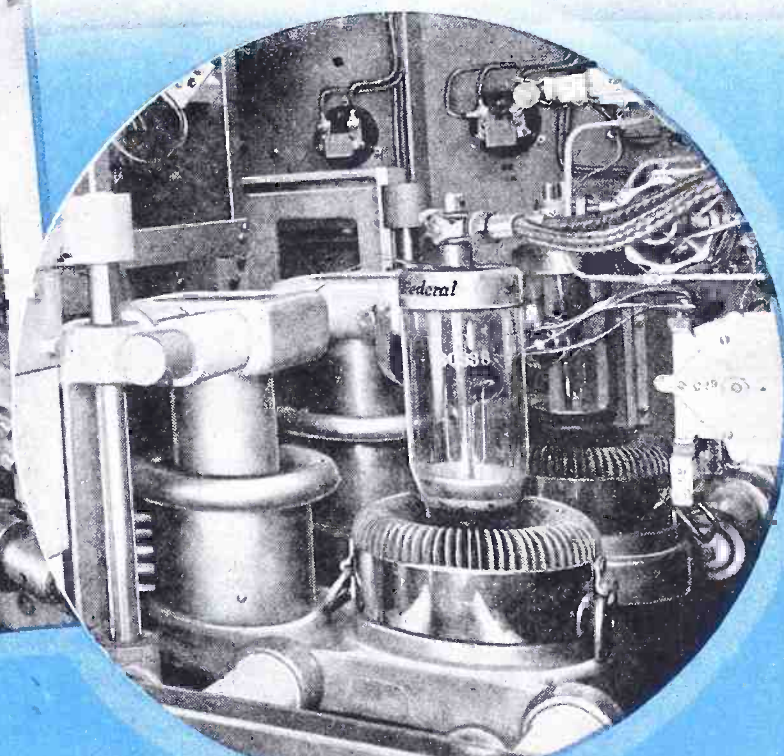
THAT *Extra Margin* OF PERFORMANCE IS *Designed* INTO FEDERAL COMMUNICATIONS EQUIPMENT





Federal, long recognized as a manufacturer of better vacuum tubes, now leads with new production methods resulting in still greater tube efficiency and length of life. Everywhere, it's Federal tubes for superior transmitting and industrial power performance.

The Federal name on communications equipment signifies exacting radio-mechanical design built in . . . plus every extra performance-giving factor.

Federal research and design development are continuous . . . adding new concepts of operation over and beyond accepted performance ratings. This extra care adds ruggedness and high performance dependability to Federal equipment.

Transmitters built by Federal are designed for smooth adjustment over the full frequency range. They are made in a great variety of frequency ranges and power sizes . . . from walkie-talkie to 200 KW transmitters . . . in frequencies of 16 Kilocycles to the upper limit of the radio frequency spectrum.

Back of every Federal transmitter are almost three decades of engineering and manufacturing experience which assure the ability to produce any type or power of communications equipment . . . for point-to-point, broadcast, radio telephone or telegraph or for aircraft, marine or mobile stations.

Look to Federal for the finest in radio communications equipment . . . now and in the future!

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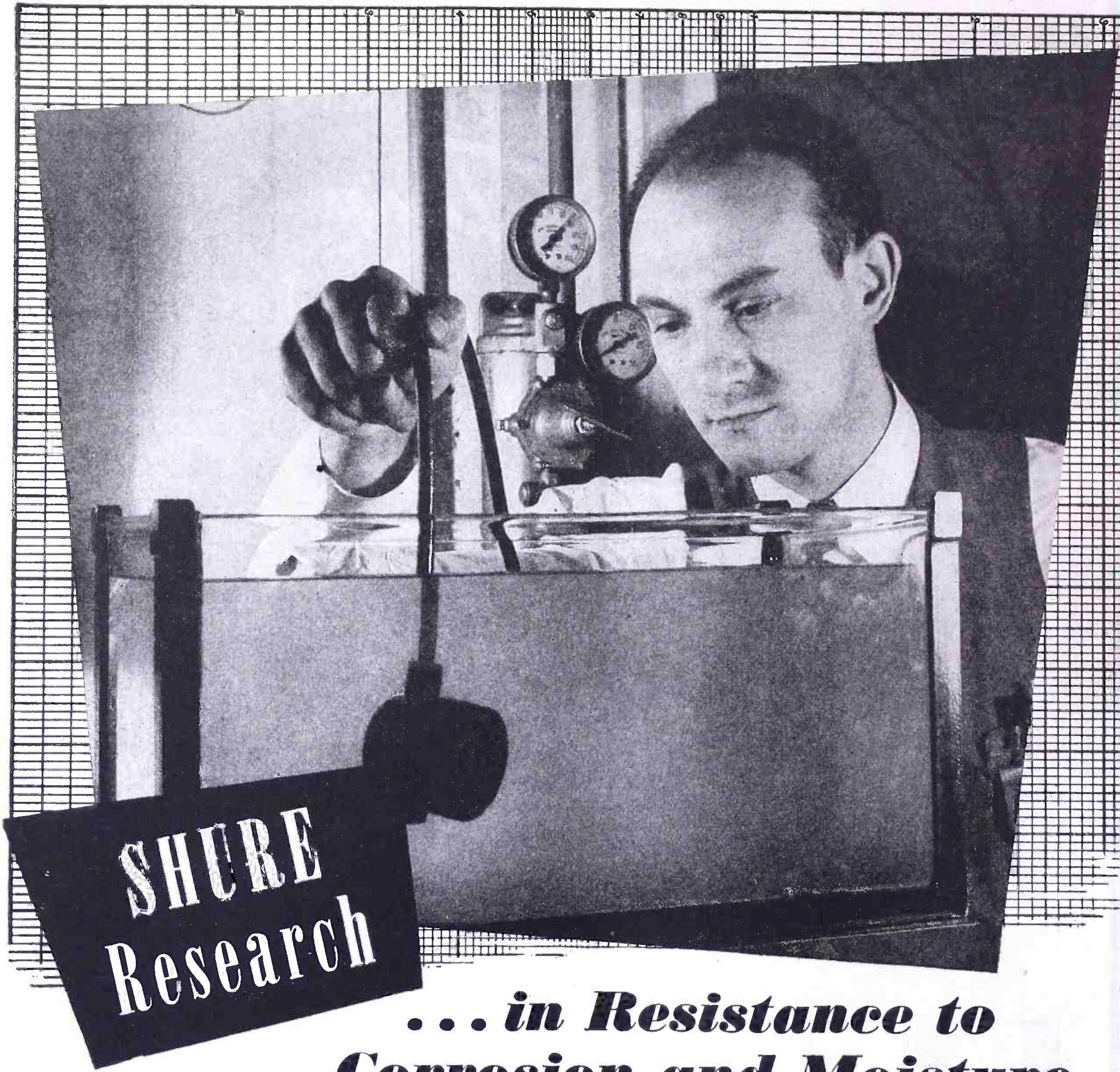
SHURE
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The S. C. A. Selenium Rectifier with the Dual Sealed-In Electrode offers:

Maximum contact area at increased pressure • Added protection against moisture and corrosion • Undisturbed electrical contact after application of surface coating • Permanence of rectifier characteristics and full plate efficiency • Increased field of applications • Shock and vibration-proof operation • Complete interchangeability with all conventional selenium rectifiers

*Available only in S.C.A. Selenium Rectifiers. Trade Mark and Patents Applied For

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TYPE 5CP
CATHODE-RAY TUBE

Type 5CP is a mighty popular cathode-ray tube in the present war effort. It is required in large numbers for oscillographic and special indicating purposes. And DuMont is indeed proud to be producing its full share of 5CP's as still another contribution to victory, on the all-important electronic front.

Here again the specialized skill of DuMont engineers and craftsmen is in evidence. While adhering rigidly to standard specifications governing this popular type, DuMont has introduced its own refinements, improvements and double-check inspection for more rugged, longer-lasting cathode-ray tubes.

Always remember, when it bears the DuMont seal it is a product of *the pioneer in the commercialized cathode-ray tube field.*

Be sure you have a copy of the new DuMont manual and catalog in your working library. Contains invaluable data on cathode-ray technique together with listings of DuMont tubes, oscillographs and allied equipment. Write on business stationery for your registered copy.

CHARACTERISTICS

5″ electrostatic deflection and focus tube. Intensifier feature for maximum deflection sensitivity and brilliance.

Choice of four flourescent screens: Green Medium (5CP1); Green Long (5CP2); White Medium (5CP4); Blue Short (5CP5).

Bulged envelope for greater mechanical strength. Tube base design provides adequate insulation between electrode leads for high-altitude installations.

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Deflection Factor: D_1D_2, 36.5 d.c. volts/kv inch, plus-minus 20%; D_3D_4, 32.0 d.c. volts/kv inch, plus-minus 20%.

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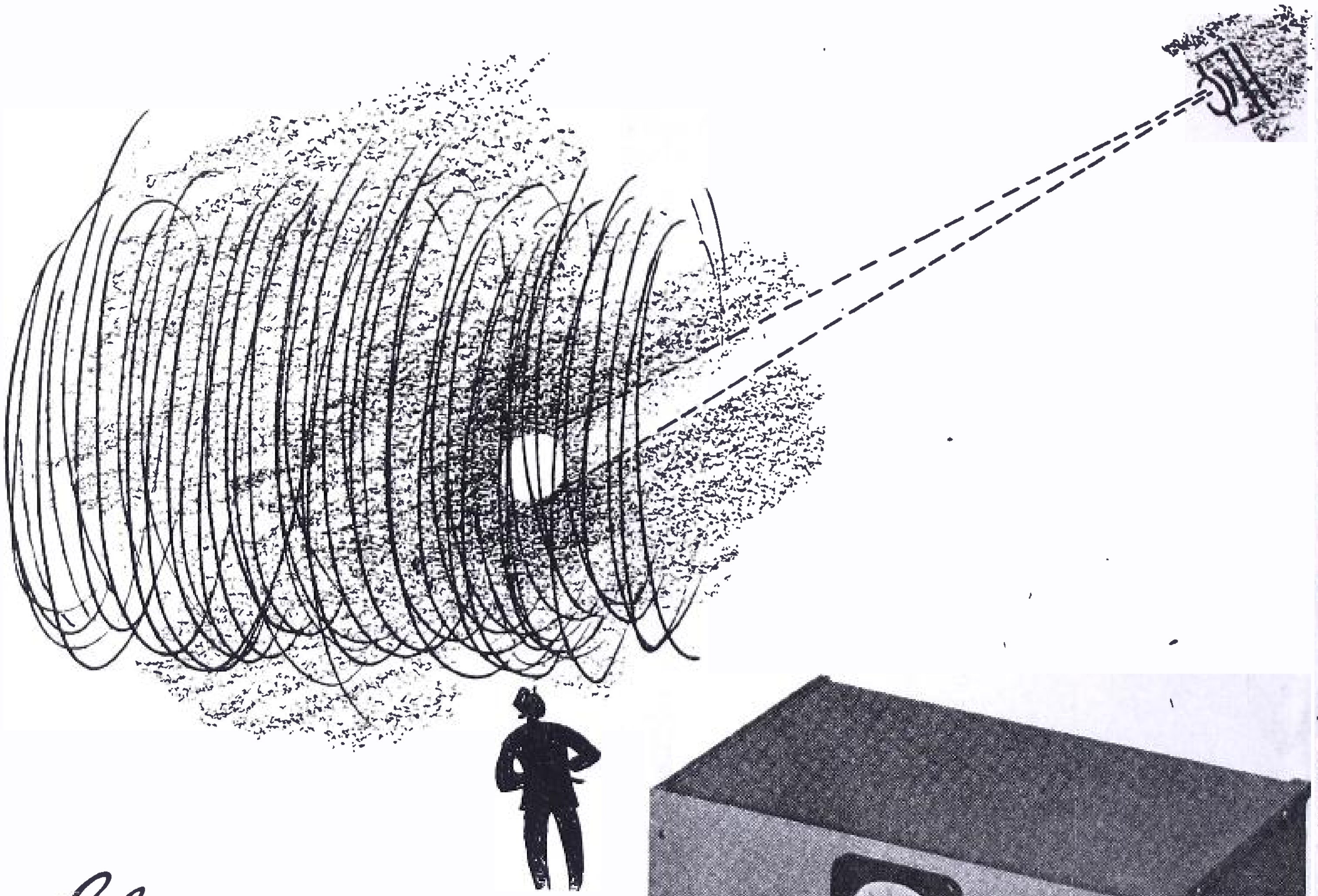

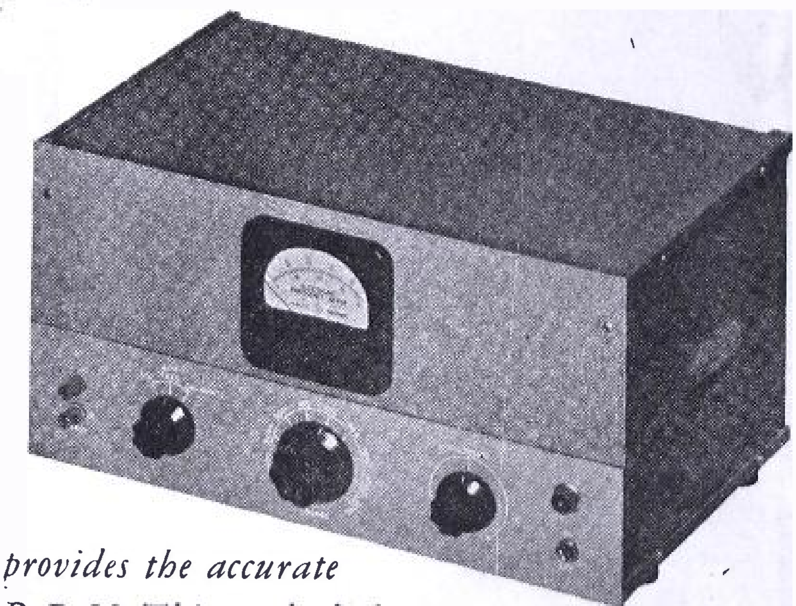

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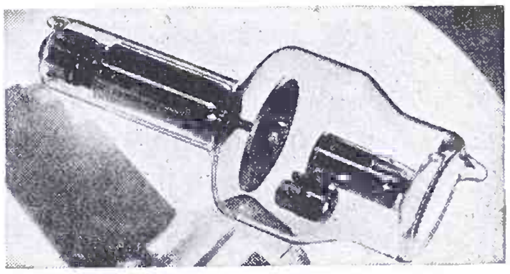

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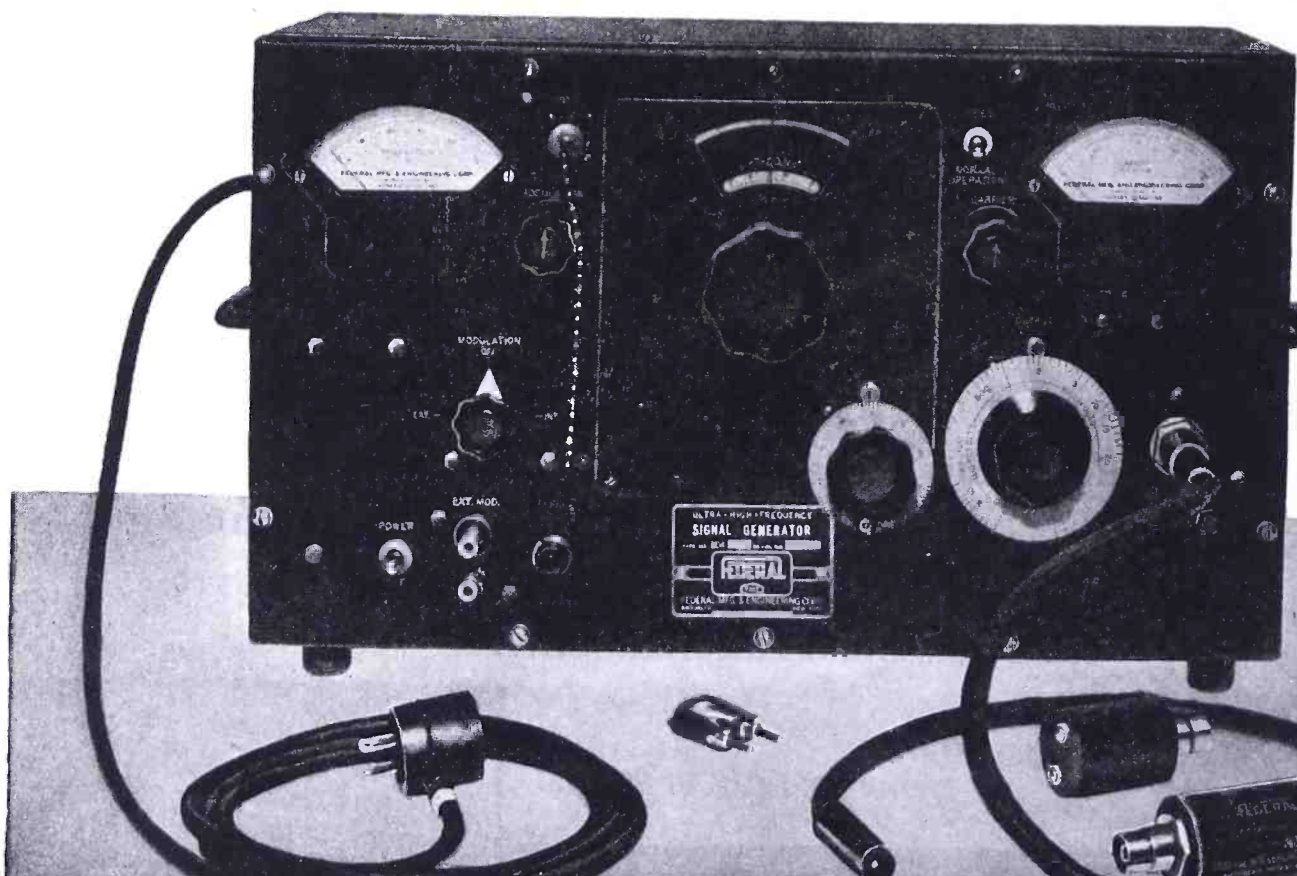

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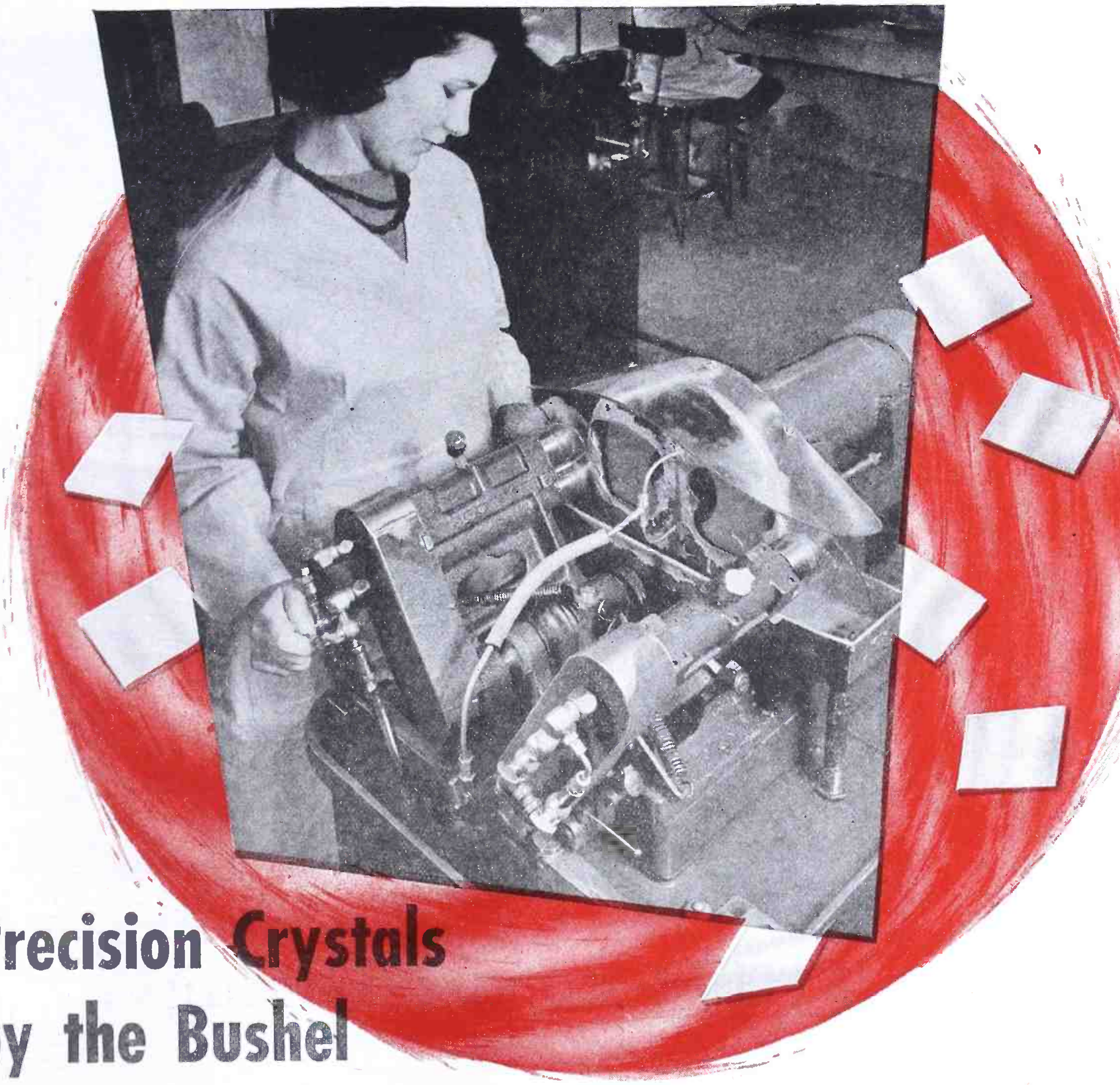

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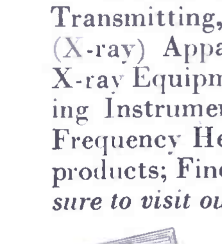

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E-7

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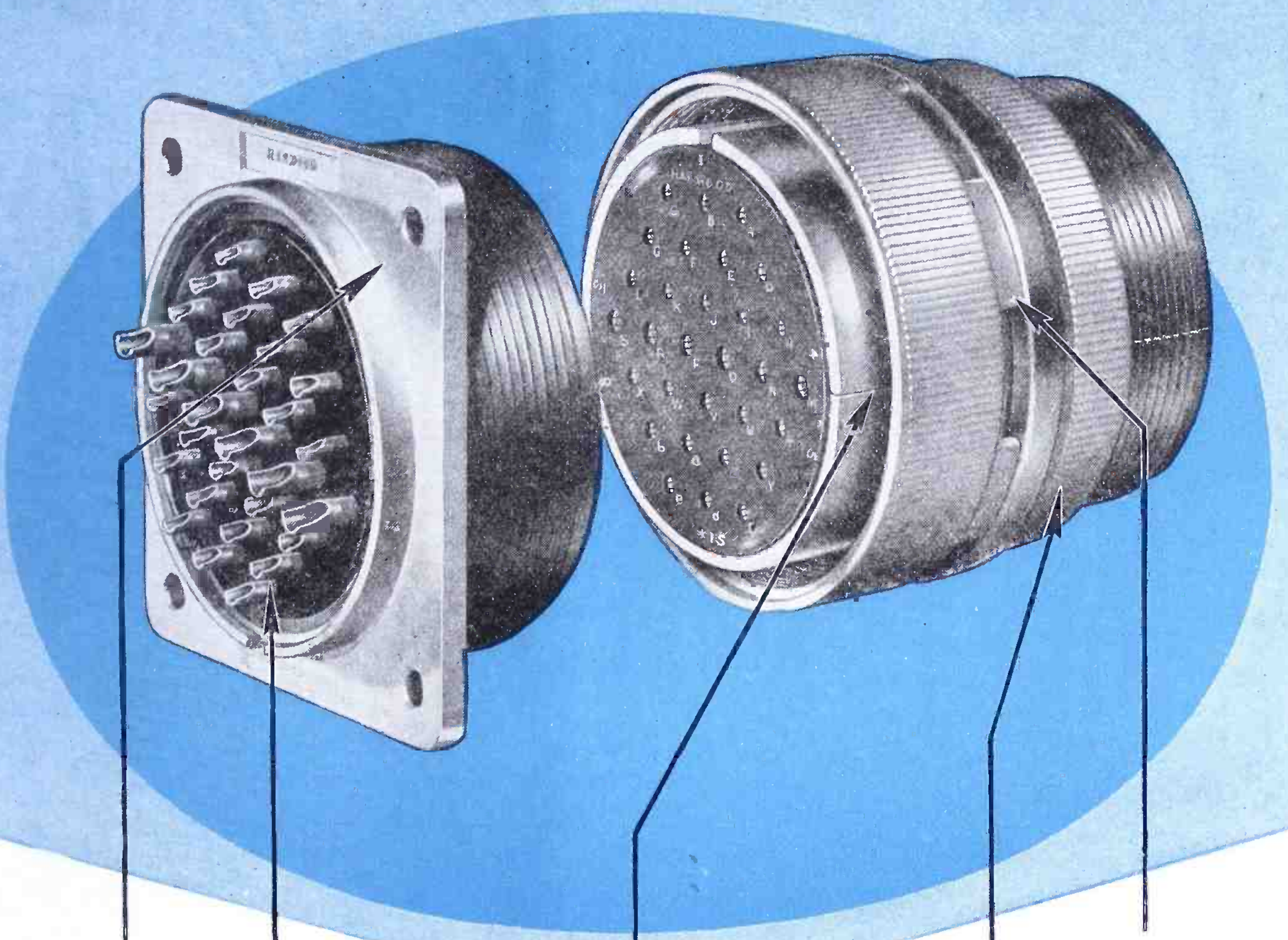

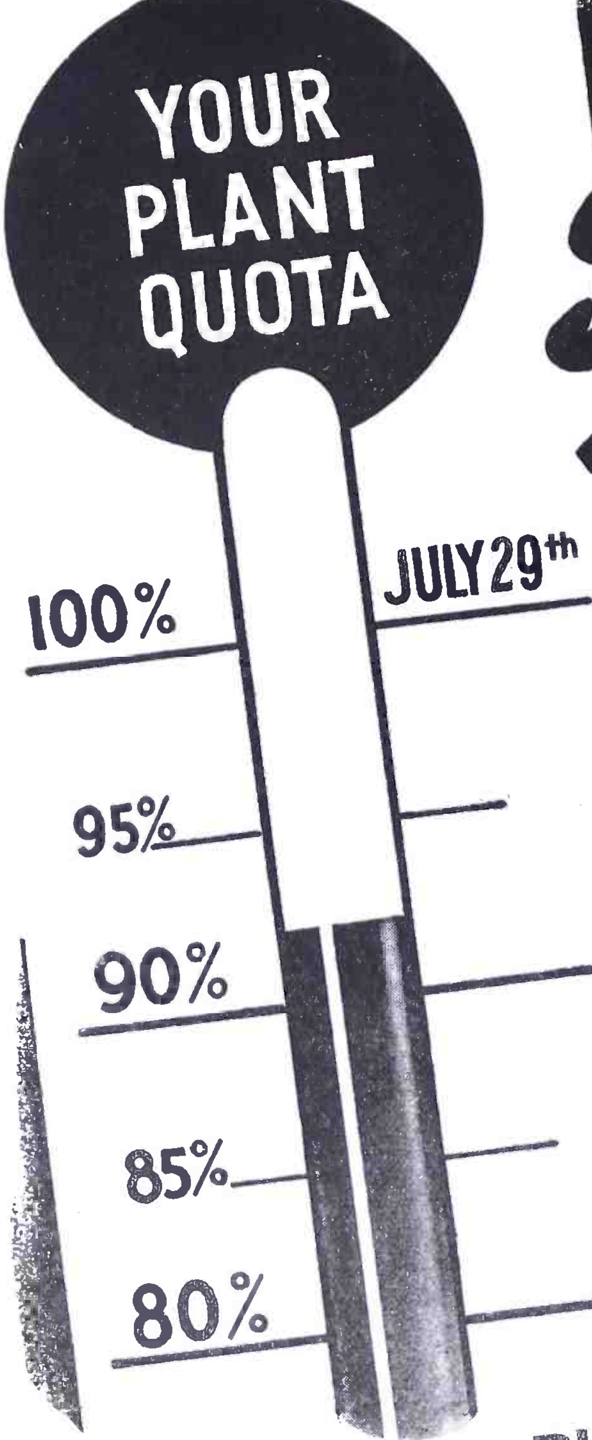

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MANAGEMENT • LABOR

—the 5th War Loan Drive is still on.

July 29th is the last pay day in the Drive.

The U. S. Treasury has set the overall goal at $16,000,000,000 —$6,000,000,000 from individuals alone. This is the biggest sum ever asked of the American people—*and it must be raised!*

Keep fighting. The 5th War Loan is a crucial home front battle of tremendous importance to the total war effort.

Tighten up your 5th War Loan Drive organization. Step up your solicitation tempo. Drive! Drive!! Drive!!! Hit your Plant Quota's 100% mark with a bang that'll proclaim to all the world that the U. S. Home Front is solidly in back of the Fighting Front.

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3. Employees are expected to contribute toward raising the cash quota by buying extra 5th War Loan Bonds: 1—Outright by cash. 2—By extra installment deductions. 3—By extra installment deductions plus cash.

Example: JOHN DOE MFG. CO.—1,000 Employees

1,000 Employees x $100 . .	$100,000 Cash Quota
Regular payroll deductions during the eight weekly payroll accounting periods of June and July.	30,000
	$70,000 (to be raised by sales of extra Bonds).

BACK THE ATTACK—SELL MORE THAN BEFORE

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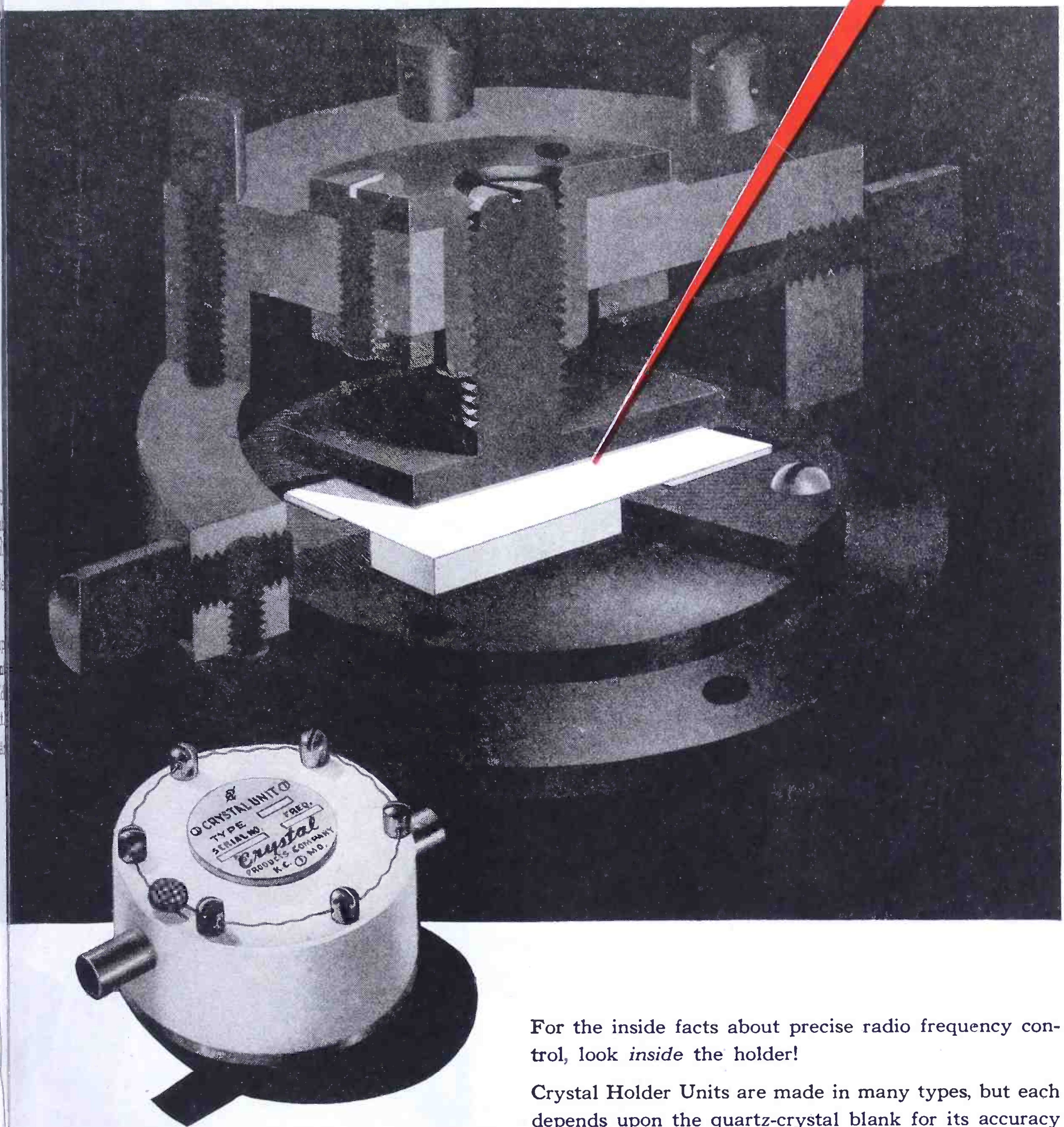

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* * JULY, 1944 * *

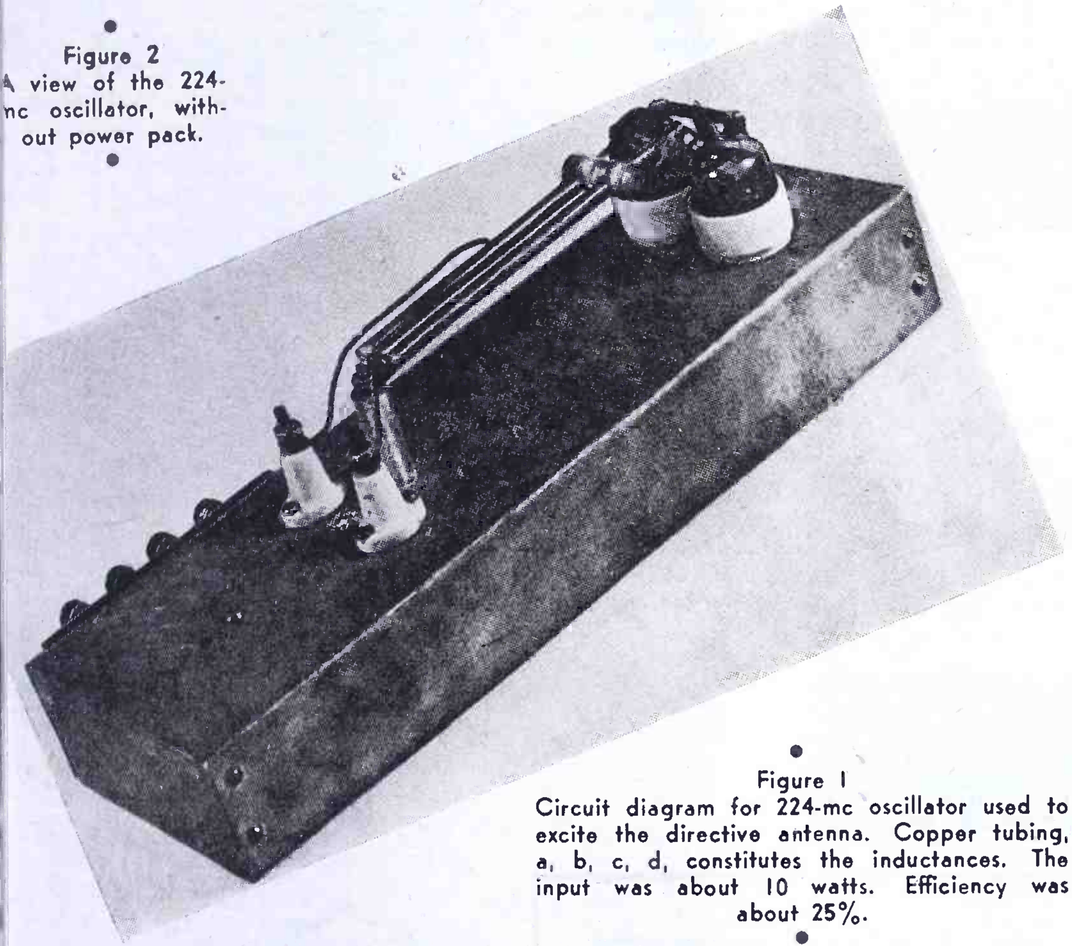


Figure 2
A view of the 224-mc oscillator, without power pack.

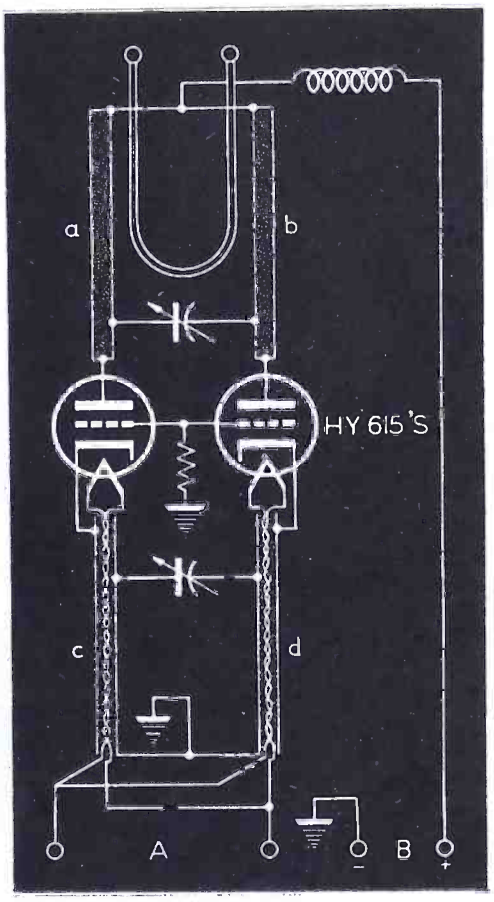


Figure 1
Circuit diagram for 224-mc oscillator used to excite the directive antenna. Copper tubing, a, b, c, d, constitutes the inductances. The input was about 10 watts. Efficiency was about 25%.

U-H-F DIRECTIVE ANTENNAS

by DR. HOWARD N. MAXWELL and CLAYTON ALWAY*
Ass't Prof. of Physics — Physics Dept.
Kalamazoo College

THE general object of a recent antenna project was to develop a rotatable antenna system for operation on frequencies in the neighborhood of 224 mc and capable of radiating energy in a direction confined to a few degrees both in a horizontal and vertical plane. The frequency 224 mc was chosen because (*1*)—it fell within one of the bands of frequencies assigned to the amateur service, on which we were licensed; and (*2*)—the half-wave antenna corresponding to 224 mc is about 65-cm long, making complicated multi-element arrays feasible. This latter reason was important because the available construction space was limited, the investigation having been conducted in one of the laboratories in the science building. Since it was practically impossible to secure new materials from the supply companies in view of priorities, we used what was available in the laboratory.

Specifically, the investigation resolved itself into three parts: (*a*)—the design and construction of a suitable oscillator; (*b*)—the design and construction of a field-strength meter to measure the radiation pattern produced by the antenna; and (*c*)—the design and construction of the directive antenna array itself.

The oscillator was designed with the following requirements in mind: Its power output had to be sufficient to excite the antenna and produce a measurable radiation pattern; it had to be stable; adjustable over a small frequency range; simple, light, inexpensive, and as efficient as possible.

We constructed a small hairpin oscillator using a 7A4. This failed to

*At present in U. S. Army.

ASA standardized symbols used in diagrams in this paper.

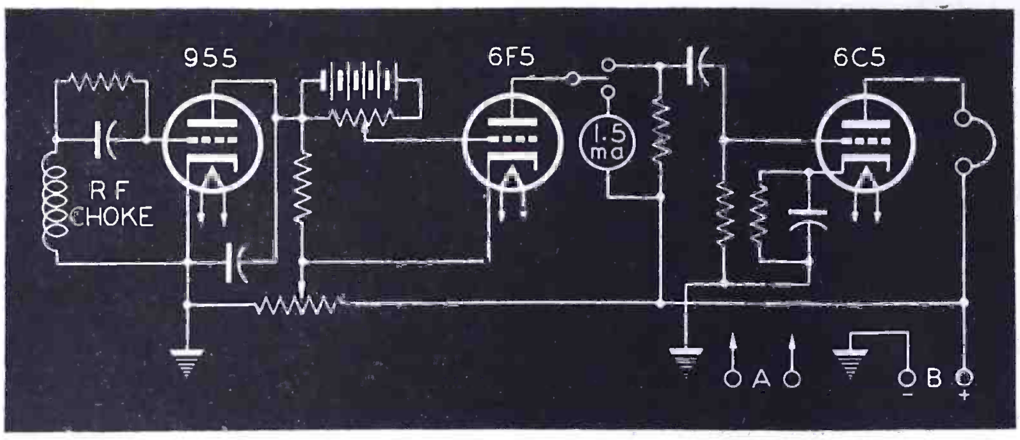


Figure 3
Diagram of the field-strength meter used in plotting the radiation pattern of the directive antenna. Antenna is connected to grid side of r-f choke.

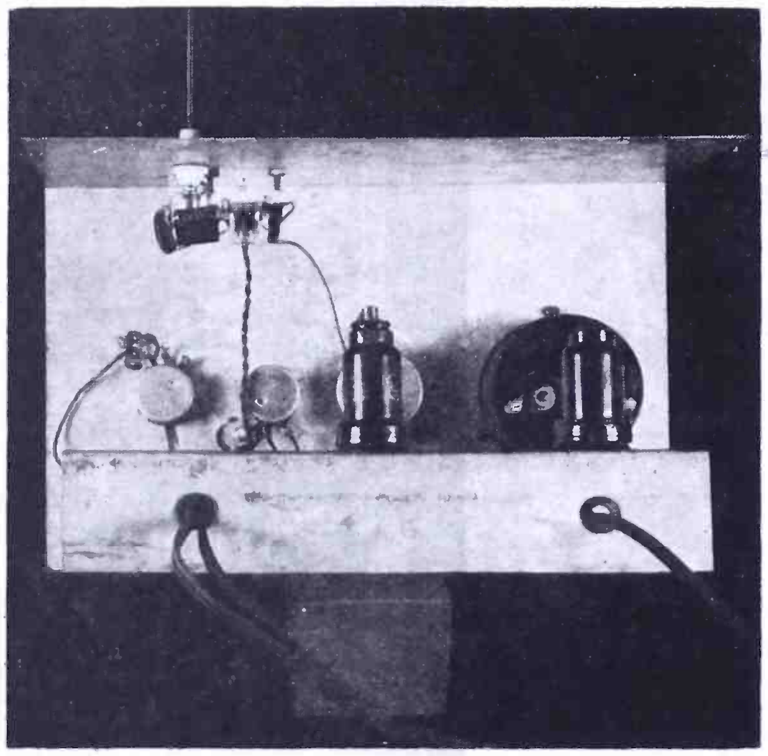


Figure 4
Rear view of the field-strength meter. The 955 acorn used in this unit, served as a grid-leak square-law detector, directly connected to a 6F5 triode, which was used as a variable mu log amplifier.

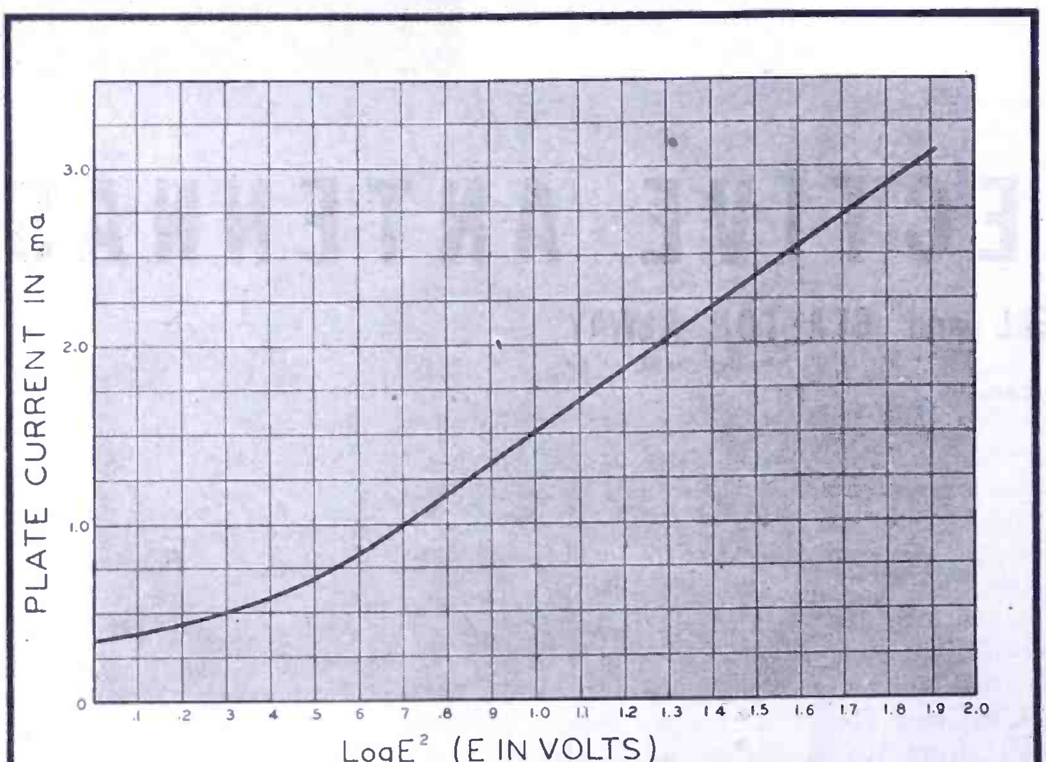


Figure 5
Calibration curve for field-strength meter. Plate current of 6F5 tube plotted against common logarithm of square of signal voltage.

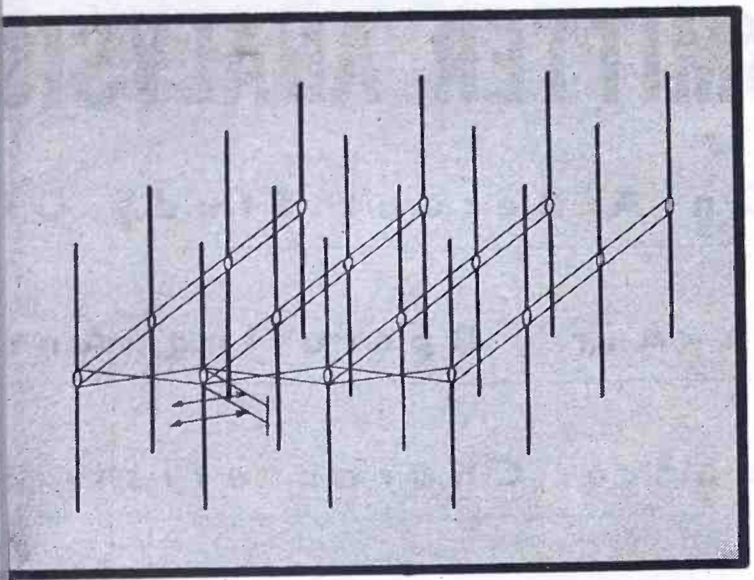
meet the necessary requirements, and so we tried two HY 615's in a linear oscillator circuit, Figure 1. It had been planned to add an RCA 815 as an amplifier, but since neither it nor a similar tube was available, the amplifier was not built. However, it was found that the oscillator alone delivered sufficient power for the purpose and that it was quite stable, although it could not be loaded very heavily. Its efficiency was about 25%, and with a maximum input of about 10 watts it could be run continuously for several hours without overheating. Copper tubing was used for the inductances and tuning was accomplished by use of copper disks adjustable by means of screws threaded through the *hot* ends of the inductances. The power output was through a hairpin link above the plate lines. The filament lines were located below the chassis. A Lecher wire system was employed to adjus the frequency to the desired value. In Figures 2 and 8 appear views of the oscillator.

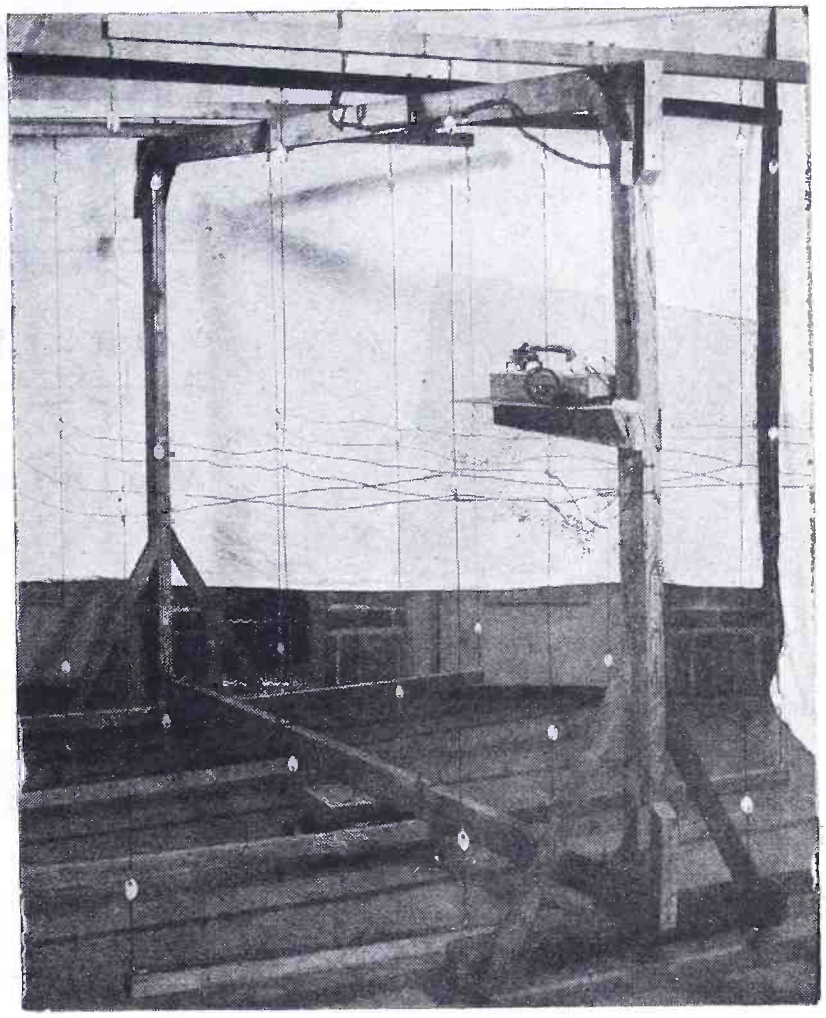
Field-Strength Meter

In the design and construction o the field-strength meter, we set u three standards: The instrument ha to be sufficiently sensitive to be abl to detect signals of low intensity an still have a large enough range t measure the strongest signals radiate by the antenna. Its accuracy had t be such that the relative merits o various antennas could be clearly de termined. It had to be simple, ligh and easily operated.

In the first attempt to fulfill th foregoing requirements, we tried 1H4 in a circuit that was essentiall a single-ended class *B* amplifier, th plate current rising when an alternat ing voltage was impressed on th grid. This instrument was found t lack sufficient sensitivity and was use only for qualitative measurements a short distances. It did prove quit useful, however, in adjusting the an tenna for maximum output.

In Figure 3 appears the circuit o the field-strength meter finally use while Figure 4 represents a pictori view of the meter. This meter co tained three tubes. An RCA 955 acor as a grid-leak *square-law* detector w directly connected to a 6F5 triod used as a variable μ logarithmic an plifier. A 6C5 triode was resistan coupled to the 6F5 for amplificati when it was desired to receive a mod lated signal. However, it was n often used and could be disconnect by means of a switch. The batte and voltage divider in the grid circu of the 6F5 were necessary to overco





the voltage drop in the plate resistor of the 955. It also provided a means of adjusting the plate current of the 6F5 to a low value when the signal was zero.

Figures 6 (above), 7 (right)
Figure 6, schematic of the antenna array. Sixteen sets of two stacked elements arranged in four endfire arrays and connected together at one end for excitation purposes were used. Spacing between adjacent elements was a half wavelength.
In Figure 7 appears the antenna array and oscillator. Note that the array is capable of rotation about a vertical axis.

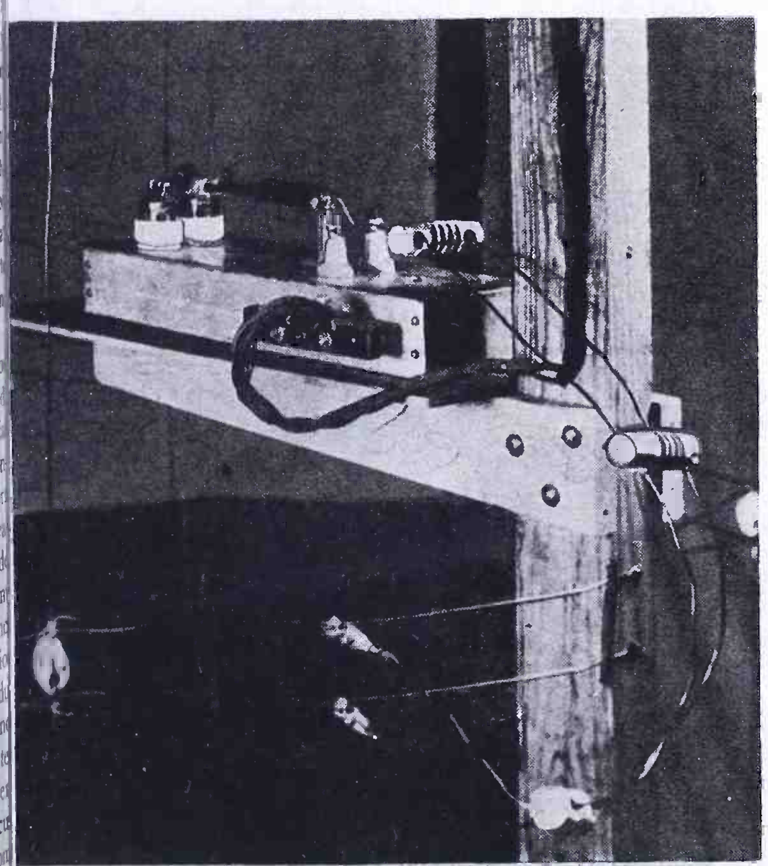
Meter's Operation

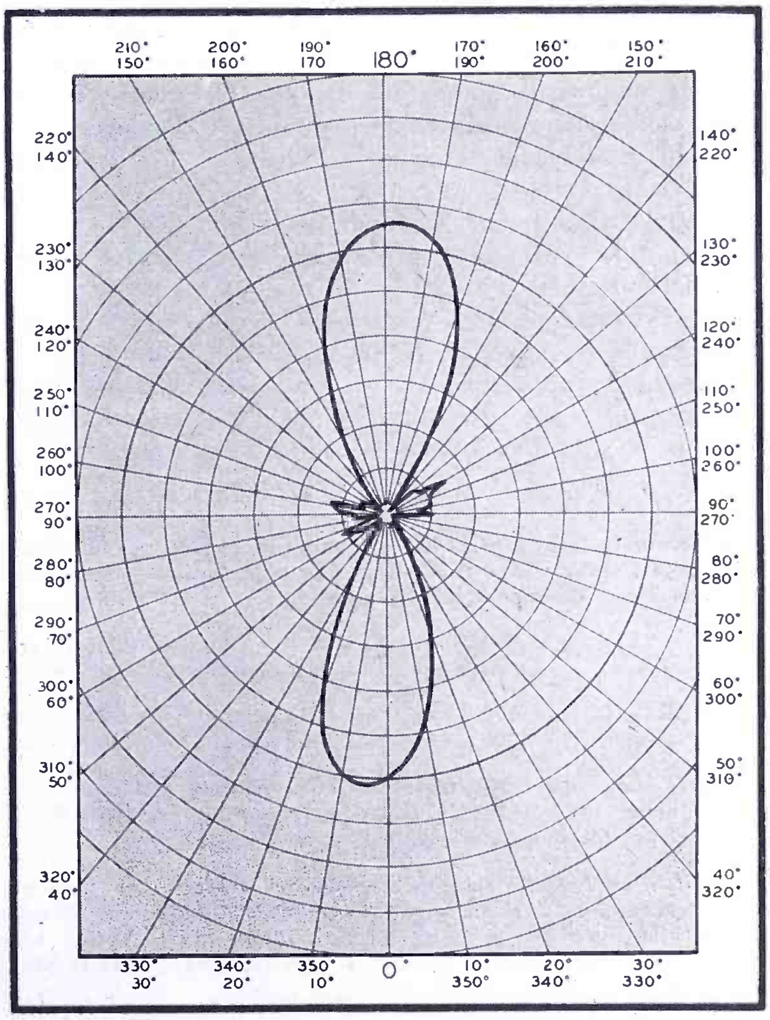
The voltage induced in the antenna of the meter was passed by a blocking condenser to the grid of the 955 tube. The voltage was rectified and the grid became negative with the result that the plate current and hence the voltage drop in the plate resistor decreased. Consequently the grid of the 6F5 became positive and produced a rise in the plate current.

The meter was calibrated by applying a known alternating voltage to the grid of the 955 through a large blocking condenser. Although the frequency of the applied voltage was only 60 cycles, the 955 has such small interelectrode capacities and short leads that the great difference in frequencies did not affect too greatly the accuracy of the calibration. Figure 5 shows a curve of 6F5 plate current plotted against the logarithm of the square of the antenna voltage. It will be observed that this calibration curve is almost linear. This linearity was a desirable feature of the meter since the response of the ear is proportional to

(*Continued from page* 59)

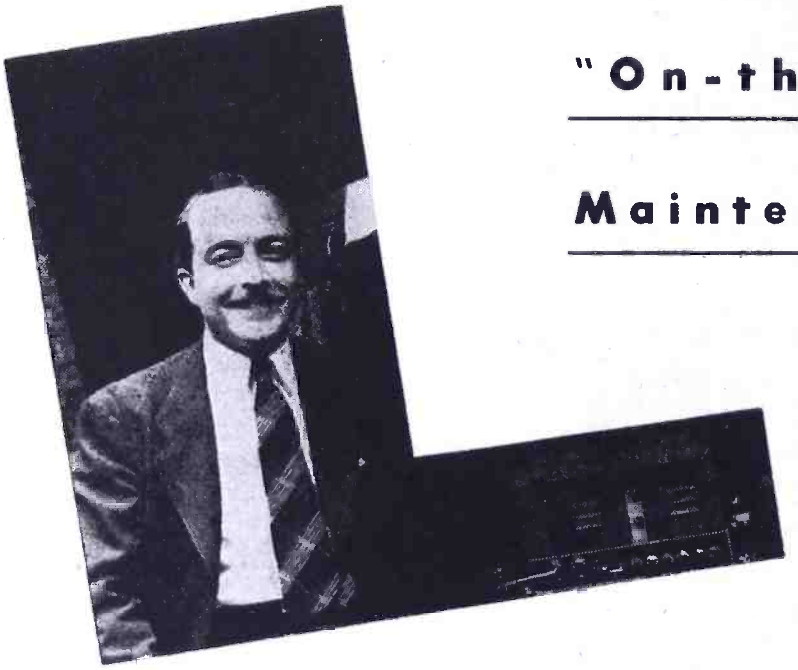
Figures 8 (below and 9 (right)
Figure 8, closeup of the oscillator showing the matching stub and 500-ohm non-resonant line connecting it to the antenna array. Figure 9, experimental radiation pattern for directive antenna of 32 elements.





F-M AND A-M TRANSMITTER ANALYSIS

Based On A Recent Study Of "On-the-Air" Operating And Maintenance Characteristics



by SCOTT HELT

Chief Engineer, WIS

Mr. Helt with one of the 2-way f-m units used by the Columbia, South Carolina police radio system, which he serves as maintenance engineer.

A RECENT investigation of f-m transmitter design, operation and maintenance, during which on-the-air transmitters and antennas were studied and operated, disclosed that f-m offered many favorable features.

An important f-m characteristic noted, for instance during the tests, was the absence of peak power during modulation.

In amplitude modulation the power in the carrier wave becomes four times as great when the percentage of modulation is doubled. When a carrier is modulated 100% in amplitude modulation, the total power of carrier plus sideband is 50% greater than that of unmodulated power. With lower percentages of modulation the sideband power is proportional to *m* squared, where *m* is the percentage of modulation expressed as a decimal. Since all this power must be supplied directly to the plate of the r-f amplifier tube during modulation, when modulating 100%, the plate of the r-f amplifier must dissipate 50% more power than when the carrier is unmodulated. The additional power dissipated at the plate must be supplied by the modulator. Thus, for 100% modulation, the modulator stage in the transmitter must supply undistorted audio frequency power equal to 50% of the unmodulated carrier plus 50% of the power dissipated at the plate of the r-f or modulated r-f amplifier, when modulated.

The instantaneous peak power output during modulation is $(1 + m)^2$. Thus, at 100% modulation the r-f amplifier must be capable of delivering instantaneous peak power of four times the normal carrier power. The greater the percentage of modulation, the more power has to be applied to the r-f amplifier. Therefore, with high powers of modulation in a-m, the plate of the r-f stage must dissipate more power, and the temperature of the plate is increased. In a-m, the r-f amplifier tube is selected for its ability to handle the modulation peaks, and the modulator tube is selected for its ability to dissipate, at the plate, the unmodulated power output.

In f-m, modulation takes place at low level, and the modulator is followed by high efficiency class *C* amplifiers. In a-m, if low-level modulation is used the modulated stage must be followed by relatively low efficient class *B* linear amplifiers. It can be shown mathematically that 33% is the maximum efficiency that can be obtained from a class *B* linear amplifier, while class *C* amplifiers have been constructed to operate at efficiencies of 60% to 70%. While such high efficiencies have not yet been obtained in the class *C* amplifiers used at 40 to 50 mc in f-m, the efficiency obtained is much greater than that of the average class *B* linear amplifier. Of course less tube capacity is required, too, in the f-m amplifier of equivalent power

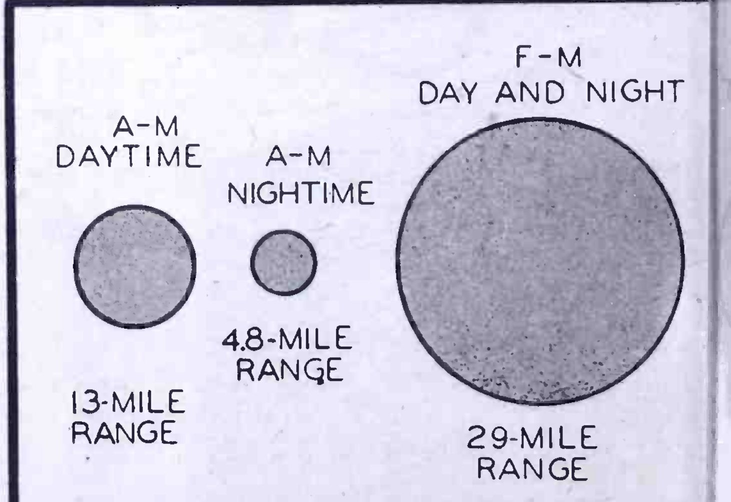
(*Continued on page* 85)

A comparison of a-m (1400 kc) and f-m (42-50 mc) signal ranges for a 250-watt station. The FCC allocation plan for local f-m stations is based upon the following signal strength data:

Time	*Signal*	*Range*	*Possible Interference at That Range*
Day	500 μv/m	13 miles	25 μv/m signals
Night	4000 μv/m	4.8 miles	200 μv/m signals

These data are taken from the FCC records and assumes an antenna height of 331'. The FCC mileage separation for allocation purposes is 173 miles for these stations.

A 250-watt f-m station with a single bay antenna 331' high would have a *corresponding day and night* range of *29* miles to the 50 μv/m contour. Only 50 μv/m are required for satisfactory f-m reception, whereas 500 μv/m are required for similar a-m reception, reports Mr. Helt.



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Today this pump is being made ›ailable to manufacturers and re›arch laboratories throughout the ›orld. You can obtain full informa›on and technical data without cost › obligation by writing direct to ›e San Bruno plant address below.

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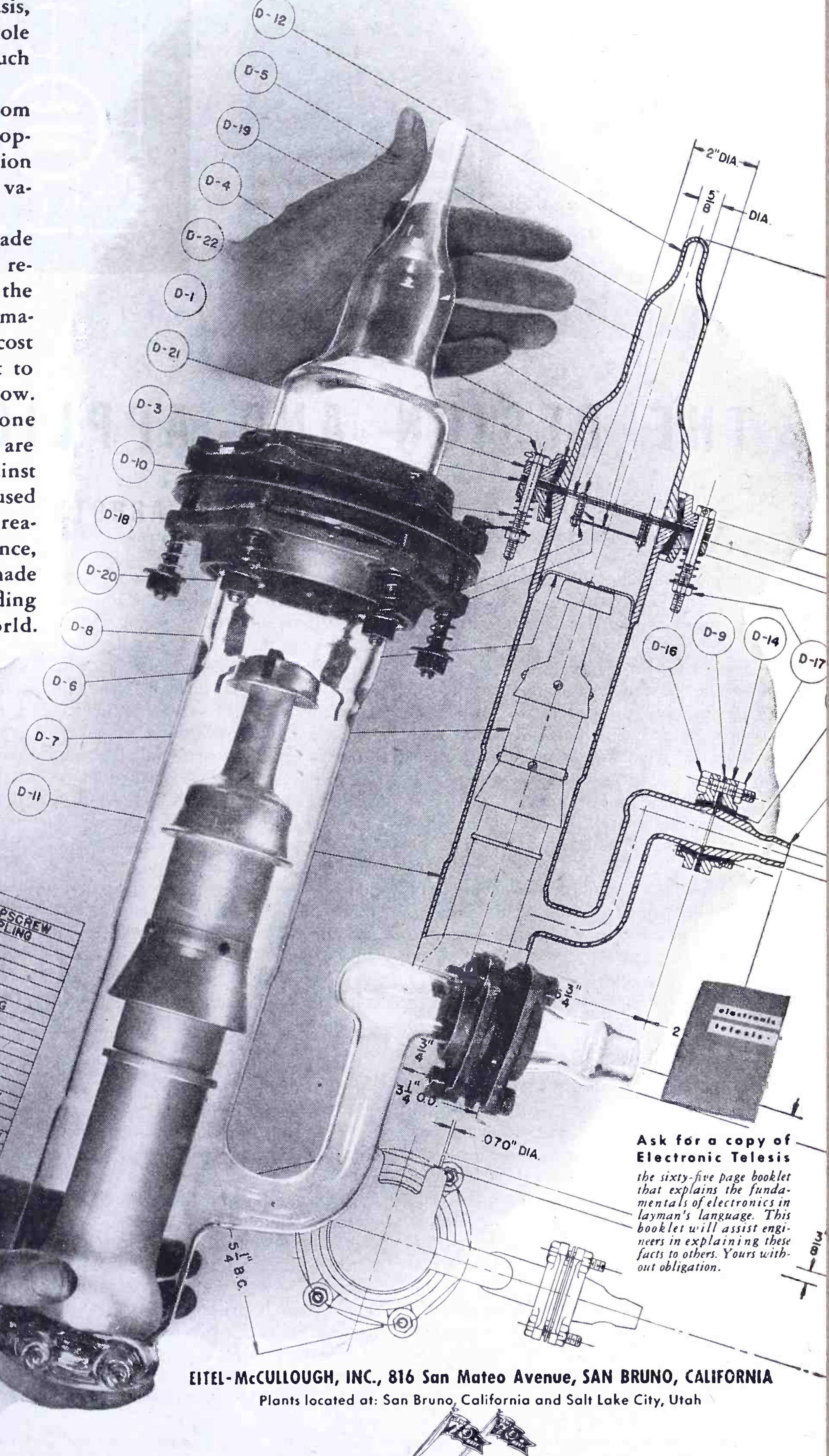

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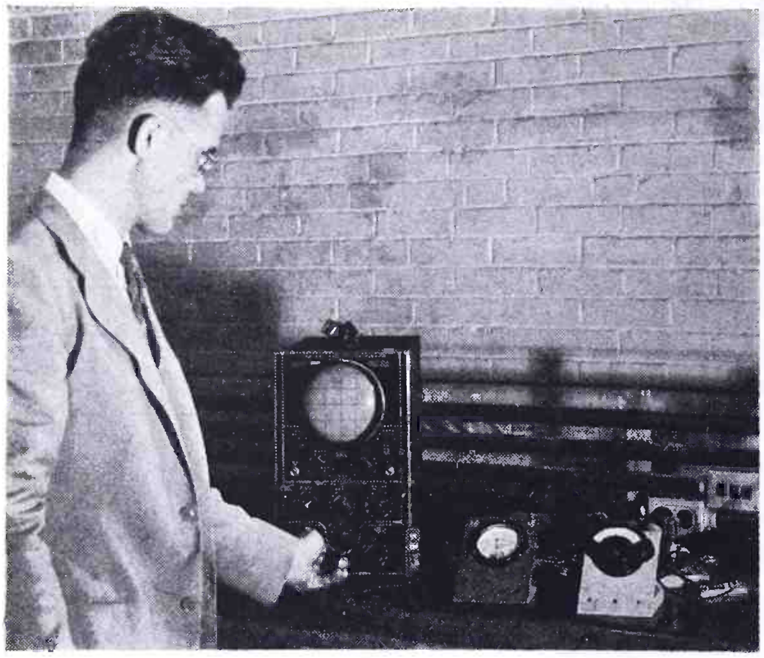
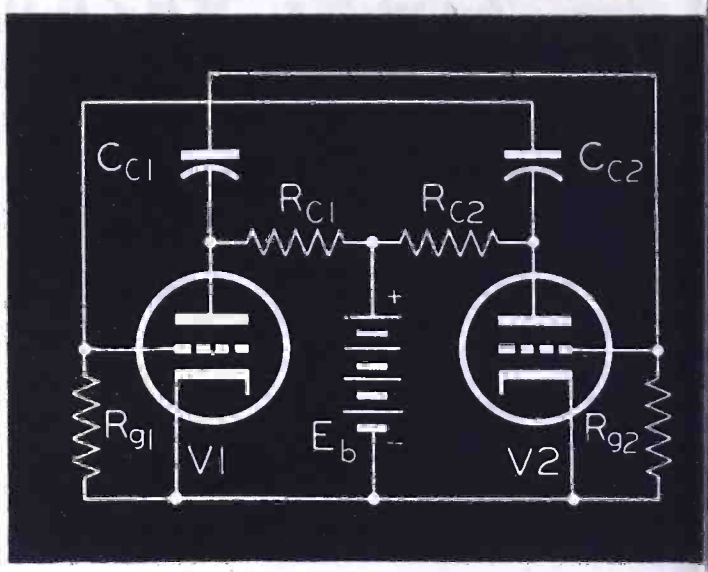




Figures 1 (above) and 1a (left)
Figure 1, the circuit of the Abraham-Block multivibrator analyzed in this paper. Figure 1a, Professor Abbott working with a multivibrator unit.

THE DESIGN AND APPLICATION O

by WILTON R. ABBOTT
Ass't Prof., Electrical Eng.
Iowa State College

A MULTIVIBRATOR may be defined as a relaxation oscillator derived from a resistance-coupled amplifier. The particular form of multivibrator to be discussed here is known as the Abraham-Block multivibrator, one of the most widely known types.

The most important applications of the multivibrator arise from the fact that its frequency may be controlled by a small voltage from another oscillator and because its output is extremely rich in harmonics.

An examination of the circuit diagram in Figure 1 shows that it consists essentially of a two-stage resistance-coupled amplifier, the output of which is coupled to the input. Because of the phase reversal in each stage the output is in phase with the input. This condition is sufficient for oscillation if the overall gain is greater than one. This last condition will ordinarily be obtained in the normal frequency range of the amplifier. While the amplifier concept shows that oscillations will exist, it gives no information concerning the output frequency or wave shape. Since both of these are important, further analysis is desirable.

The circuit of Figure 1 can be made completely symmetrical. Suppose, to simplify the following discussion, that the circuit be considered symmetrical. Then it might seem reasonable to suppose that the tubes will carry equal currents. However, this supposition must be examined in more detail. Assume that for some reason the plate current of V_1 increases a small amount for a short instant. As is well known, this type of variation occurs many times a second in all tubes, so it would not be necessary to wait long for such an increase. Because of the circuit connections, the grid of V_1 will be affected by the change in plate current with a consequent further change in plate current. It is this consequent change which is to be investigated.

The assumed increase in plate current reduces the plate voltage of V_1 because of the increased *IR* drop across R_{c1}. However, the voltage across C_{c1} cannot change a finite amount instantaneously. Such a change would mean that the energy stored in the condenser could change instantaneously. But this would mean infinite power—a condition not ordinarily met with in practice. Since this voltage cannot change instantaneously, it follows that rapid changes in the plate potential of V_1 must be accompanied by equal changes in the grid potential of V_2.

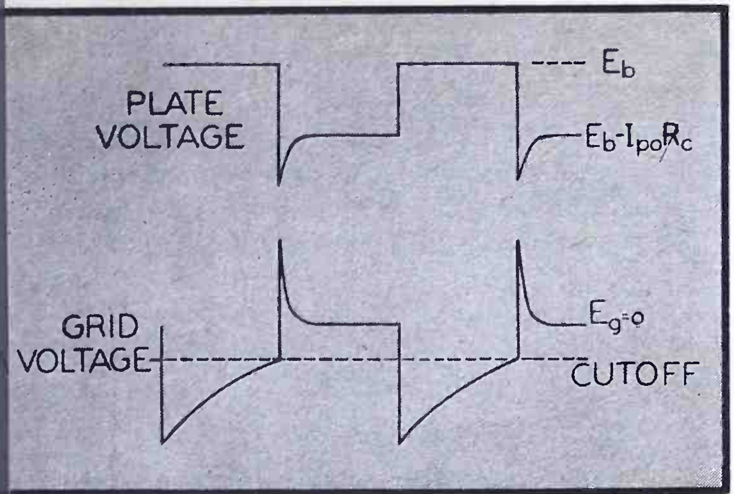
But a decrease in grid potential of V_2 will result in a decrease of its plate current. This drop in plate current results in a decrease in the voltage drop across R_{c2} and thus a rise in the plate potential of V_2. Following the preceding argument, this rise is transmitted to the grid of V_1 resulting in an increase in the plate current of V_1. Thus it has been shown that an initial increase of current in one tube results in a further increase of current in the same tube and a decrease of current in the other tube. Similar reasoning would show that an initial decrease current in one tube results in a furt decrease of current in the same t and an increase of current in the ot tube. Therefore an initial condit of equal currents in the two tube extremely unstable.

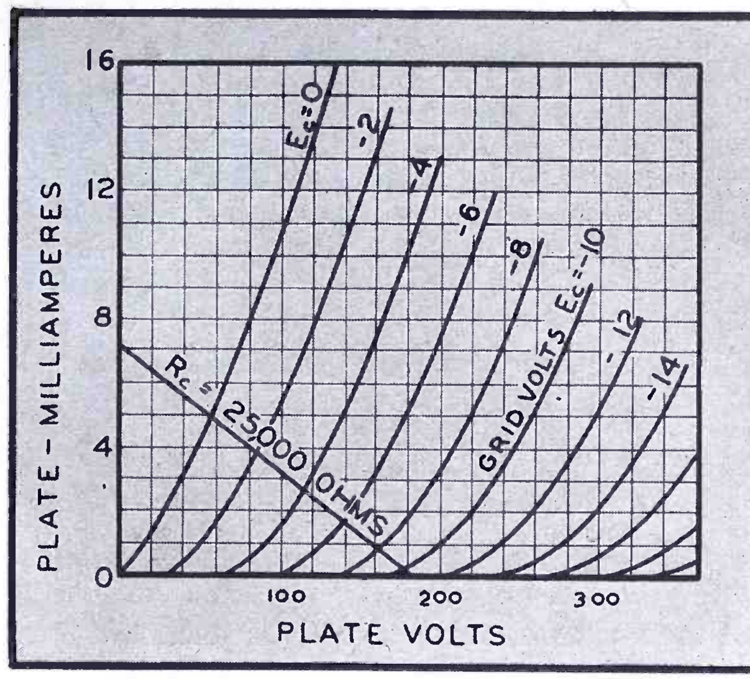
The above process will cont until one of two things happ Either the tube whose current is creasing will reach saturation or tube whose current is decreasing reach cutoff. Obviously the latte the more desirable condition, and sign efforts will be bent towards end.

Further study of Figure 1 sh that the condition in which one of tubes carries no current is also stable. In order for a potentia exist between the grid and cathod either tube a current must through the grid leak resistor. cause of the blocking condensers is possible only under transient co tions. In other words, if the gric tential is different from zero, it be changing. To be more precise cept when conduction is transfer from one tube to the other, the cu through the grid leak resistor mu decreasing.

Let us consider further the ca V_2 whose grid was carried below off potential. The grid potential mediately starts to rise. Eventua reaches cutoff and a small cu starts to flow. This current decr the plate potential of V_2. This crease is transmitted to the grid c and the now familiar process place, with the grid of V_1 being ried below cutoff. The transfe

ASA standardized symbols used in diagrams in this paper.





Figures 2 (above) and 3 (right)
Figure 2, grid and plate voltages of a multivibrator. Figure 3, average plate characteristics of each triode unit of 6SN7GT.
(Figure 3, courtesy RCA)

MULTIVIBRATORS

mploying the Abraham-Block System

As a Basis of Planning

nduction takes place very rapidly. e actual time consumed in the trans- is determined by the interelectrode wiring capacitances of the circuit. der most circumstances this time is y short compared to the rest of the le. In the present discussion it will assumed to be completely negligi-. Even if not strictly negligible, time will usually be less than un-tainties introduced by variations in circuit elements.

t remains to consider what happens V_2 during the part of the cycle in ich it conducts. As will be seen r, the charge on C_{c1} changes dur- V_2's nonconducting period, so that grid goes positive when conduction nsfers. During the nonconducting riod the condenser discharged ough R_{g2}. With the grid positive, vever, grid current flows, in effect ting a fairly low resistance in par-l with R_{g2}. Thus the condenser charge up quite rapidly. Pub-ed data are not ordinarily available the grid current characteristics of es usually used in multivibrators. ually, however, the effective grid stance is so low, that to a good ap-ximation it may be assumed that grid potential of the conducting tube drops to zero instantly. It will, of course, remain at zero until transfer of conduction again occurs. If more accurate results are needed, grid current characteristics must be obtained.

Figure 2 shows the grid and plate voltages of one of the tubes.

Multivibrator Design Procedure

In designing a multivibrator to operate at a specified natural frequency, we first defined the symbols to be used: E_b = plate supply voltage; E_{cb} = cutoff grid voltage corresponding to a plate voltage E_b; I_{po} = plate current with zero bias and plate voltage of $E_b - I_{po}R_c$.

Referring to Figure 1 let us assume that V_2 is conducting and carrying I_{po} which has been chosen well within the plate current rating of the tube. Since the grid bias and plate current are known, the plate voltage is found from the tube characteristics. Then,

$$R_{c2} \doteq (E_b - E_p)/I_{po} \qquad (1)$$

Normally R_{c1} and R_{c2} will be taken equal. If for any reason different plate currents are required for the two tubes, the above procedure can be repeated for V_1. If it is preferred to specify a value for R_{c2}, the resulting value of I_{po} may be found by cut and try, or graphical methods.

Now with V_1 cutoff and V_2 with zero bias, there is no voltage across R_{c1} or R_{g2}. Therefore, the voltage across C_{c1} is just E_b. Considering the instant at which the grid of V_1 has just risen to cutoff, the voltage across C_{c2} is $E_b - E_{cb} - I_{po}R_{c2}$.

Next, because of transfer of conduction, the plate voltage of V_2 suddenly rises to E_b. The change is equal to $I_{po}R_{c2}$. This rise is transmitted to grid of V_1 which is now at $+I_{po}R_{c2}$ volts. As we have seen, however, it drops rapidly to zero. Assuming it drops to zero instantaneously, the plate current of V_1 is then I_{po} immediately after transfer of conduction. Therefore the plate voltage of V_1 is $E_b - I_{po}R_{c1}$. The voltage has dropped an amount $I_{po}R_{c1}$. Therefore the grid voltage of V_2 is $-I_{po}R_{c1}$. It is well known that the current in a resistor in a series *RC* circuit is given by the equation

$$i = I_o \exp(-t/RC) \qquad (2)$$

where I_o is the current, when $t = 0$; $exp(x)$ means the base of natural logarithms raised to the power x, R is

(*Continued on page* 40)

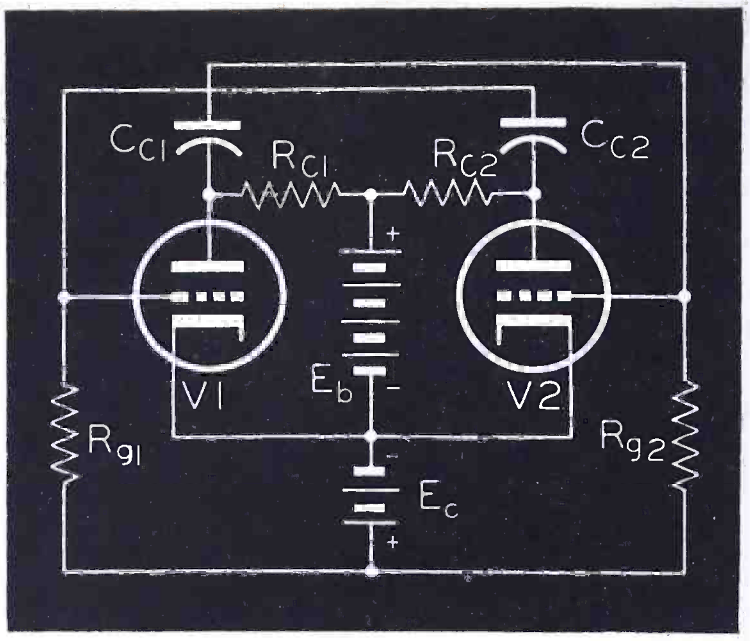


Figure 4
A multivibrator with a positive bias. This system affords greater stability.

the total series resistance, and *C* the total series capacitance. In this case *R* is $R_{c1} + R_{g2}$, *C* is C_{c1}, and I_o is $(I_{po}R_{c1})/R_{g2}$. The grid voltage is $-iR_{g2}$. Therefore

$$e_{g2} = -I_{po}R_{c1} \exp[-t/(R_{c1}+R_{g2})C_{c1}] \quad (3)$$

If T_2 is the time from the start to the end of the nonconducting period of V_2,

$$E_{cb} = -I_{po}R_{c1} \exp[-T_2/(R_{c1}+R_{g2})C_{c1}] \quad (4)$$

Taking the natural logarithm of both sides of the equation and solving for $(R_{c1} + R_{g2})C_{c1}$,

$$(R_{c1}+R_{g2})C_{c1} = T_2/[\ln(I_{po}R_{c1})/(-E_{cb})] \quad (5)$$

If T_1 is the time from the start to the end of the nonconducting period of V_1,

$$(R_{c2}+R_{g1})C_{c2} = T_1/[\ln(I_{po}R_{c2})/(-E_{cb})] \quad (6)$$

$$T_1 + T_2 = 1/f \quad (7)$$

If $I_{po}R_{cb} < -E_{cb}$, transfer takes place before the grid of the conducting tube drops to zero and this analysis breaks down.

If the frequency and the relative values of T_1 and T_2 are specified, everything in equations *5* and *6* is known but the capacitances and the grid leak resistances. Reasonable values for these which satisfy the equations can now be chosen and the design is complete.

The analysis of a multivibrator is very similar to the design. We determine I_{po} and E_{cb} from the tube characteristics. T_2 and T_1 can then be found from equations *5* and *6* and the frequency from equation *7*.

Example and Solution

Example: A multivibrator, with a natural frequency of 3,333 cycles per second, using a 6SN7GT double triode and a plate supply of 180 volts is to be designed. One of the triodes is to conduct during 2/3 of the cycle. Then $T_1 + T_2 = 0.0003$, $T_1 = 0.0002$, $T_2 = 0.0001$ second. Plate characteristics of the tube are given on Figure 3.

Solution: We choose $R_{c1} = R_{c2} =$ 25,000 ohms. The load line for this resistance is drawn on the characteristics and is seen to intersect the zero bias curve at 5.0 milliamperes. This is I_{po}. Cutoff at 180 volts plate potential is —11 volts. This is E_{cb}.

Substituting in equations *5* and *6*

$$(R_{g2}+25000)C_{c1} = .0001/[\ln .005 \times 25000/11.0] = .0001/[2.30 \log_{10} 11.36] = .0000412$$

$$(R_{g1}+25000)C_{c2} = .0002/[\ln .005 \times 25000/11.0] = .0000824$$

We then choose $R_{g1} = R_{g2} =$ 100,000 ohms. Then $C_{c1} =$ 330 mmfd and $C_{c2} =$ 660 mmfd. This completes the design.

Greater stability is obtained if a positive bias is used as shown in Figure 4. The previous analysis can be adapted to this case very easily it is assumed that the grid leak sistors are so much larger than d-c resistance from grid to catho that the grid can go positive only small amount. Assuming this to be I_{po} will be almost exactly the curr defined previously. Again, the g voltage of V_2, when it becomes no conducting, is $-I_{po}R_{c1}$. From Ohr law

$$E_c - iR_{g2} = -I_{po}R_{c1} \quad ($$

So

$$i = (E_c + I_{po}R_{c1})/R_{g2} \quad ($$

From this it follows that during t nonconducting period

$$e_{g2} = E_c - (E_c+I_{po}R_{c1}) \exp[-t/(R_{c1}+R_{g2})C_{c1}] \quad (1$$

At the end of the period

$$E_{cb} = E_c - (E_c+I_{po}R_{c1}) \exp[-T_2/(R_{c1}+R_{g2})C_1] \quad (1$$

Solving

$$(R_{c1} + R_{g2})C_{c1} = T_2/\ln[(E_c+I_{po}R_{c1})/(E_c - E_{cb})] \quad (1$$

Similarly

$$(R_{c2}+R_{g1})C_{c2} = T_1/\ln[(E_c+I_{po}R_{c2})/E_c - E_{cb})] \quad (1$$

Now suppose the conditions of t example are unchanged, except that bias voltage of $+22\frac{1}{2}$ volts is intr duced. Then,

$$(R_{g2}+25000)C_{c1} = .0001/\ln(22.5+125)/(22.5+1 = .0001/\ln 4.4 = .000067$$

$$(R_1+25000)C_{c2} = .0002/\ln 4.4 = .000135$$

If again $R_{g1} = R_{g2} =$ 100,000 ohr then $C_{c1} =$ 540 mmfd, and $C_{c2} =$ 10 mmfd. Varying the bias voltage giv a very convenient method of adjusti the frequency.

Because of the approximations ma the above analysis is not accurate f high frequency operation of multi brators. The analysis of this case beyond the scope of this paper. It possible however to get a qualitat idea of the upper frequency limit fr the amplifier concept. Oscillations w be impossible at frequencies so hi the circuit ceases functioning as amplifier. It should be possible to e tend the upper frequency limit app ciably by designing each stage as video amplifier.

Synchronization

It is not the purpose of this paper discuss in any great detail the sy chronization of multivibrators. Ho ever, a brief discussion is desiral Under proper conditions it is possi to synchronize a multivibrator at so submultiple of the frequency of anot oscillator. In general terms the ra of the multivibrator frequency, f_m, the controlling frequency, f_c, may reduced to a fraction *m/n*, where

(*Continued on page* 84)

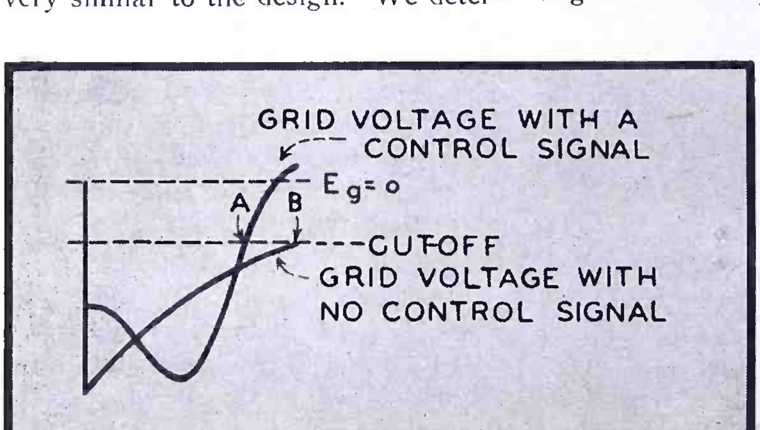


Figure 5
The effect of control signal on the grid voltage. This effect is achieved when the synchronizing voltage is introduced in series with the grid of V_1.

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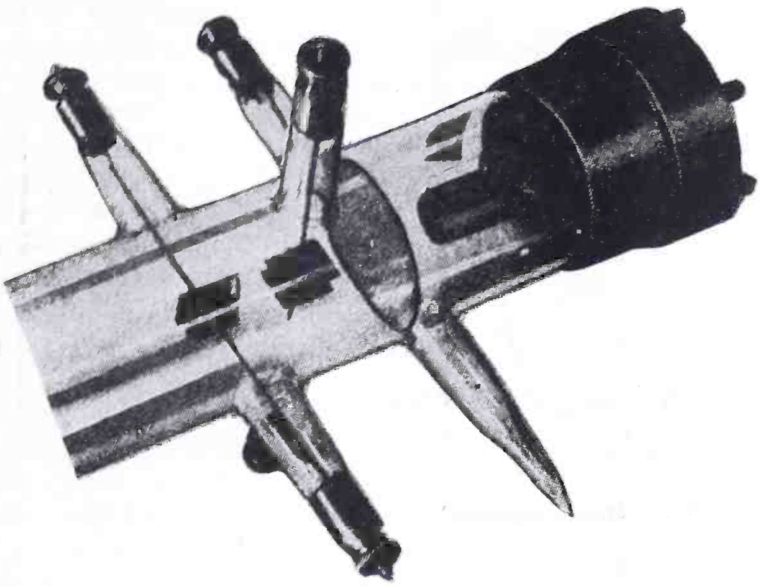
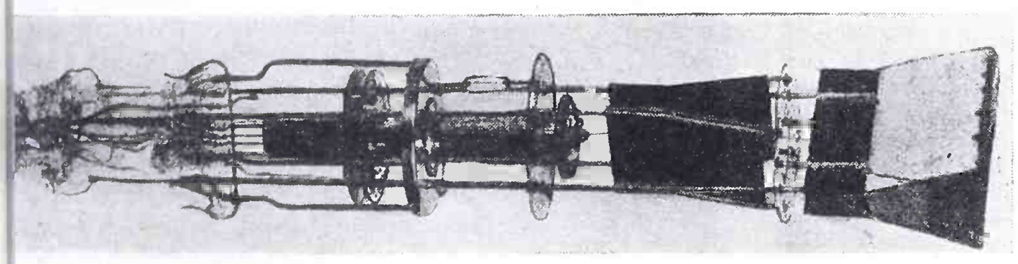
CATHODE-RAY TUBE DEVELOPMENT

Early History . . . Mathematical Concepts . . . Present Day Problems



Above, Von Ardenne tube of 1932. Below, electron gun of the Ediswan tube.



by J. R. BEERS

Development Engineer
North American Philips Co., Inc.

PROBABLY the first tube that afforded a physical demonstration of cathode-ray characteristics as Crookes' tube. In this tube, hich was gas-filled and of the cold-thode type, various shaped anodes ere used to study electron behavior. One such tube used an anode in e shape of a maltese cross. In this be, electrons leaving the cathode used the anode-end of the glass en-lope to fluoresce, except for an ea directly shaded by the anode. he shadow thus projected deter-ined the path of the electron beam.

In 1906, Braun devised a tube that corporated electrodes for the gen-ation and deflection of a single beam electrons. This was probably the st design suitable for oscillographic pplications. This tube still used a ld cathode and was gas-filled for cusing purposes.

Early designs were soon followed tubes having hot cathodes and ehnelt cylinders wherein a combina-on of gas focusing and electron tical focusing were employed. The rliest tubes of this type were the Western Electric's 224 and the Von Ardenne tube of 1932. These tubes had certain failings such as short life, instability, limitation of spot size and modulation difficulties. As a result, much experimental work followed in high vacuum and electron lens fields.

Investigations carried on by Zworykin, Farnsworth, Van Ardenne and others prompted rapid progress, and gave us the basis for all of our present cathode-ray tube designs. Figure 2 illustrates a design for electrostatic control in high vacua tubes.

Original Mathematical Concepts

In discussions of electron optics it is convenient to make comparisons to the more commonly known geometrical optics of light-rays through refractive media. In each case the minimum time of travel between two given points becomes the desired goal.

As shown by Fermat's principle and mathematically expressed for geometrical optics by the equation

$$\int dt = \int n/c \, ds = 1/c \int n ds = \text{minimum} \qquad (1)$$

where n = refractive index of medium
c = speed of light in vacua

In the case of a beam of electrons, the condition for minimum is given by

$$\int p ds = m \int v ds = \text{minimum} \qquad (2)$$

where m = mass
v = velocity
p = mv (impulse)

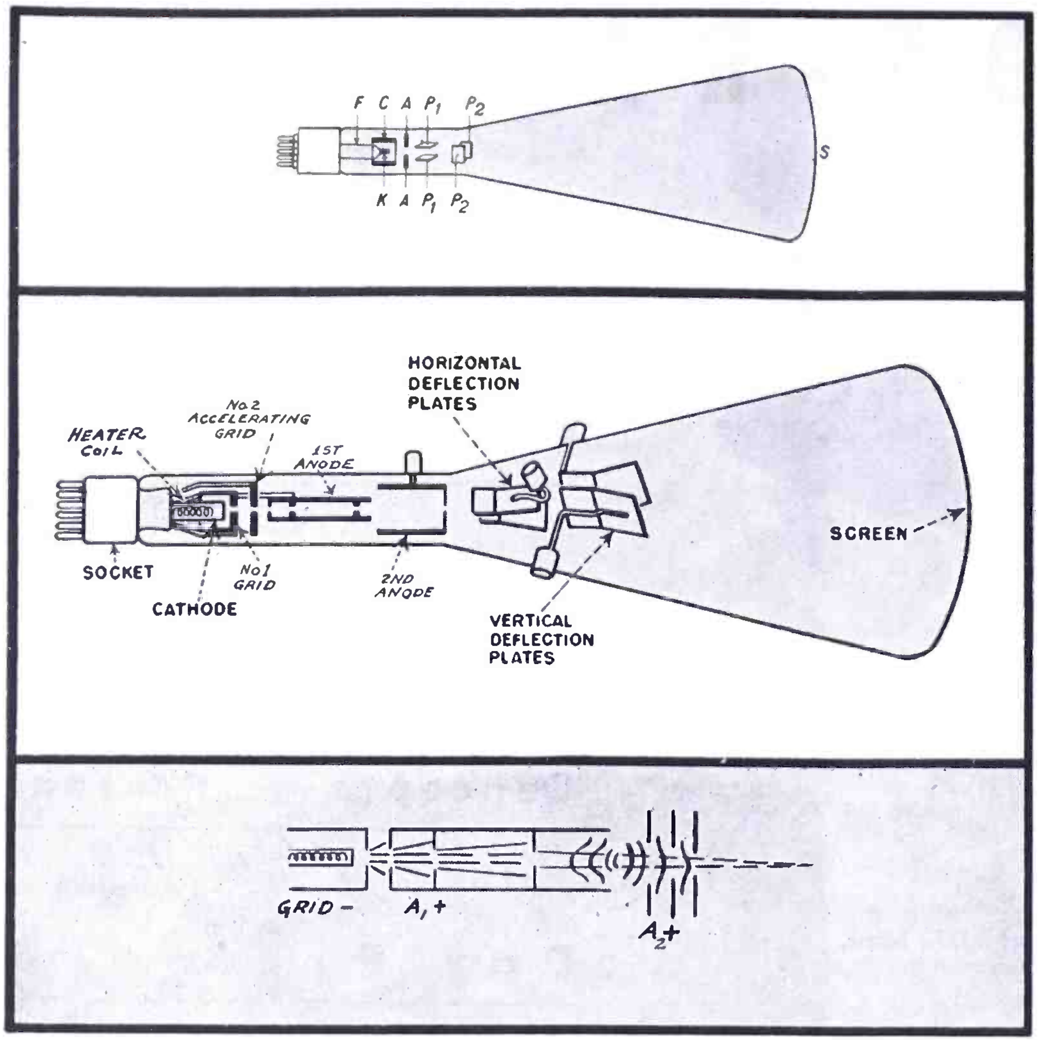
From comparison of equations *1* and *2*, it becomes apparent that velocity of electrons in electron optics corresponds to refractive index in geometric optics. It is to be noted, however, that while the refractive indices for light-rays have a range of from *1* to *2*, the ratio of velocities of electrons at their source and at their destination (which corresponds to optical refractive index) may be varied at will.

Speed of electrons, up to 4500 volts applied to final anode, is computed by the equation

$$v = 5.95 \times 10^7 \sqrt{V}$$

where v = velocity in cm/sec
V = final anode voltage

ASA standardized symbols used in this paper.



Figures 1 (above, top), 2 (above, center), 3 (above, bottom)
Figure 1, sketch of a gas-filled cathode-ray tube. *K* is cathode, *F* are lead-in wires, *C* is Wehnelt cylinder, *A* is anode, P_1 and P_2 are deflecting plates, *S* is screen. Figure 2, a typical high vacuum cathode-ray tube with electrostatic deflection plates. Figure 3, diagram showing how focusing action occurs in cathode-ray tube. Note how lines of force are set up between first and second anode.

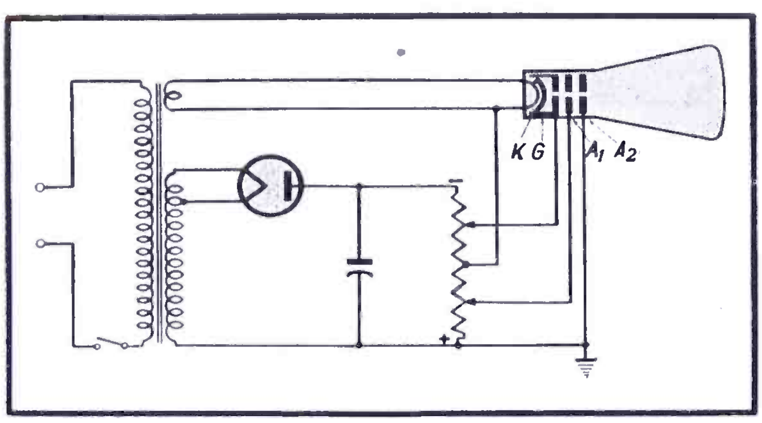


Figure 4

Simplified feed circuit of cathode-ray tube. By means of a control, the brightness and sharpness, respectively, of the fluorescent spot can be varied.

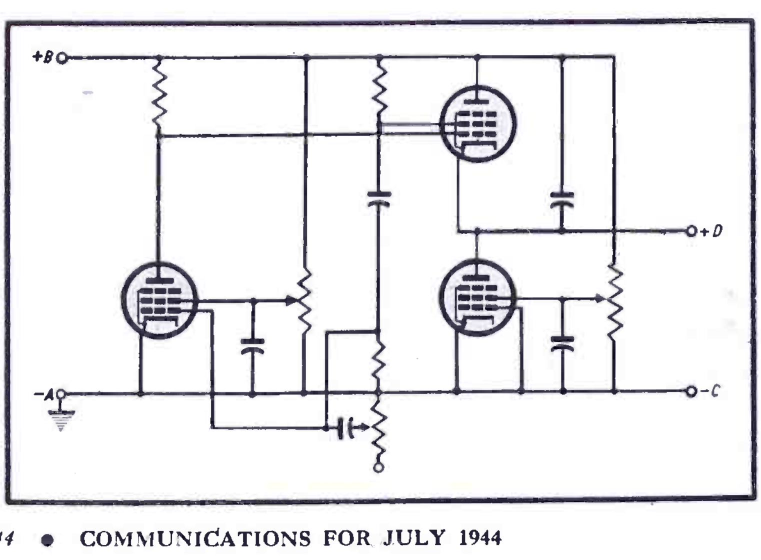


Figure 5

Circuit details of the time-base unit. A constant direct potential of about 400 volts is applied across terminals *AB*. The saw-tooth voltage for the deflector plates is taken from terminals *CD*.

Again in geometric optics, the rela tion of image and object may b shown by the equation

$$A_1\Omega_1 n_1^2 = A\Omega n^2$$

where *A* represents image area
Ω represents angle of beam
n represents refractive index

In electron optics, the velocity, *V*, substituted for the refractive inde *n*. Since the object in the cathod ray tube is necessarily a very sma spot, it is evident that to meet the co ditions of the above equation, th velocity of the electrons in the obje area must be several hundred time that of the electrons in the image are

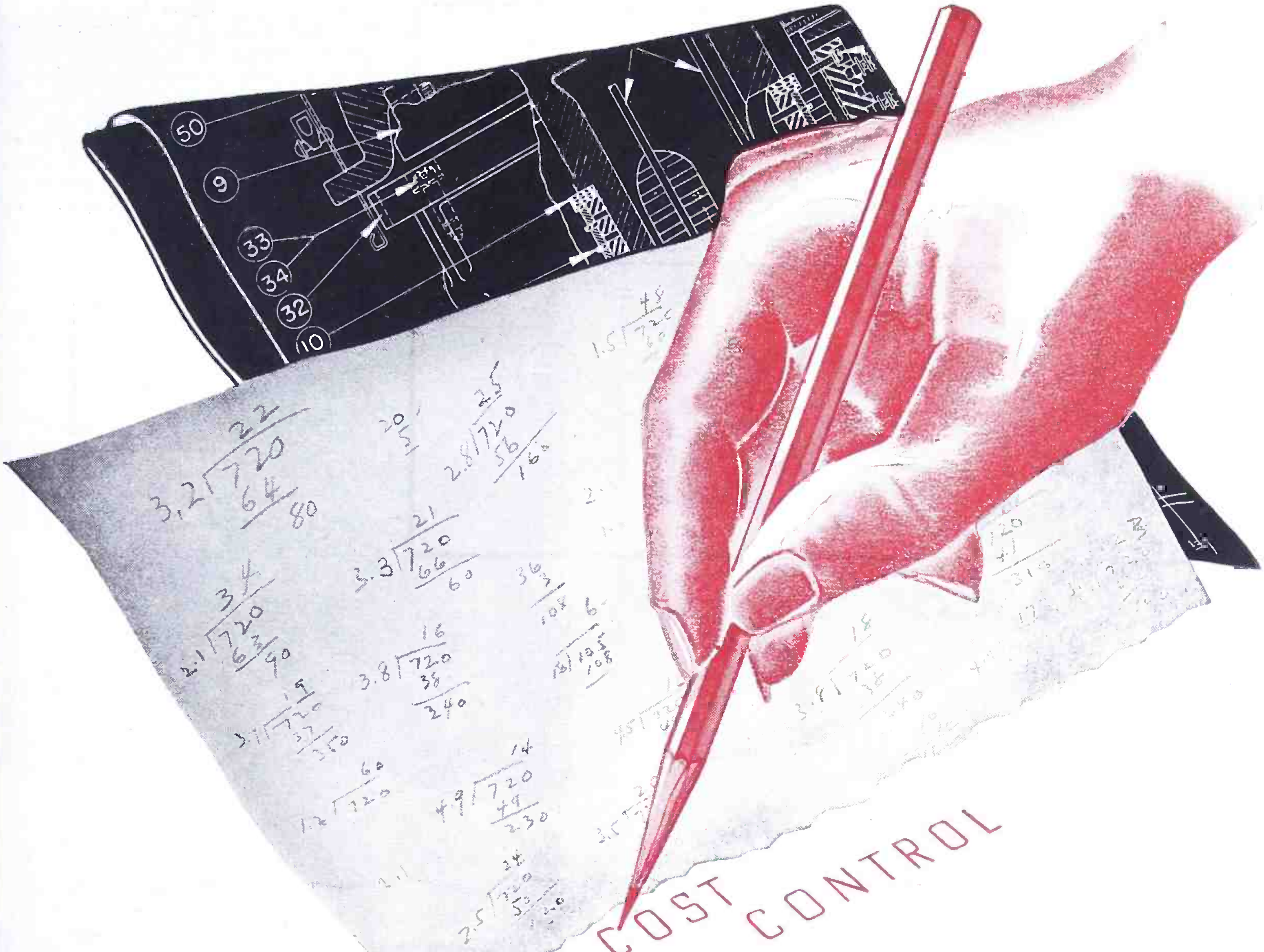
Brilliancy of the fluorescent spot dependent upon the wattage delivere to the screen. This wattage is dete mined by the beam current and spee of the electrons as controlled by th applied voltage. As shown previousl the velocity is a function of the ap plied final voltage; spot size is als a function of this voltage which be comes evident when the mutual re pulsion of electrons forming the bea is considered. Since the divergenc of electrons in the beam is a functio of the time of travel from gun t screen, it will be a decreasing functio as the speed of the electrons increase or as the final voltage is increased.

As the focusing of light-rays geometric optics results from the travel through refracting media, the focusing of electrons is accom plished in passing through rotation symmetric electric fields of varyin strength. This focusing action occu as shown in Figure 3, which indicat the lines of force as set up betwee first and second anode of an electr gun.

The number of electrons admitt to the system is controlled by the d gree of negative potential applied the grid. By means of stopping a limiting apertures mounted within th first anode, the electrons which trav parallel to the axis of the system a selected as the most satisfactory f assembling into a fixed beam.

How Tube Functions in System

In application of cathode-ray tub there are two distinct methods of us In one, a beam of fixed intensity wattage input to the screen is caus to trace varied patterns upon t screen by simultaneously applyi pulsating direct-current voltages alternating-current voltages to bo sets of deflection plates, the patter formed being a picture of the appli voltages. In such applications a vo age of known amplitude and frequen is usually applied to the plates whi



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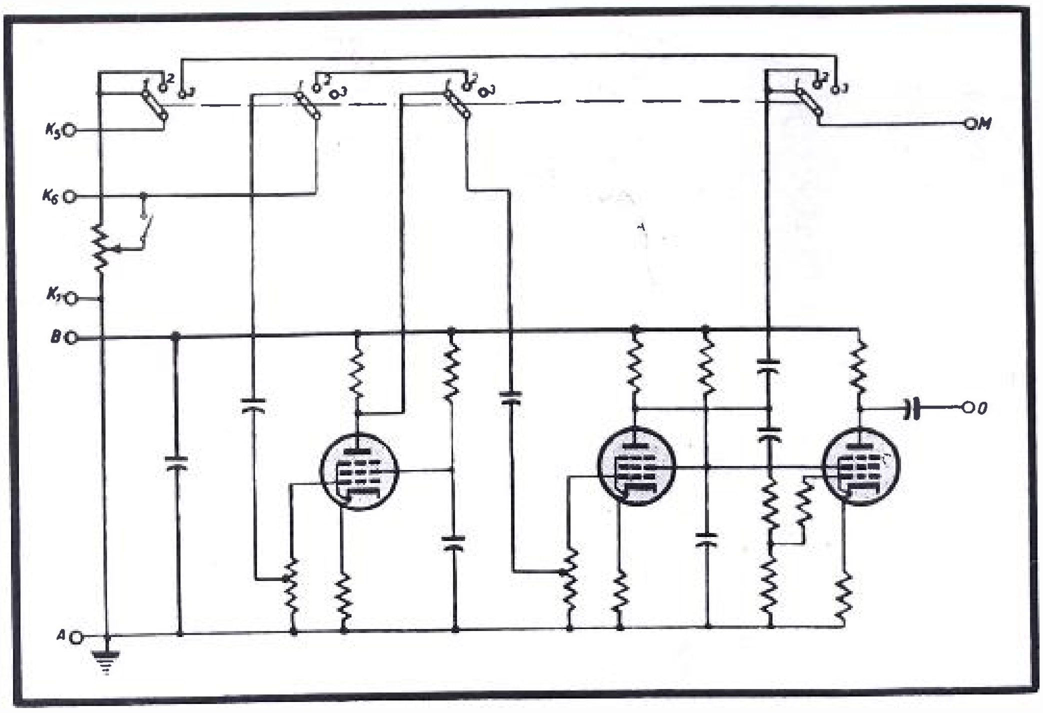

Figure 6

Simplified circuit of the amplifier for signal under investigation. A direct potential of about 400 volts is applied across terminals *A* and *B*. The incoming signal is applied across K_5 and K_7 (or K_6 and K_7). By means of switch S_3 different types of amplification can be selected. The amplified or unamplified signal is applied through terminals *M* and *O* to the plates, which impart a vertical deflection to the cathode-ray tube.

form the horizontal trace. This serves as a time base and permits study of the waveform of impulses under investigation which are applied to the vertical deflection plates. Circuit for such a time base is shown in Figure 5. The circuit for amplification of signals applied to horizontal plates is shown in Figure 6.

In the second case, pulsating voltages of known frequency and amplitude are applied to each set of plates so as to form a predetermined pattern. And the cathode-ray beam is modulated by applying a varying signal voltage to the grid of the tube, thereby forming a picture by contrast of light and darkness on the tube screen. Figure 4 shows one means of grid control.

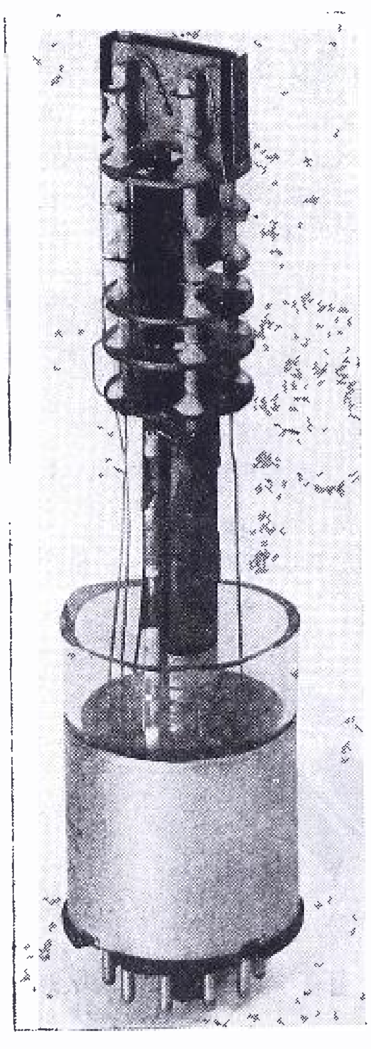

Figure 7

Cathode-ray tube mount manufactured by RCA.

This description, of course, refers to tubes having electrostatic deflection construction, although it is to be noted that similar patterns may be obtained from magnetic deflection type tubes in which deflection is produced by applying similar impulses to fixed magnet coils externally located around the tube neck.

In the design of electrostatic tubes there are quite a few factors to be taken into consideration. In the gun alone there are many independent variables upon which the characteristics of the tube depend. Some of the more important of these properties include:

(*1*)—Cathode emitter coating
(*2*)—Cathode to grid spacing
(*3*)—Grid aperture
(*4*)—Grid to first anode spacing
(*5*)—Diameter and length of first anode
(*6*)—Diameter and spacing of apertures within first anode
(*7*)—Spacing between first and second anodes
(*8*)—Voltage applied to grid
(*9*)—Voltage applied to first anode
(*10*)—Voltage applied to second anode
(*11*)—Distance from first anode to screen

Characteristics of the tube determined by variations in the above include:

(*1*)—Spot size
(*2*)—Modulation voltage
(*3*)—First anode current
(*4*)—Second anode current
(*5*)—Beam current

In addition to the above it is necessary to determine the characteristics of the deflection system to give required sensitivity. This may be computed from the formula

$$D = \frac{V_d \times L_p \times d_s}{2 \times S_p \times V_2}$$

where V_d = deflection voltage, L_p = length of plates, d_s = distance to screen, S_p = spacing between plates, V_2 = final anode voltage.

From an inspection of the above variables and dependent variables in cathode-ray tube design it is readily seen that there can be considerable flexibility in design. Evidence of this flexibility is demonstrated by an inspection of the gun and deflection plate systems as used by various manufacturers. Regardless of design variation, there are certain basic requirements which cannot be ignored. Some of these requirements are:

(*1*)—Sound mechanical design
(*2*)—Accurate alignment of parts
(*3*)—Flawless and efficient screens
(*4*)—Proper application of conductiv coatings

These characteristics will be dis cussed in another section of this serie of papers.

The Present-Day Tube—Its Problems

The cathode-ray tube used in thi country today has a relatively hig vacuum compared to earlier practic Both here and in Europe, the fir models were so-called gas-focusse tubes. These have been replaced wit high vacuum types because the late design provides much more reliab characteristics and a much more stab beam.

Gas-focussed tubes were satisfa tory for oscillographic uses but are n satisfactory for more refined circui nor for television. Naturally, the ne high-vacuum cathode-ray tube osc loscope displaced the old instrume The older recording device with i moving coil, drum and mirror had objectionable mechanical time-lag. T cathode-ray beam has no inertia a makes possible the study of seve different waves at one time. Not o that, the patterns on the tube scre can be photographed for referen purposes.

By using different phosphors on t screen, it is possible to vary the ca ode-ray tube characteristics over qu

(*Continued on page* 89)

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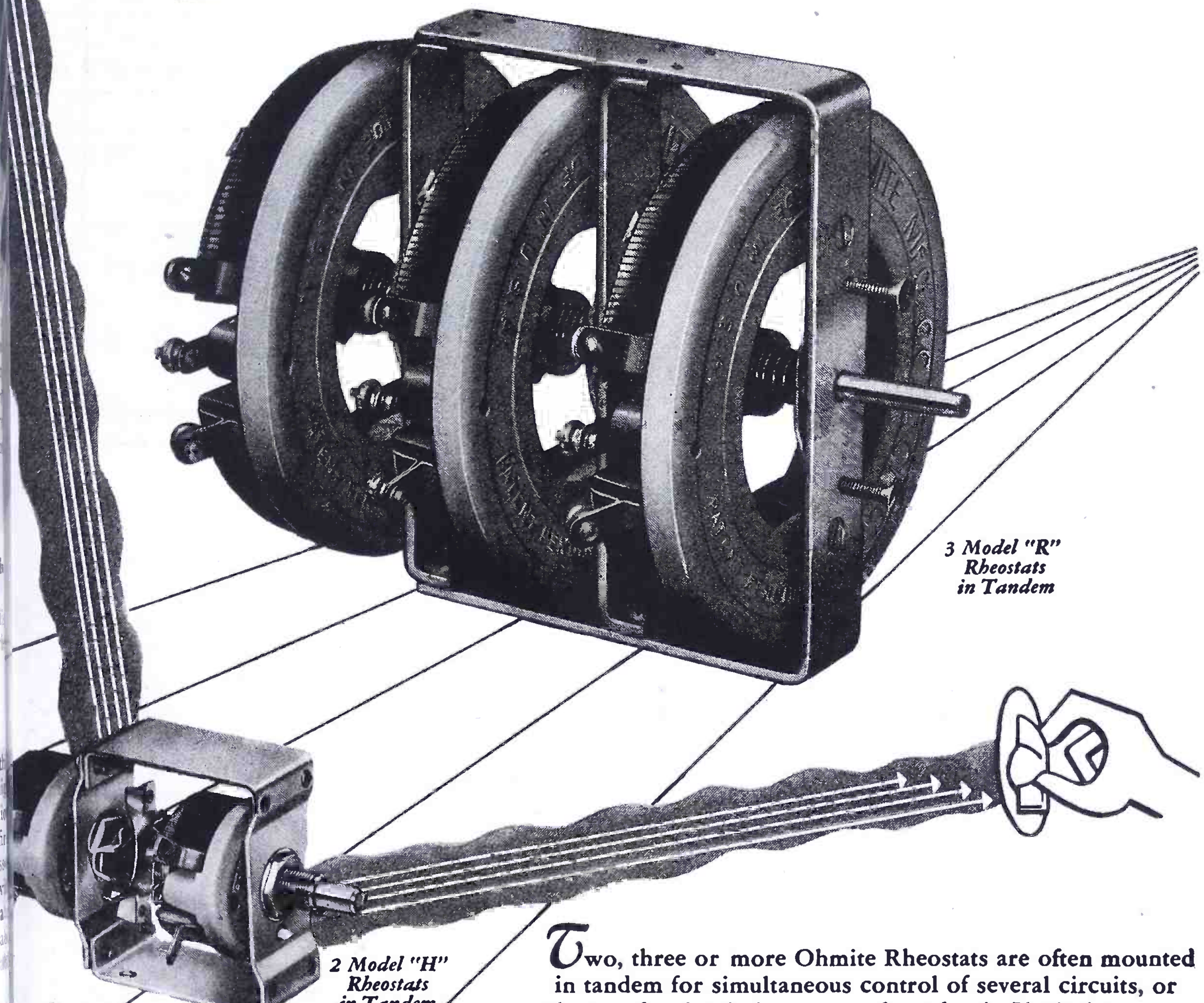

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ELECTRICAL DIFFERENTIATIO

AND INTEGRATIO

Of Current O

Voltage Wavefor

by GEORGE B. HOADLEY

Assistant Professor

Graduate Electrical Engineering Dep't

AND

WILLIAM A. LYNCH

Instructor

Graduate Electrical Engineering Dep't

Polytechnic Institute of Brooklyn

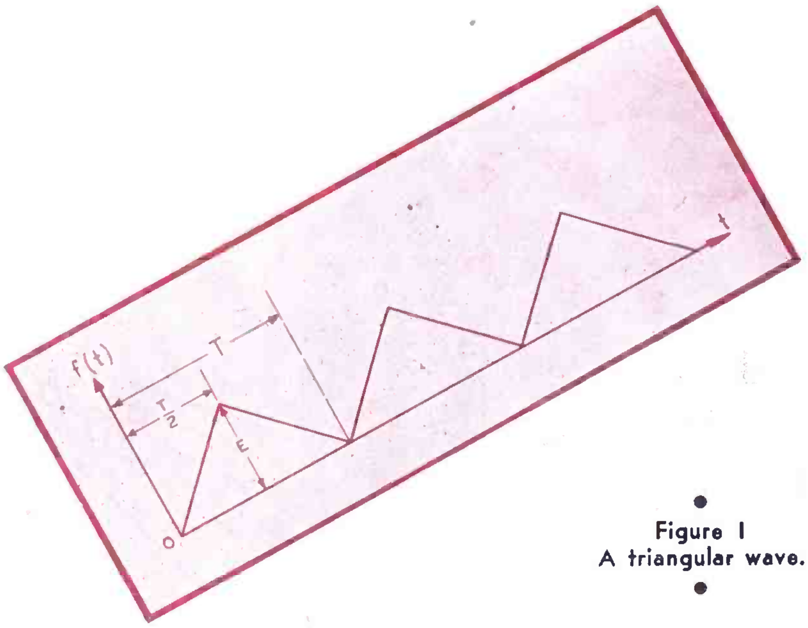


Figure 1
A triangular wave.

THERE are numerous applications for electrical differentiation and integration in modern electrical engineering practice, particularly in the field of vacuum-tube circuits. Circuits for this purpose are well known and widely used, but some of the fundamental aspects of the problem are not always fully appreciated. It is the purpose of this paper to trace the development of these circuits from the fundamental laws involved, and to discuss some of the departures in mathematical rigor which result in practical applications. The departures of the practical circuit from the ideal come about mainly because of, (*1*) particular requirements of the current or voltage source; (*2*) the difficulty of realizing *pure* reactive components; and (*3*) other requirements in connection with utilizing or transmitting the derived and integrated waveforms. Certain problems arise in adapting circuits to these practical considerations so that the mathematical operations are approximated electrically. Fortunate it is that many vacuum-tube applications require only a fair approximation to the mathematical process.

Electrical differentiation is based upon the following well-known fundamental laws:

(*1*)—The current in a condenser is the product of its capacitance and the time derivative of the voltage across it.

(*2*)—The voltage drop across a pure inductance is the product of its inductance and the time derivative of the current through it.

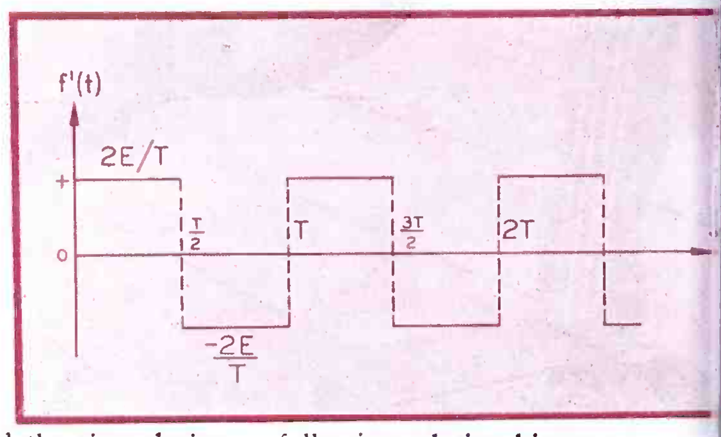


Figure 2
The derivative of the wave in Figure 1.

Expressed mathematically, these laws are . . .

I $$i = C\frac{de}{dt}$$

II $$e = L\frac{di}{dt}$$

When integrated *I* and *II* yield the following relationships:

III $$e = \frac{1}{C}\int i\,dt + E_o$$

IV $$i = \frac{1}{L}\int e\,dt + I_o$$

in which E_o and I_o are constar integration. *C* is of course ca

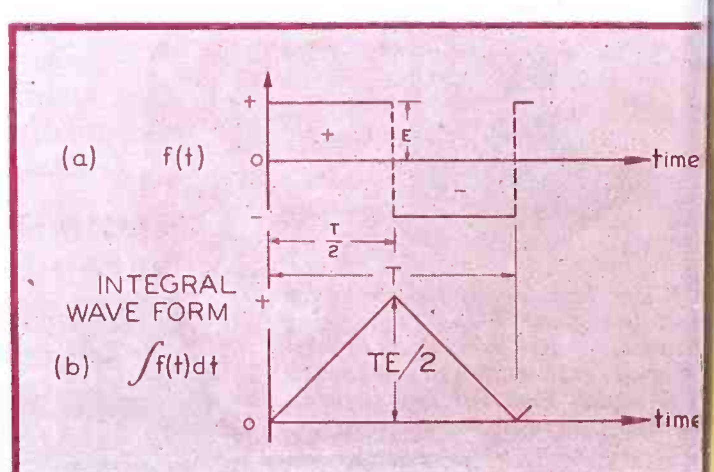
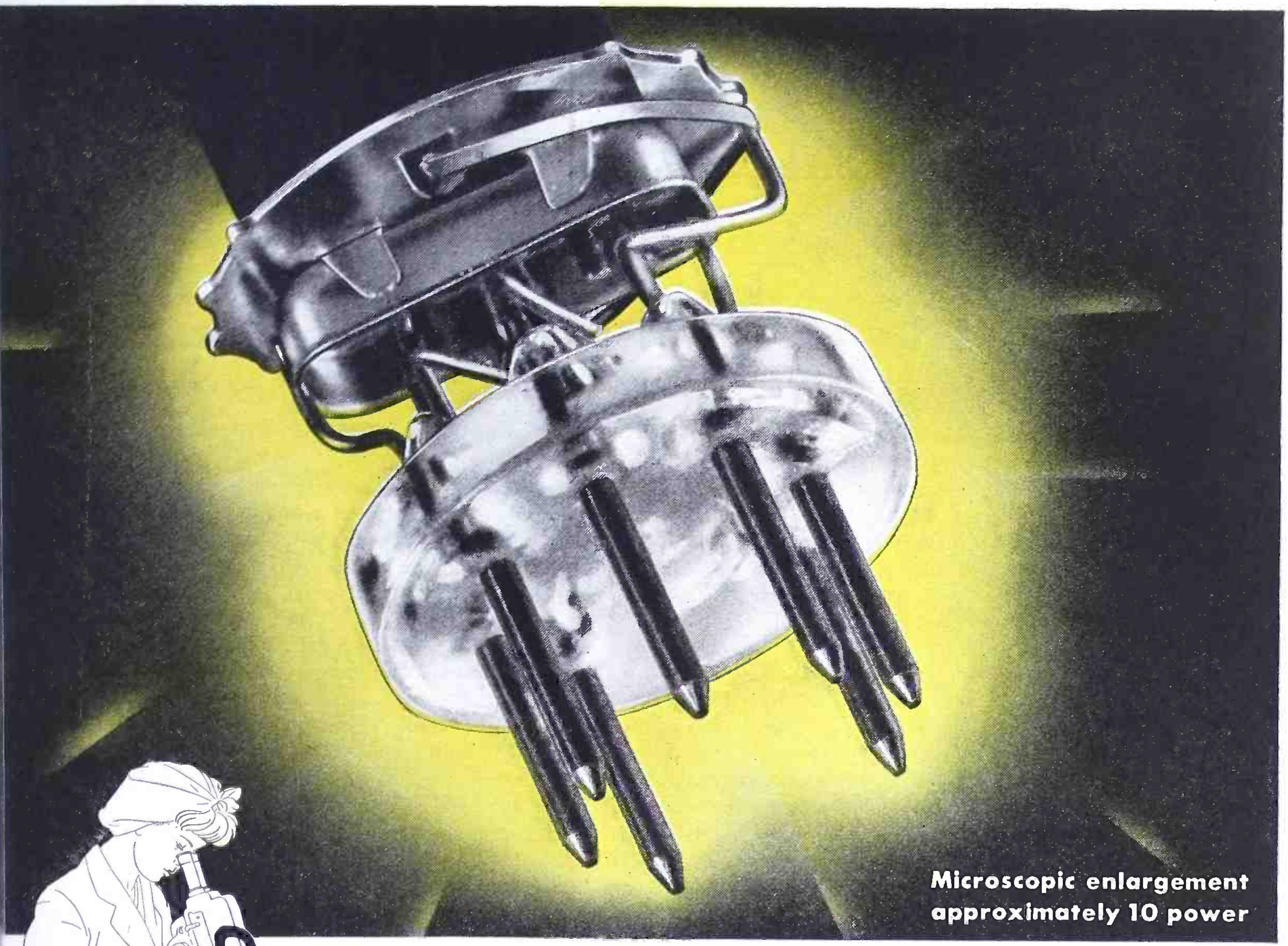


Figure 3
The integration of a wave.



Science on the Production Line

Commonly you think of the microscope as a scientific laboratory instrument. But at National Union, these days, you will find it even more extensively used, as a *production* machine, insuring microscopic precision step by step through many processes of manufacture.

With the aid of microscopes, National Union workers accurately check almost invisibly small parts. They *see* to it that welds are sound, clearances are exact and the structure is mechanically perfect. In the photograph above for example, a N. U. 6AG5 miniature tube mount, no higher than your thumb nail is enlarged approximately 10 times, to permit minute examination of important structural factors. Enlargements up to 500 times—making a hair on your head look as tall as a tree—are just as readily obtained, when needed. Moreover, this tube, assembled from 31 individual parts, must pass 40 individual inspections, in addition to thorough examination under the microscope.

Here, again, is one of those unusual techniques developed by National Union engineers to make tube manufacture a more exact science. Such infinite care makes certain that every electronic tube which carries the National Union name will deliver a uniformly high level of performance with long service life. *Count on* National Union.

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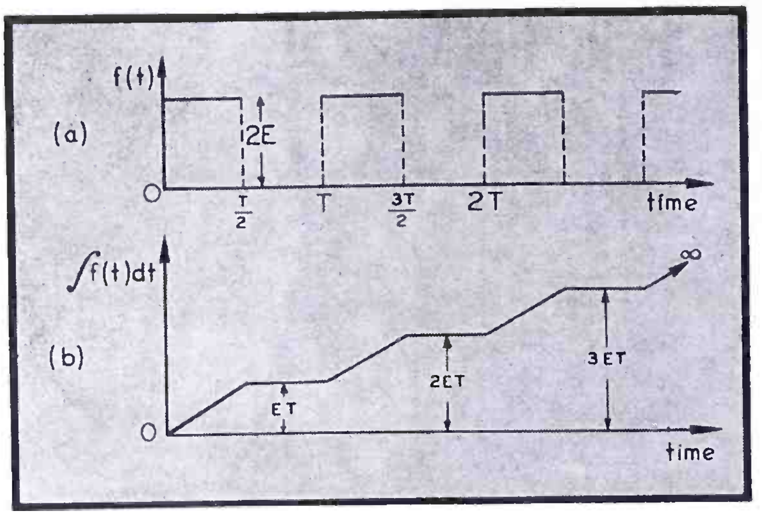

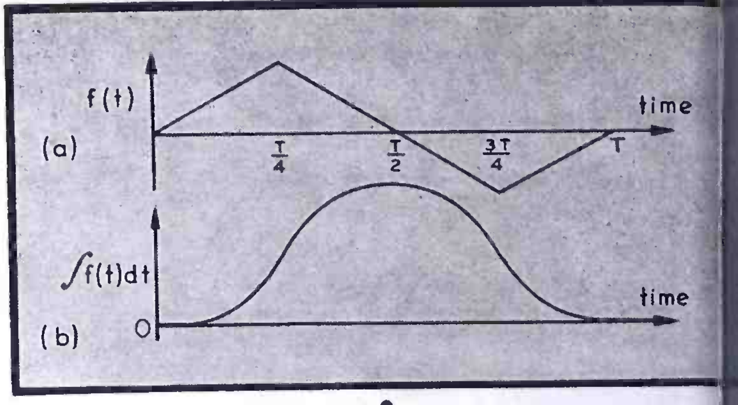

Figure 4 (left) and 5 (above)
Figure 4, the integration of a wave containing a d-c com ponent. Figure 5, the integration of a triangular wave

tance, but L may be interpreted to mean either self or mutual inductance. These integral equations may be interpreted to formulate two reciprocal laws:

(*3*)—The voltage drop across a condenser is the product of its reciprocal capacitance and the time integral of the current through it.

(*4*)—The current in a pure inductance is the product of its reciprocal inductance and the time integral of the voltage across it.

Before considering the electrical processes, it might be well first to observe the result of performing the mathematical operations on certain of the familiar recurrent time functions. Given a time function which is a simple function of time, it is usually possible to draw by inspection, the derived waveform. Take for example, a function $f(t)$, consisting of a recurrent series of isosceles triangles, as shown in Figure 1. The time rate-of-change of the function $f(t)$, which is often designated by $f'(t)$, is a positive constant whose magnitude is $2E/T$, when t is between 0 and $T/2$. From $T/2$ to T, $f'(t)$ is $-2E/T$, after which the cycle repeats. The derived waveform consists, therefore, of constant values of $2E/T$ whose durations are $T/2$ units in time and whose polarities alternate. This is then a rectangular waveform, symmetrically disposed about the time axis, as shown in Figure 2.

The process may be continued and the rectangular waveform differentiated. The time rate-of-change now has three values: zero, $+\infty$ and $-\infty$. The derived function is seen to consist of an alternating series of infinite points spaced $T/2$ units apart in time. Perfect geometry is never achieved in practical waveforms of current and voltage, so that an actual rectangular wave would have a finite slope where the polarity changes over. Moreover, actual circuits are not perfect differentiators, so the derived wave would appear as an alternating series of pulses having finite amplitudes and durations that are not zero.

Integration of a time function may be thought of as the summation over a time interval of the area enclosed between the function and the time axis. The integral of a time function is then a plot of the area as a function of time. Again consider the rectangular wave, as shown in Figure 3a. For each increment of time, dt, an increment of area dA is summed and since the area increments are identically equal in the interval from 0 to $T/2$, the area grows linearly with time. The area fu tion reaches a maximum at $T/2$ si this value represents the total posit area of one period of the rectangu function. In the time interval fr $T/2$ to T, area increments are s tracted and the net area shri linearly, reaching zero value at ti T. The integrated function, shown Figure 3b, is the isosceles triangu wave of Figure 1.

It is important to note that the tegral waveform must return to z in one cycle to satisfy the condit that it be recurrent. This requires t the waveform to be integrated m be symmetrically disposed about time axis. The integrated wave may may not be symmetrical about time axis, depending upon where integration is begun.

In practice, a rectangular wave o is biased so that it is zero every al nate half cycle. To investigate further, let us begin with a rectang wave which varies only positi above a zero value, as shown in Fig 4a. Upon integrating this wave, result is similar to that of Figure in the interval from 0 to $T/2$, cept that the slope is twice steep. From $T/2$ to T, however, area is zero and the integral wave mains horizontal. As the next cycle is traversed, the integral v continues to slope upward. Thu slope is either a positive constan zero, and it is evident that a recur waveform cannot be obtained. fact has rather important implicat in the electrical circuits to be cussed, since no physical circuit support a continually rising voltag current without failing.

Let us consider next, the inte tion of the triangular wave, an meet the requirement for a recu integral wave, consider the trian wave to be symmetrical about the axis, as shown in Figure 5a. 0 to $T/4$, the growth of area is portional to the square of the hence the area function is para and has a constantly increasing

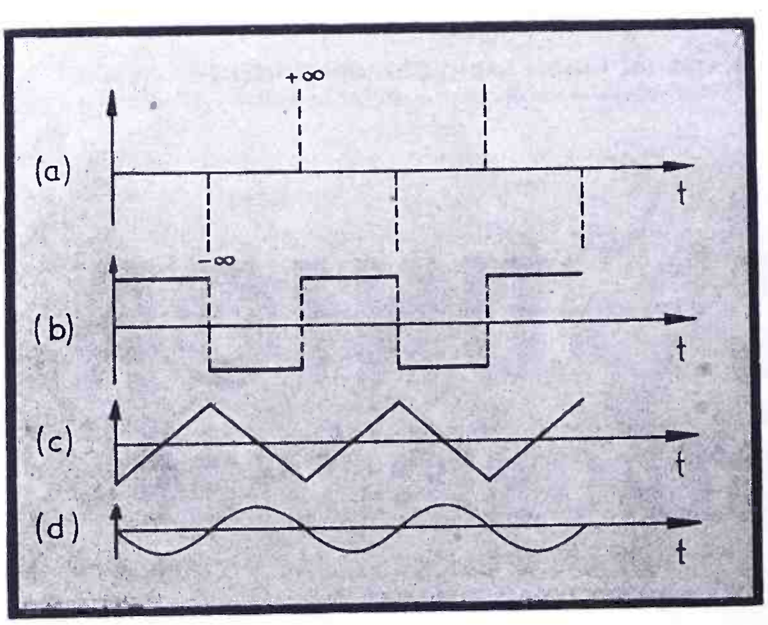

Figure 6
The series of waves derived from a triangular wave.

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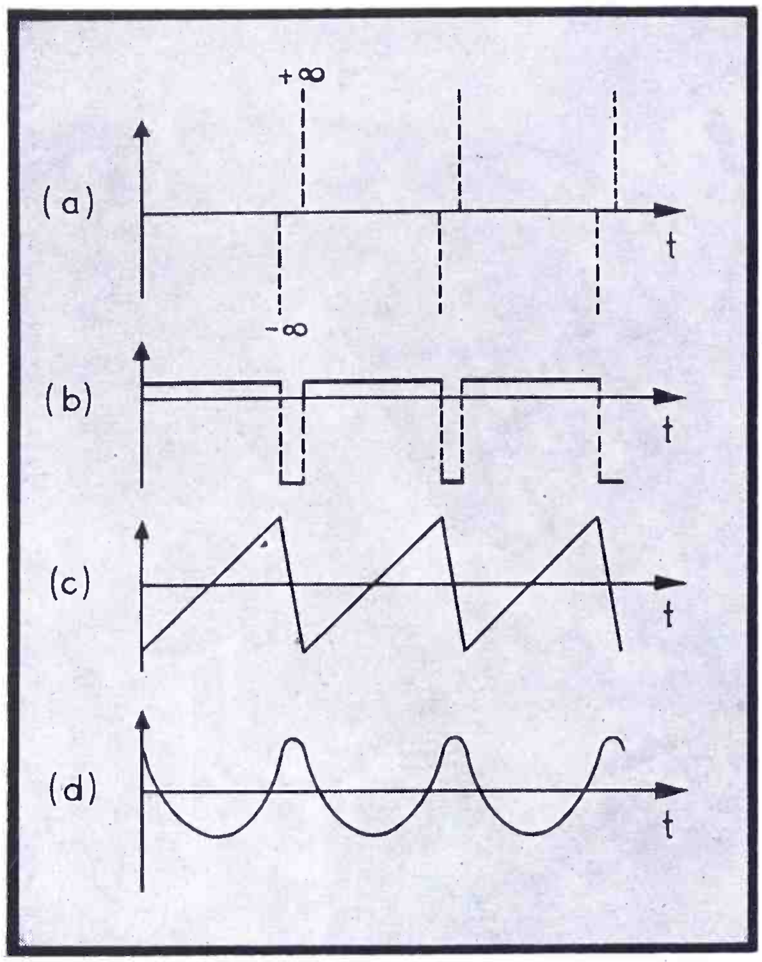
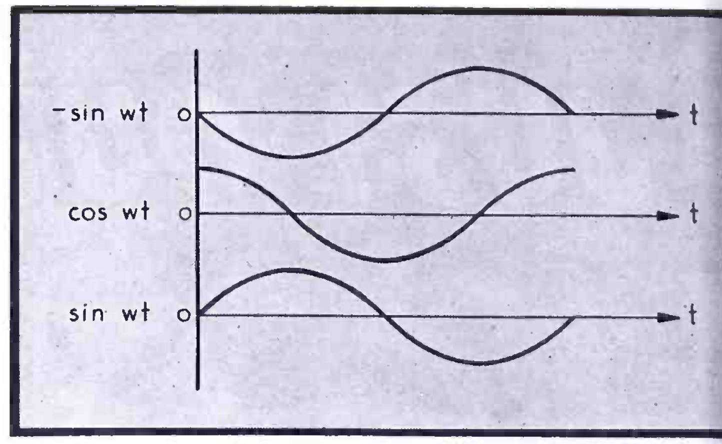




Figures 7 (left) and 8 (above)

Figure 7, the series of waves derived from a non-symmetrical triangular wave. Figure 8, the series of waves derived from the cosine.

ward slope. From $T/4$ to $T/2$, the rate of growth is constantly decreasing, hence the integral curve exhibits a point of inflection at $T/4$. From $T/2$ to T, the integral falls from its maximum value to zero, again passing through a point of inflection at $3T/4$. The resultant wave, shown in Figure *5b*, consists of a series of parabolas joined together, with the maxima and minima advanced in time by 90° with respect to the orginal waveform.

Figure 6 shows the family of functions which has just been discussed. These functions are so related that each is the derivative of the one immediately beneath it, and the integral of the one above. These are drawn with the average value in each case equal to zero.

Figure 7 shows another familiar family of time functions, and a similar group of waveforms can be drawn for the sinusoidal functions for purposes of comparison. Figure 8b shows the function cos ωt. Above it, *a* is its derivative, $-\sin \omega t$, while beneath it, *c* is its integral, $\sin \omega t$. In the case of the sinusoidal functions, differentiation or integration leaves the shape of the waveform unaltered, and merely shifts the phase. This is one of the important properties of sinusoidal functions and one of the reasons for using the sine wave as the basis for analysis of non-sinusoidal forms.

Basic Circuits for Differentiating

Equations *I* and *II* suggest methods of differentiating electrically with either a condenser or a coil. To differentiate a particular time function with a condenser, equation *I* is satisfied if the condenser is placed across a voltage source having the required waveform. The current in the condenser will then have the form of the derived function. Note that it is necessary that the function to be differentiated, in this case, be a *voltage* function. Thus the source must be a *voltage source,* i.e., its voltage waveform must be independent of the curr which it supplies. This means th the source is one of very low i pedance.

In order to be able to utilize the rived waveform, it becomes necessa to place a small resistance in ser with the condenser, so that a volta drop proportional to the current obtained. Figure 9 shows the circ for differentiating with a condens

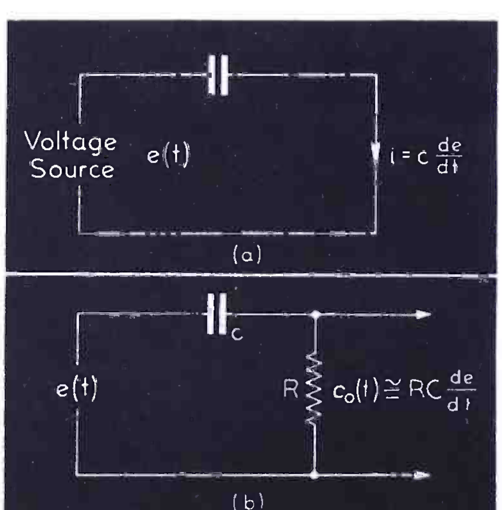
The necessity for employing series resistance destroys to a deg the rigor of the differentiation, si the current is now a function of b *R* and *C*.

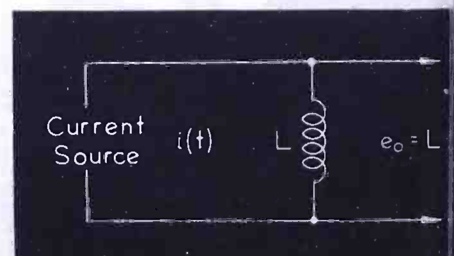
To differentiate with a coil, eq tion *II* is satisfied if a pure inducta is placed across a source whose curr variation with time is the time fu tion to be differentiated. In this ca the equation requires that the sou be a *current source,* i.e., its curr waveform must be independent of voltage which it supplies. This me that the source is one of very high pedance.

The circuit is shown in Figure Here again the differentiation rigorous only if the coil is a pure ductance.

Physical coils have resistance in winding, which adds another tern equation *II*. More serious than resistance, however, is the presenc distributed capacitance which forn resonant circuit with the inducta and tends to set up oscillations w shock excited by sudden changes the current, or of the output voltag

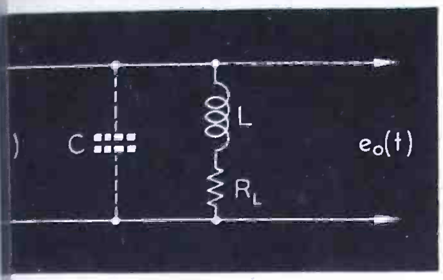
Differentiation with an inducta can be accomplished successfully if ratio of *L* to *R* is high and if the rivative of the current function not exhibit abrupt discontinuities. such discontinuities do exist, dam may be utilized to suppress the

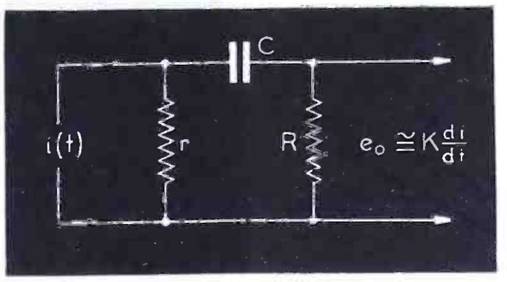


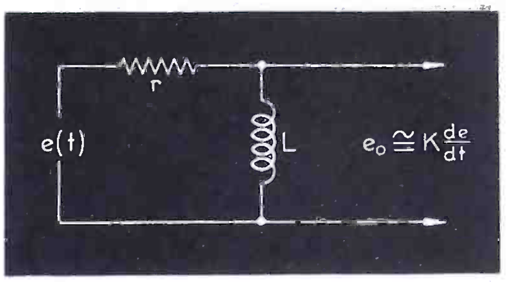


Figures 9 (left) and 10 (right)

Figure 9, ideal *(a)* and practical *(b)* circuit for differentiating a voltage $e(t)$. Figure 10, circuit for differentiation using an inductance.







Figures 11 (top left), 12 (top center) and 13 (above)

Figure 11 shows the disturbing elements in the circuit of Figure 10. Figure 12, differentiating with a condenser from a current source. Figure 13, differentiating with an inductance from a voltage source.

…y of the circuit to oscillate. Fig-1 shows the *L* differentiator cir-…s it actually appears.

…e two differentiating circuits thus …scussed have been limited in their …cation by the requirements placed …e source. This restriction can be …ome by converting the available …e to the type required. If, for …ple, a current source is available, … is desired to differentiate with a …nser, it becomes necessary to …rt the current source to a voltage …e. This is accomplished by plac- … low resistance (a high conduc-…) across the current source. Fig-2 illustrates this circuit. Alter-…ly, a voltage source of very low …lance can be obtained electroni-… using a cathode follower.

…n similar manner, a voltage source …be converted to a current source …eans of a high series resistance. … differentiation may be accom-…d using a coil, as shown in Fig-3. A current source may also be …hed electronically, through the …f a pentode having high plate re-…ice, or one employing negative …nt feedback.

…en a choice is available, it is gen-… preferable to differentiate with …*C* circuit, because almost pure …itance is easier to obtain than is …t pure inductance. There are in-…es, however, where a coil must …ed, and the circuit must be de-…d accordingly.

…its For Integration

…king use of equation *III*, a con-…r connected across a current …e will provide a voltage drop … is the integral of the cur-… Figure 14 shows such a …e integrating circuit. A diffi-… is generally encountered with …se of this circuit, which can be appreciated by referring to the discussion in connection with Figure 4. For the integral function to be recurrent, it is necessary that the current function vary either side of zero value in such a way that there is no d-c component. Such a current source is not readily obtainable. The most common current source is a pentode vacuum tube, whose plate current varies in proportion to the applied grid voltage, but the current is always positive. Thus a condenser connected between the plate and cathode would charge up in steps, in accordance with Figure 4, until its voltage equalled the plate-cathode voltage. The tube would then be so biased that it would no longer conduct.

This difficulty can be overcome by shunting the condenser with a high resistance as shown in Figure 15, so that the same amount of charge leaks off during the time that the current is essentially zero, as is added when the current is a maximum. This results in the wave shape shown in Figure 16.

In order to obtain an integrated waveform when a voltage source is available, it is necessary to simulate a current source by the introduction of a large resistance in series, as is shown in Figure 17.

To use inductance for integration,

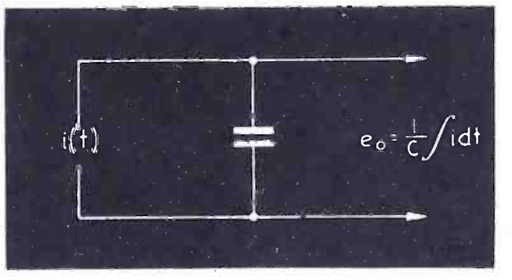


Figure 14 (above)

Basic capacitor integrating circuit.

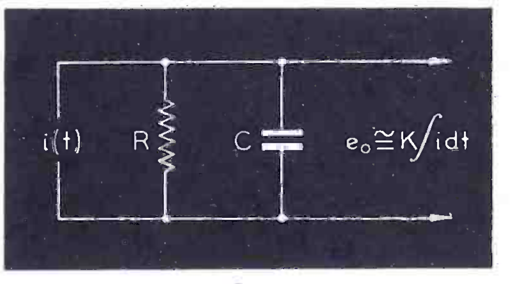


Figure 15 (above)

Integrating circuit to accommodate a current source with a d-c component.

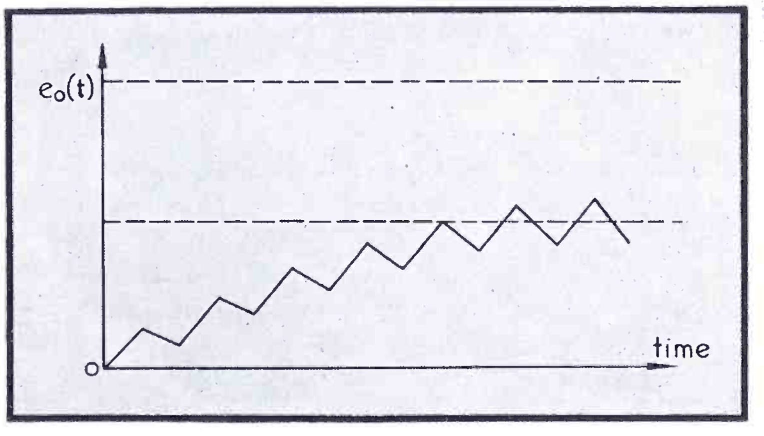
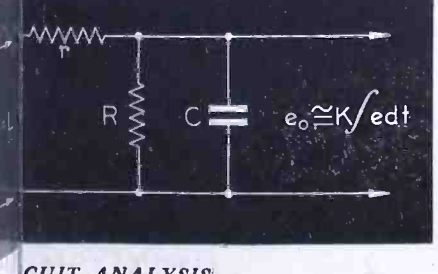


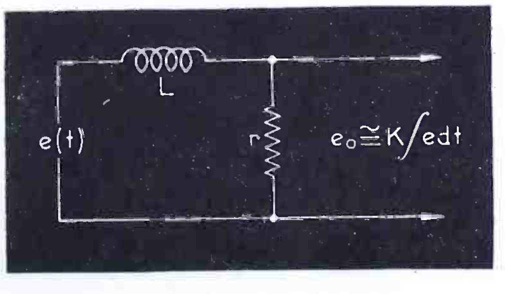
Figure 16

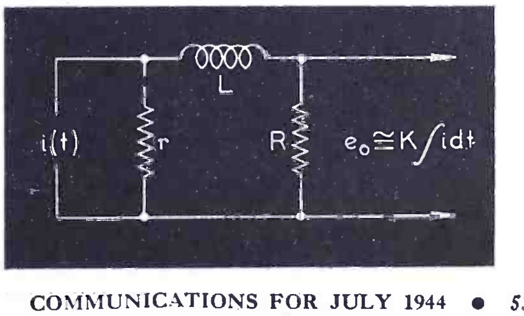
Build up of the voltage in the circuit of Figure 15 when a biased input is used.

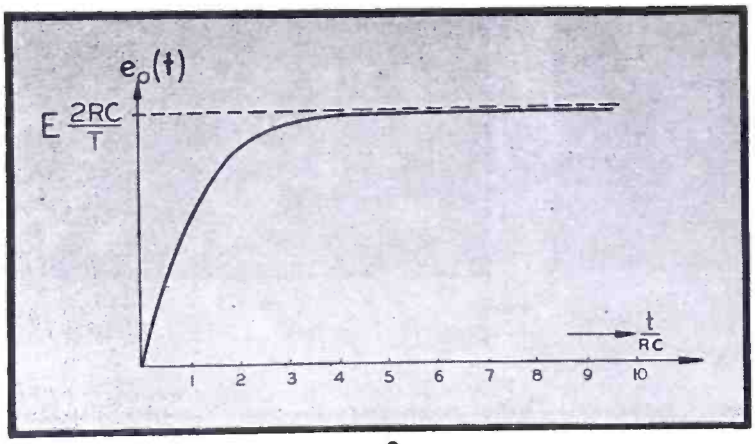
Figures 17 (below, left), 18 (below, center), 19 (below, right)

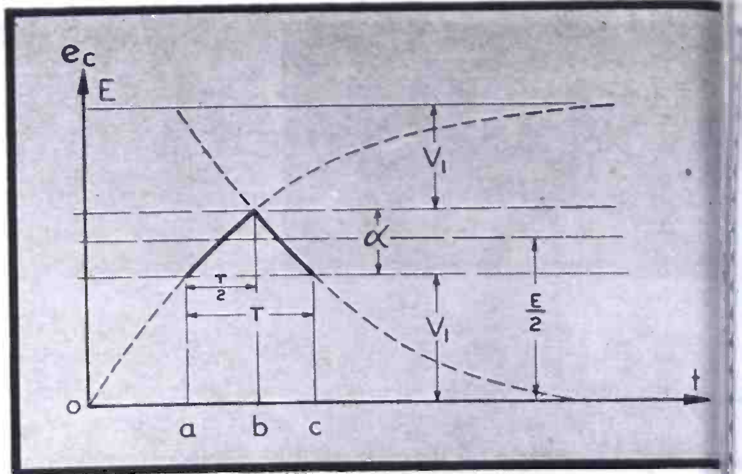
…re 17, integrating circuit using a capacitor and a voltage source. Figure 18, integrating circuit using a coil and voltage source. Figure 19, integrating circuit using an inductance and a current source.











Figures 20 (above, left), 21 (above, right)
Figure 20, normalized exponential curve. Figure 21 shows one cycle of the steady-state integration of a biased wave.

we find by reference to equation *IV*, that a voltage source is required. If this is available the circuit of Figure 18 may be used. A current source can be turned into a voltage source by the same procedure that we used previously, resulting in the circuit of Figure 19.

Neither of these inductance integrators will integrate a steady, d-c component. If such a component is present in the applied $e(t)$ or $i(t)$, as it will be if the integrator is fed from the plate circuit of a vacuum tube, there will be a d-c component in the output voltage, also. Added to this there will be the integral of all of the input waveform, except the d-c component.

Inductance integrators are subject to spurious oscillations which result from the natural resonance of the inductance with the stray capacitance of the coil. This is objectionable only if the wave to be integrated has sudden changes from one value to another; that is, if the wave has discontinuities.

Transient Solution of the RC Differentiating Circuit

The behavior of the circuit of Figure 9b can be predicted by finding the transient solution for the voltage across *R*, when a simple voltage function is impressed upon the circuit. Specifically, $e(t)$ may be chosen as the isosceles triangular wave of Figure 1, the period and amplitude of which are respectively, *T* and *E*. Consid[ering] the interval from *0 to T/2*, [the] voltage function may be written

$$e(t) = \frac{2E}{T} t$$

The differential equation for the [cir]cuit of Figure 9b is

$$iR + \frac{1}{C}\int idt = e(t)$$

This can be solved for the curr[ent] after differentiation. Thus

$$i = e'(t)\,C - RC\frac{di}{dt},$$

and since e′(t), for the example cho[sen] is 2E/T, equation *3* becomes

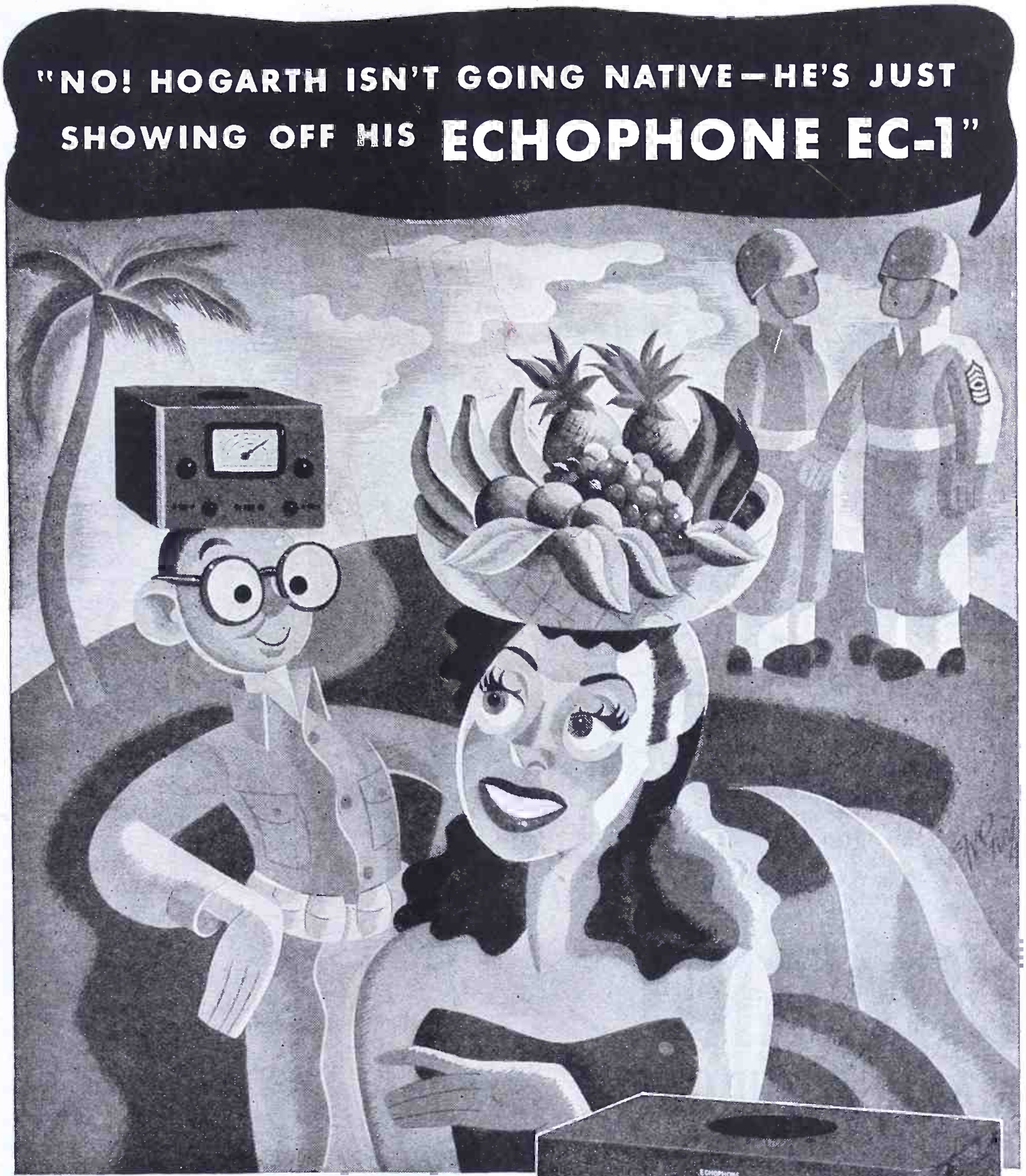
$$i = \frac{2EC}{T} - RC\frac{di}{dt}$$

Solving this and multiplying the re[sult]

(*Continued on page* 56)

Figure 22
Table of differentiating and integrating circuits.

OPERATION	VOLTAGE SOURCE (LOW IMPEDANCE)	CURRENT SOURCE (HIGH IMPEDANCE)	WAVE SHAPES: INPUT	WAVE SHAPES: OUTPUT	DESIGN EQUATIONS: VOLTAGE SOURCE	DESIGN EQUATIONS: CURRENT SOU[RCE]
DIFFERENTIATION CAPACITIVE $i = c\frac{de}{dt}$	C, R	C, r, R	E OR I, T	E_o	RC<<T; $E_o = 4ECR/T$	RC<<T; rC<<T; $E_o = 4IrCR/$
DIFFERENTIATION INDUCTIVE $e = L\frac{di}{dt}$	r, L, R	L, R			$\frac{L}{R}$>>T; $\frac{L}{r}$>>T; $E_o = 4LE/rT$	$\frac{L}{R}$>>T; $E_o = 4IL/$
INTEGRATION CAPACITIVE $e = \frac{1}{C}\int idt$	r, C	C			rC>>T; $E_o = ET/4rC$	$E_o = IT/4C$
INTEGRATION INDUCTIVE $i = \frac{1}{L}\int edt$	L, R	L, r, R			$\frac{L}{R}$>>T; $E_o = RTE/4L$	$\frac{L}{R}$>>T; $\frac{L}{r}$>>T; $E_o = RTrI/$


"NO! HOGARTH ISN'T GOING NATIVE—HE'S JUST SHOWING OFF HIS ECHOPHONE EC-1"

(*Continued from page* 54)

by R to obtain the output voltage function

$$e_o(t) = i(t)R = \frac{2ERC}{T}[1-\exp(-t/RC)] \quad (5)$$

Figure 20 shows the function $e_o(t)$ plotted against the generalized time variable, t/RC. Instead of the function rising to its maximum value at $t/RC = 0$ as required for perfect differentiation, the rise is exponential and requires a lapse of 5 units to reach 99.3% of the maximum value. The desired degree of approximation to the ideal depends upon the value of the time constant RC. The smaller this can be made, the shorter will be the time required for the function to reach its ultimate value. However, as RC is reduced, so also is the maximum value. Therefore, as the ideal differentiation is approached, the amplitude of the voltage, $e_o(t)$ becomes a very small percentage of the amplitude of the applied voltage. This is true in general for both differentiating and integrating circuits. As an example, if the time constant were made 1/100th of the period, the amplitude of $e_o(t)$ would be 1/50th of E and the function would rise to 99.3% of this value in 1/20th of the period.

If the applied voltage function had been a rectangular wave instead of a triangular one, the function $e_o(t)$ would consist of a series of pulses whose trailing edges would have the same exponential shape as that of Figure 20. These pulses will approach the ideal infinite pulse as RC is made progressively smaller. In practical circuits, however, the pulse amplitude will be found to decrease materially with very small values of RC, due to finite rise time of the rectangular function itself.

Transient Analysis of RC Integrator

A simple method of establishing a criterion with which to judge the performance of the circuit of Figure 15 is to apply a rectangular current and determine the resultant linearity of the integral function which, ideally, is a perfect triangular wave.

For the integral waveform to have equal slopes on the rise and fall, i.e., an isosceles triangle, the effective charging potential must equal the effective potential drop when the condenser discharges through R. This requirement is satisfied if the peak-to-peak amplitude of the triangular wave is centered about a d-c value equal to $E/2$, where E is the ultimate voltage to which the condenser could charge. Figure 21 shows in detail one period of the integral wave after the steady state has been reached.

The equation for the rising part of the curve is

$$e_c = (2V_1+\alpha) - (V_1+\alpha)\exp(-t/RC) \quad (6)$$

where t is measured from point a.

The equation for the falling part of the curve is

$$e_c = (V_1+\alpha)\exp(-t/RC) \quad (7)$$

where t is measured from point b.

At point b, these two equations must give the same value of e, so by substituting $t = T/2$ in equation 6, and $t = 0$ in equation 7, we have

$$2V_1+\alpha-(V_1+\alpha)\exp(-T/2RC) = V_1+\alpha \quad (8)$$

whence

$$\exp(-T/2RC) = \frac{V_1}{V_1+\alpha} \quad (9)$$

From this, and the value of V_1 in terms of E, we get

$$\alpha = E\frac{1-\exp(-T/2RC)}{1+\exp(-T/2RC)} \quad (10)$$

which gives us the value of the output voltage, peak to peak. Since we know that we will have almost linear curves if the integrator is to be useful, we can represent the exponential by the first

(*Continued on page* 58)

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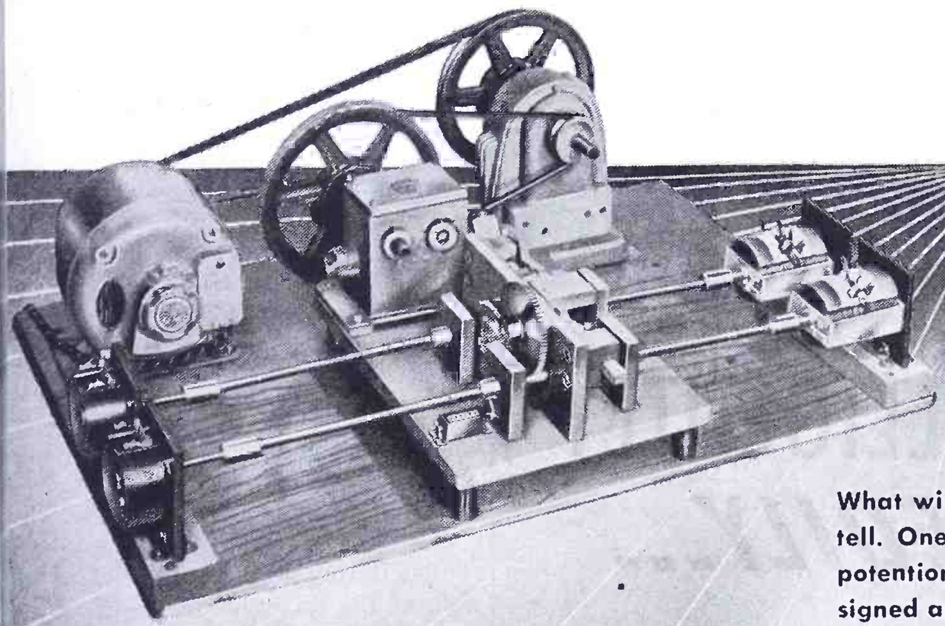
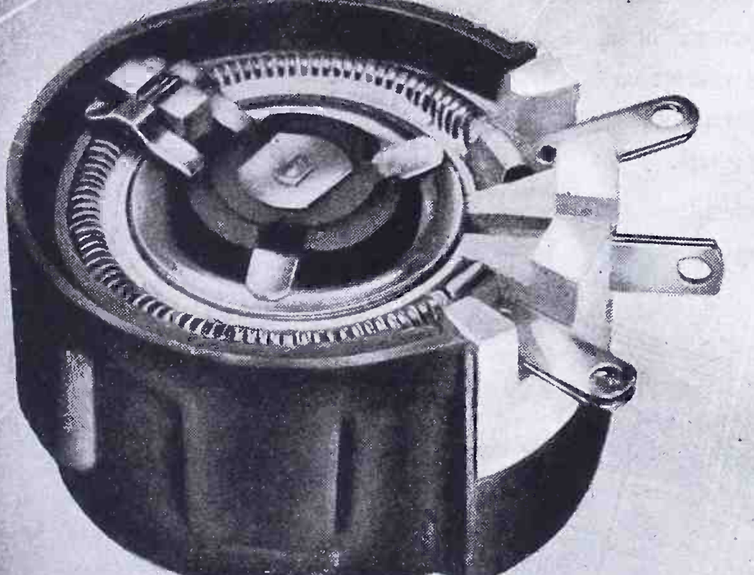


What will happen in 1959 nobody can foretell. One fact is clear, however, The DeJur potentiometer that you buy today is so designed and constructed as to provide at least 15 years of efficient operation. This figure . . . and it is a conservative one . . . is based on simulated production-line tests in our laboratory as well as reports from the field.



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(*Continued from page* 56)

and second terms of the infinite series which gives us

$$\alpha \cong E\,\frac{1-1+T/2RC}{1+1} = ET/4RC \quad (11)$$

In order to find how perfectly the circuit performs integration, we can examine the linearity of one of the sloping lines.

The linearity can be expressed in terms of the change in slope of the function from *0* to *T/2*. At any time *t*, the voltage across the condenser is given by

$$e_c = (V_1 + \alpha)\,[1 - \exp(-t/RC)] \quad (12)$$

and the instantaneous slope is found by differentiation

$$\frac{de_c}{d(t/RC)} = (V_1 + \alpha)\exp(-t/RC) \quad (13)$$

When time is equal to zero, the slope is simply

$$(V_1 + \alpha) \quad (14)$$

The final slope, when $t = T/2$ is

$$(V_1 + \alpha)\exp(-T/2RC) \quad (15)$$

The ratio of these is then

$$\exp(-T/2RC), \quad (16)$$

and the amount by which this departs from unity is

$$1 - \exp(-T/2RC) \cong -T/2RC \quad (17)$$

Thus, if the slope at the end of each side of the triangles in Figure 2 is to be only 1% different than the slope at the beginning of each triangle, we must write

$$T/2RC = 0.01 \text{ (or less)} \quad (18)$$

which will enable us to choose *RC* if we know the frequency of the wave we wish to integrate.

If we are integrating a 500-cycle square wave, *T* becomes 0.002 second so

$$RC = \frac{0.002}{2 \times 0.01} = 0.1$$

Thus, if *C* is 0.1 microfarad, we have

$$R = \frac{0.1}{10^{-7}} = 10^6 \text{ ohms} = 1 \text{ megohm.}$$

This value of *R* is the minimum value permissible for integration with slopes at the ends of the curve agreeing within 1%.

For this example, we find the peak-to-peak amplitude of the output wave is

$$E\ T/4RC = 0.005\ E$$

that is, only one-half of one per cent of the input! Inspection of equations *11* and *17* will show that the better the integrator, the smaller the output voltage.

U-H-F ANTENNAS

(*Continued from page 35*)

he logarithm of the power, and hence o the logarithm of the square of the oltage.

irective Antennas

Before discussing the type of directive antenna which was finally built nd tested, let us review briefly the hree important types of directive antennas. There are the vee or rhombic ype, the reflector-director type, and he multi-element driven array. The rst type, the vee or rhombic, as the ame indicates, is composed of a set f wires arranged in the shape of a ee or rhombus. It is excited at the losed end and radiation occurs in the lirection of the open end. Since the vires must be several wavelengths ong to secure directivity, this type of ntnna is usually too large to be roated, but is quite useful in permanent nstallations where non-rotatable diectivity is desirable.

The reflector-director type, a comnon type of directive antenna, usually onsists of a driven half-wave element vith reflector wires behind and someimes (if the driven element is vertial) to the sides of the driven element. The reflector wires are, of course, parallel to the driven element. In the ront are placed one or more director elements also parallel to the main element. The reflectors are longer and he directors shorter than the driven element. Radiation is in the direction of the directors. To achieve a very narrow radiation pattern, the spacing between the driven element and the numerous reflectors must be of the order of several wavelengths. Hence, any exceedingly directional antenna, such as it was desired to build, would have been too large to fit into the space available.

The third type, the multi-element driven array, usually consists of a number of half-wave elements, so positioned and excited, that the individual fields of each element combine to reenforce one another in the desired direction of radiation. The driven array type of antenna may be subdivided into three classes . . . endfire, broadside, and stacked. In the endfire type, the elements are placed in a straight line, usually about a half-wavelength apart and excited 180° out of phase with the adjacent element. Such a procedure produces destructive interference in a direction perpendicular to the line of elements, and reenforcement parallel to it. The broadside antenna is similar to the endfire, but each element is

(*Continued on page 60*)

U-H-F DIRECTIVE ANTENNAS

(*Continued from page 59*)

excited in phase with the others so the maximum radiation occurs in a direction perpendicular to the line of elements. In the stacked type, the elements are placed end-to-end, with an appropriate phase shifting circuit connecting them. This type of antenna is usually erected vertically, and in such a position confines the radiation to a horizontal plane.

Reflection and Polarization

Each of these sub-classes of the driven array antenna is quite directive and due to its relatively small size is readily adapted to being rotated. For ultrahigh frequencies, where the waves are not reflected by the Kennelly-Heaviside layer and the type of polarization of the waves thus makes no difference, these driven arrays are generally erected with the elements vertical, since this type of construction requires less space for the same number of elements.

Narrow Radiation Patterns

Since it was desired to build a rotatable antenna with as narrow a radiation pattern as possible and subject to the limitations mentioned earlier, a combination of all three types of driven arrays was employed to secure maximum directivity in a minimum of space. The final result is shown in Figure 6, which is a schematic diagram of the antenna array, and in Figure 7, a photograph of the array.

There were 32 elements in all—16 sets of two stacked elements arranged in four endfire arrays connected together at one end for excitation purposes. The spacing between adjacent elements was a half wavelength. The power was fed in at one end through a quarter-wave matching stub and a non-resonant 500-ohm line, Figure 8. The spacing between the elements was 26″, while the length of the elements themselves was slightly shorter (25½″) to compensate for end effects. As the lengths were carefully measured, no trouble was experienced in getting the antenna to resonate properly. The overall dimensions of th[e] array were about 78″ x 78″ x 70″, wit[h] the wooden frame mounted on castor[s] to permit rotation about a vertica[l] axis.

Radiation Pattern Plot

To plot the radiation pattern, Figur[e] 9, the antenna was excited, oscillato[r] tuned to the proper frequency, and th[e] field strength meter, Figure 10, pu[t] into operation at a distance of abou[t] 40′. With the end of the array towar[d] the meter, the plate current of the 6F[.] was about 3 ma. When the antenn[a] was rotated from this position (th[e] meter remaining fixed in position) the plate current dropped off rapidly The antenna was rotated through 360° readings of meter plate current bein[g] taken every five degrees. As Figur[e] 9 shows, the resultant radiation pattern of the antenna was that of a lemniscate with several irregularly shape[d] lobes between the two main ones. Th[e] intensity of the field dropped to abou[t] 50% of the maximum value when th[e] antenna had been rotated through 20[°] and was nearly zero for an angle o[f] 30° from the maximum. The maximum value of the largest of the extraneous lobes was about 20% of tha[t] of one of the lobes of the lemniscate The total energy radiated in these extraneous lobes is about 10% of tha[t] radiated in one of the regular lobes o[r] less than 5% of the total energy radiated by the antenna array. It wa[s] found that operating the array at [a] frequency different from the fundamental altered the radiation patter[n] considerably.

•

Figure 10 (below)
The field-strength meter as set up in th[e] laboratory to measure the radiation patter[n] of the antenna. With this setup the 3[2] element antenna array was studied. Th[e] antenna was rotated through 360°, reading[s] being taken every 5°. The resultant radiation pattern was that of a lemniscate wit[h] several irregularly shaped lobes between th[e] two main ones.

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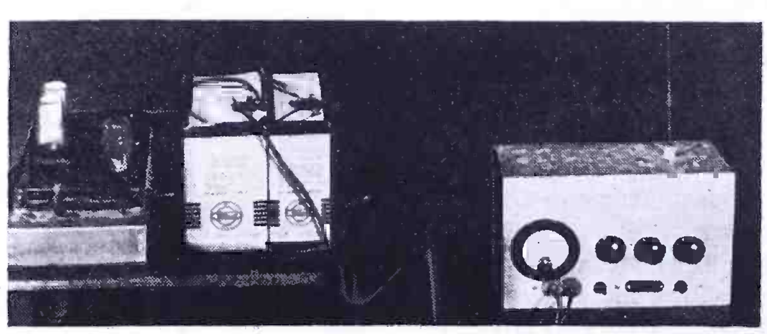


-H-F BURSTS ANALYZED BY FCC ENGINEERS

)BSERVATIONS on long-distance bursts causing interference in the very high frequency band which in-udes the band 42-50 megacycles now as-gned to f-m, have been disclosed by the CC.

The amplitudes of the bursts, accord-g to FCC engineers, have varied from e lowest levels which can be measured to levels well in excess of that re-ired to render a satisfactory f-m broad-st service. During periods of maxi-im activity they may occur at the rate several hundred per hour. However, e amplitudes of but few of the bursts e sufficient to cause serious interference a receiver operating within the pro-cted area of an f-m station under pres-t FCC standards.

A *burst* is defined as a sharp increase signal strength of very short duration seldom covering more than the time nsumed by a single spoken word or a te or two of music—from an f-m sta-n located at a considerable distance om the observer. Since February, 1943, CC engineers have been recording re-ption from certain f-m stations to de-rmine the nature and extent of the in-ference.

The bursts were observed from the gher powered f-m stations only. This ay account for the failure of amateurs, perimenters and others to have re-rted this type of interference in this equency range. The bursts are not nor-ally observed from nearby f-m stations, ice the steady ground wave signal is of fficient strength to obscure them, but ey may be observed in such instances a system of pulsing or by a direc-nal antenna which discriminates against e ground wave. At greater distances here the steady signal is absent or of w intensity, the bursts may be heard rough the loudspeaker or may be re-rded by a suitable recorder.

Bursts have been observed by both ethods at distances up to 1,400 miles om certain f-m stations, but are neither intense nor so numerous at the longer stances as they are at distances of 300 700 miles. Commission engineers ob-rved a systematic variation in the rela-e numbers of bursts which occur from ur to hour during the day, the highest mber occurring near sunrise and the west near sunset.

It was pointed out these bursts may be ated in some way to bursts of some-hat longer duration and greater fre-ency of occurrence which have been ported by other engineers on frequen-s below 20 megacycles. The distances er which the f-m bursts are received, as ll as certain measurements of signal th length, indicate they are ionospheric origin, just as are the bursts at the wer frequencies. There is also sub-antial agreement between the daily riations in the f-m bursts and the lower equency bursts which is further evi-nce that they are related and may per-ps be due to a common cause.

Bursts were also observed by FCC en-neers on certain television stations at megacycles, but insufficient data have en collected on these to make any de-mination of the relative amplitudes, equencies of occurrence, and durations

(*Continued on page* 88)

BOOK TALK . . . –

COMMUNICATION CIRCUITS

By Dr. Lawrence A. Ware, Associate Professor of Electrical Engineering, and Dr. Henry R. Reed, Professor of Electrical Engineering, State University of Iowa . . . 2nd Edition . . . 330 pp. . . . New York: John Wiley & Sons, Inc. . . . $3.50.

A revised text on the theory of communication circuits. The fundamentals of transmission lines and associated networks are covered, from the low audio through the ultrahigh frequencies.

The increased importance of Maxwell's equations is indicated in a special appendix which explains and adapts these equations in the treatment of wave guides and coaxial cables.

New material added throughout the book includes the study of impedance matching at higher frequencies; the circle diagram method for determining conditions for impedance matching; the practical aspects of wave guides, such as the selection of tube sizes, modes of transmission for specific purposes, and methods of excitation and detection; the theory of rectangular and cylindrical wave guides, and the physical aspects of wave guide transmission; and the solution of circuits.

Since the book does not attempt to present a complete study in any one field, several references to other texts are given for the student who wishes to supplement this study.

• • •

THE MICROSCOPE AND ITS USE

By Frank J. Muñoz, Technical Microscope Consultant, and Dr. Harry A. Charipper, Professor of Biology, New York University . . . 334 pp. . . . Brooklyn, New York: Chemical Publishing Company, Inc. . . . $2.50.

The evolution of the miscroscope, its modern construction and use in science, medicine, industry and research, are dealt with in this non-technical treatise.

The authors, one a commercial technical consultant and the other an academician, complement each other's contributions to the text, giving the reader a well-rounded practical and theoretical story of the miscroscope.

• • •

FUNDAMENTALS OF TELEPHONY

By Arthur L. Albert, Professor of Communication Engineering, Oregon State College . . . 374 pp. . . . New York: McGraw-Hill Book Company, Inc. . . . $3.25.

An elementary study of wire telephony, intended for beginning students and telephone workers rather than technically trained engineers.

The first four chapters in the book cover basic electrical theory and the problem of acoustics as related to the principles of telephony. The remaining ten chapters describe and illustrate the make-up and operation of telephone transmitters, receivers, sets and circuits, lines, manual systems, dial systems, loading measurements, noise and cross-talk, and repeaters and carriers.

• • •

FUNDAMENTALS OF RADIO COMMUNICATIONS

By Dr. Austin R. Frey, Lehigh University . . . 393 pp. . . . New York: Longmans, Green & Company . . . $4.00.

This book offers a thorough grounding in the terminology of radio communications, the more important types of circuits, and the methods of employing vacuum tubes to generate, control and detect high-frequency currents.

The topics discussed are limited to resonant circuits, thermionic emission and diodes, grid-controlled vacuum tubes, voltage and power amplifiers, oscillators, modulation and demodulation, r-f transmission lines, and radiation. Each of these subjects is developed as thoroughly as possible to give an understanding of the available methods of analysis, and the application of these methods to the solution of circuit problems. Essential mathematics are also detailed and, in many cases, simplified. Several references are made to current periodicals where the text treatment is necessarily incomplete.

The physics or engineering student should obtain a sound background of the basic principles of radio communications from Dr. Frey's presentation of the subject.

• • •

PATENT LAW

By Chester H. Biesterfeld, Member of the Bar: New York and D. C. . . . 225 pp. . . . New York: John Wiley & Sons, Inc. . . . $2.75.

A simple treatment of the substantive patent law that should be of interest to engineers, chemists and students.

Originally presented as a series of lectures at the University of Delaware, the volume discusses various subjects of the patent law such as priority of invention, originality, patent application, interferences, infringements, licenses, trade secrets, etc., with an explanation of the underlying principles involved. Citations and decisions on recent court cases are included to illustrate and support each patent subject.

• • •

MATHEMATICS ESSENTIAL TO ELECTRICITY AND RADIO

By Lieut. Nelson M. Cooke, U.S.N., member IRE, and Joseph B. Orleans, Head of Mathematics Department, George Washington High School, New York . . . 418 pp. . . . New York: McGraw-Hill Book Company, Inc. . . . $3.00.

For the radio or electrical engineering beginner, this book presents basic mathematics as applied to everyday problems in the field. Beginning with a review of the essentials of algebra, geometry and trigonometry, the text continues with a sequential arrangement of electrical theory, without loss of mathematical continuity. Pertinent illustrations and examples supplement each problem.

Simple explanations of Ohm's law and Kirchhoff's laws are included, as are complete definitions of all radio and electrical terms.

NEWS BRIEFS OF THE MONTH...

TREASURY PROCUREMENT SURPLUS WAR PROPERTY DIVISION TO SELL RADIO SURPLUS

A listing of surplus merchandise, including broadcast receivers and tubes, that will be offered for sale has just been released by the Treasury Procurement Surplus War Property Division. Companies wishing further information on this equipment should send their request, along with a statement of their specific merchandise lines, to the division's nearest regional office.

Procurement offices are located at 76 Ninth Avenue, New York 11, New York; Room 300, 209 South LaSalle Street, Chicago 4, Illinois; 1229 Twentieth Street, N.W., Washington 25, D. C.; 30 Van Ness Avenue, San Francisco 2, California; Park Square Building, Boston 16, Massachusetts; 10 Forsyth Street Building, Atlanta 3, Georgia; 2605 Walnut Street, Kansas City 2, Missouri; 2005 Fifth Avenue, Seattle 1, Washington; Faller Building, 8th and Walnut Streets, Cincinnati 14, Ohio; Exchange Building, 7th floor, 1030 Fifteenth Street, Denver 2, Colorado; 609 Neil P. Anderson Building, Fort Worth 2, Texas.

* * *

O'LEARY HEADS WPB RADIO & RADAR SECTION IN NEW ENGLAND

Frederick A. O'Leary has been named chief of the radio and radar section of WPB's New England production department. Mr. O'Leary, with the WPB for sixteen months, was formerly associated with Raytheon Manufacturing Company, and the Eastern Company of Cambridge, Massachusetts. He succeeds Michael Scott, who has been commissioned in the U. S. Navy electronics division, Office of Procurement and Materiéls, Washington, D. C.

* * *

FCC AUTHORIZES EXPERIMENTAL AT&T NEW YORK-BOSTON STATIONS

The Federal Communications Commission has extended conditional grants for construction by the American Telephone & Telegraph Company of two experimental Class 2 stations, using twelve bands of frequencies from 11 to 23 megacycles, in the u-h-f and v-h-f ranges. The stations will be located in New York City and Boston, terminal points of a proposed wideband, point-to-point radio repeater circuit capable of relaying telegraph and telephone communications, frequency modulation, facsimile or television broadcasting.

The stations have been authorized for unlimited time operation, with power of 10 watts, in the following frequency bands: 1,914,040 kc to 1,929,960 kc; 1,974,010 kc to 1,985,990 kc; 2,193,900 kc to 2,206,100 kc; 2,253,870 kc to 2,266,130 kc; 3,993,000 kc to 4,007,000 kc; 4,052,970 kc to 4,067,030 kc; 4,292,850 kc to 4,307,150 kc; 4,352,820 kc to 4,367,180 kc; 11,489,250 kc to 11,510,750 kc; 11,689,150 kc to 11,710,850 kc; 12,288,850 kc to 12,311,150 kc; 12,488,750 kc to 12,511,250 kc, inclusive.

* * *

APCO CONFERENCE IN SEPTEMBER

The eleventh annual national conference of the Associated Police Communication Officers will be held at the Commodore Perry Hotel, Toledo, Ohio, September 18, 19 and 20.

SIGNAL CORPS AWARD TO DR. BEVERAGE

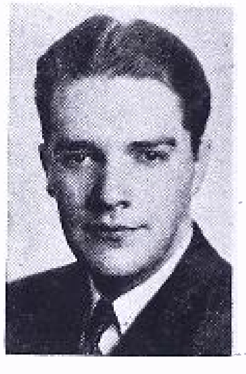
The U. S. Army Signal Corps' Certificate of Appreciation was awarded recently to Dr. Harold H. Beverage, associate director in charge of communications research of RCA Laboratories. The certificate cited Dr. Beverage's cooperation in the installation of the Signal Corps' radioteletype circuit in the North Atlantic route.

* * *

REHFELDT AND HOLUBOW WITH ELECTRONIC ENGINEERING CO.

E. J. Rehfeldt, formerly with Thordarson as manager of export sales and as advertising and sales promotion manager, has joined Electronic Engineering Company, Chicago. Plant is at 735 West Ohio Street, Chicago 10, and branch office at 5200 West Chicago Avenue, Chicago. Mr. Rehfeldt will be in charge of planning and production. The company is specializing in the manufacture of electronic equipment such as transformers, chokes and wave filters.

Harry Holubow, also formerly with Thordarson as design and research engineer, is chief engineer of EEC, and J. S. Cislak is sales manager.



E. J. Rehfeldt

Harry Holubow

* * *

ALFRED A. GHIRARDI MARRIES

Miss Evelyn Reilly of New York City and Long Island was married recently to Alfred A. Ghirardi. Mr. and Mrs. Ghirardi are now residing in Arizona.

WPB SEEKING FARM BATTERY PRODUCTION

Every effort is being made to increase the supply of farm radio batteries, the WPB has announced, even though they compete with military batteries for production facilities. The WPB position was made known at a recent conference with the dry cell battery and zinc battery shell industries which were urged to exert every possible effort to expand dry cell battery production to meet increasing military and civilian requirements. Army and Navy representatives estimated that military requirements exceed production of batteries by 30%.

* * *

TELEVISION STATIONS OFFER WAR BONDS FOR SYMBOL

Six of the nation's nine operating stations have launched a contest to find a symbol that best exemplifies the spirit and purpose of television. The event sponsored by the TBA and the participating television stations, provides a $25.00 War Bond to the viewer submitting the symbol judged by a station to be the best, and a $50.00 War Bond to the national winner.

Stations participating include WRGB, WABD, WPTZ, WBKB, W6XAO and W6XYZ.

The symbol selected will be adopted by the TBA as its official trademark. The contest closes on July 31.

* * *

RMA PARTS GROUPS ORGANIZED

For consideration and action on problems of each major group of RMA parts manufacturers, sectional organization of twelve parts groups has been completed. Included are two new sections, the vibrator section and the special product section, the latter including parts manufacturers not specifically covered by the other eleven sections.

The twelve sections and their respective chairmen are: capacitors—Paul Hetenyi, Solar Manufacturing Corp., New York, N. Y.; coils—Leslie F. Muter, The Muter Company, Chicago, Illinois; fixed resistors—J. H. Stackpole, Stackpole Carbon Co., St. Marys, Pa.; instruments—R. L. Triplett, Readrite Meter Works, Bluffton, Ohio; sockets—Hugh H. Eby, Hugh H. Eby, Inc., Philadelphia, Pa.; special products—W. R. MacLeod, King Laboratories, Inc., Syracuse, N. Y.; switches—Robert A. O'Reilly, Oak Manufacturing Company, Chicago, Ill.; transformers — James M. Bennan, Jefferson Electric Company, Bellwood, Illinois; variable condensers—Russell E. Cramer, Radio Condenser Company, Camden, N. J.; variable resistors—H. E. Osmun, Centralab, Milwaukee, Wisconsin; vibrators—Ray F. Sparrow, P. R. Mallory & Co., Inc., Indianapolis, Ind.; and wire—R. G. Zender, Lenz Electric Mfg. Co., Chicago, Illinois.

* * *

FAIRBANKS NOW JOBBING DIVISION SALES MANAGER FOR CORNELL-DUBILIER

Dan Fairbanks has been appointed jobbing division sales manager for Cornell-Dubilier Electric Corporation, South

(*Continued on page 66*)

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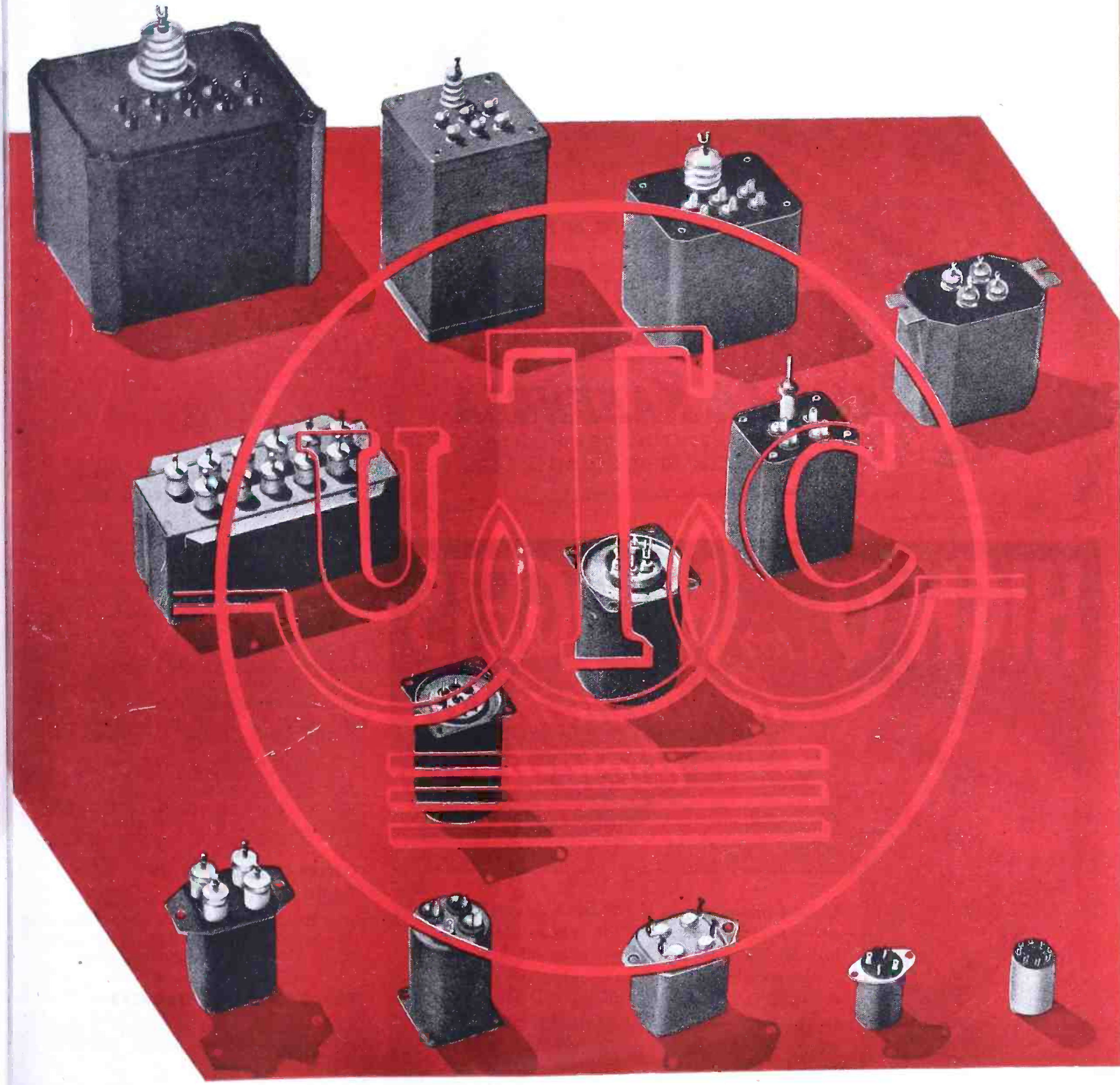

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NEWS BRIEFS

(*Continued from page 64*)

Plainfield, New Jersey. Mr. Fairbanks held a similar position for the past twelve years with the International Resistance Company of Philadelphia. He will make his headquarters at the company's New Bedford, Massachusetts, plant.

* * *

RCA COMPLETES ONE MILLIONTH ARMY CRYSTAL

One million *X* crystals have been manufactured by RCA Victor's manufacturing division at Camden, New Jersey, for installation in U. S. Army Signal Corps equipment. To commemorate this event, the millionth crystal was placed in a gold-plated container and presented to Colonel Eugene V. Elder, commanding officer of the Philadelphia Signal Corps Procurement Division.

* * *

R. M. HILL AND G. GRAY FORM SWITCH MANUFACTURING CO.

The formation of Grayhill, a manufacturing company for the engineering and production of mechanical and electrical switching devices for electronic and aircraft industries, has been announced by Ralph M. Hill and Gordon E. Gray. General offices are at 1 North Pulaski Road, Chicago 24, and manufacturing facilities at LaGrange, Illinois.

W. S. Lewis is general manager and chief mechanical engineer. Arnold Wassell is in charge of the design and production of the plastic parts used in the company's products.

A four-page bulletin, which illustrates and describes the roto-switch and snapit switch now being made by Grayhill, is available on request.

* * *

GENERAL RADIO WINS THIRD WHITE STAR

The third white star has been added to the Army-Navy "E" flag of the General Radio Company, Cambridge, Mass.

* * *

TBA GAINS NEW MEMBERS

The Theatre Guild and RKO Television Corp. have become affiliate members of the TBA.

* * *

GALVIN PREDICTS POSTWAR F-M AND TELEVISION IMPROVEMENTS

The improved use of f-m and the general use of television by the public in the early postwar stages was predicted recently by Paul V. Galvin, former RMA president and president of Galvin Manufacturing Corp. Mr. Galvin stated that television will be as great an industry as radio; while f-m will also be more common, because of the broadcast chains' new policy of sending their chain programs out through f-m channels.

* * *

RCA APPOINTS GLENN HENRY OF WPB

Glenn Henry has been named head of the sound and industrial department of Radio Corporation of America, Camden. Mr. Henry recently resigned from his post as chief of the audio and industrial section of WPB's radio and radar division.

* * *

UTAH WINS WHITE STAR

A white star for their "E" flag was awarded recently to Utah Radio Products Company, Chicago.

* * *

COL. CUNNINGHAM RETURNS TO UNITED AIR LINES

Following an absence of more than two years, while he was on active duty with the Army Air Forces, Colonel J. R. Cunningham has returned to United Air Lines where he is resuming his activities as director of communications.

* * *

THREE COMPANIES RECEIVE ARMY SIGNAL CORPS CERTIFICATES

Major General Harry C. Ingles, Chief Signal Officer of the U. S. Army, recently presented the Signal Corps' Certificate of Appreciation to RCA Communications, Inc,. the American Telephone & Telegraph Company, and to the I. T. & T. subsidiaries: Mackay Radio & Telegraph Company, Inc., and the Commercial Cable Company.

RCA Communications executives receiving the Signal Corps' Certificate. Left to right: Maj. Gen. Harry C. Ingles, Chief Signal Officer, U. S. Army; the late William A. Winterbottom, former vice-president and general manager of RCA Communications, and Lt. Gen. James G. Harbord, chairman of the board of RCA.

* * *

TELEVISION RECEIVER PURCHASES LEAD IN SAVINGS PLAN

A savings plan of wartime earnings for peacetime purchases, in operation at the Franklin Square National Bank, Long Island, and recently described on a television program, showed that a large percentage of those using the plan were saving for television receivers of the $400.00 type.

* * *

GENERAL INSTRUMENT ANNIVERSARY BROCHURE

A 24-page report depicting the progress of the General Instrument Corporation, 829 Newark Avenue, Elizabeth 3, New Jersey, during its 20 years of operation has just been released. Featured are various types of capacitors made by G. I., Army-Navy "E" ceremony, and company advertisements. A "war's end" forecast contest is one of the highlights of the

(*Continued on page* 70)

AFTER completing the biography of Father Flanagan of Boy's Town, and donating the entire manuscript to Father Flanagan's Boy's Home, Gilson VanderVeer Willets has recently returned to his home in San Francisco. GVW is one of our founders and in his reminiscing letter recalls those first meetings of the "Old Time Operators Association," with Peter Podell, Jim Maresca, Sam Schneider and Bill Fitzpatrick doing yoeman work in the new born organization. Gilson has since its inception been chairman of the San Francisco chapter of VWOA and can be reached by interested West Coast veterans at 1434 Twenty-sixth Avenue, San Francisco, Calif. . . . We are deeply interested in getting some more material about those early days of VWOA to be included in our Twentieth Anniversary Year Book. Yes, Jim Maresca, Fred Klingenschmitt, Ben Beckerman, Peter Podell, George Clark, Arthur Batcheller, A. Barbalate, Frank Orth and the other charter members should be able to supply us with a complete and comprehensive story of the birth and early growth of our Association. What say, let's hear from all of you!

R. S. Henery continues active with RCAC at Port Jefferson where he serves as the chapter chairman of VWOA. . . . G. W. Johnstone, life member and director of news and special events of the Blue Network did an outstanding job at the Republican National Convention. After a short rest he went back to Chicago with a large staff to cover the Democratic Convention proceedings.

Dr. F. A. Kolster of radio compass fame is back in New York after some years on the West Coast. . . . When last heard from, life member Captain C. H. Maddox, one of the earliest of Navy radio pioneers, was in charge of a submarine flotilla in the Pacific. Good news coming back from those parts shows that he is doing his bit to introduce Tojo to Davy Jones. . . . Major W. S. Marks, Jr. is now at the Camp Coles Signal Laboratory at Red Bank, N. J. . . . R. S. Palmer is a partner in the firm of Palmer and

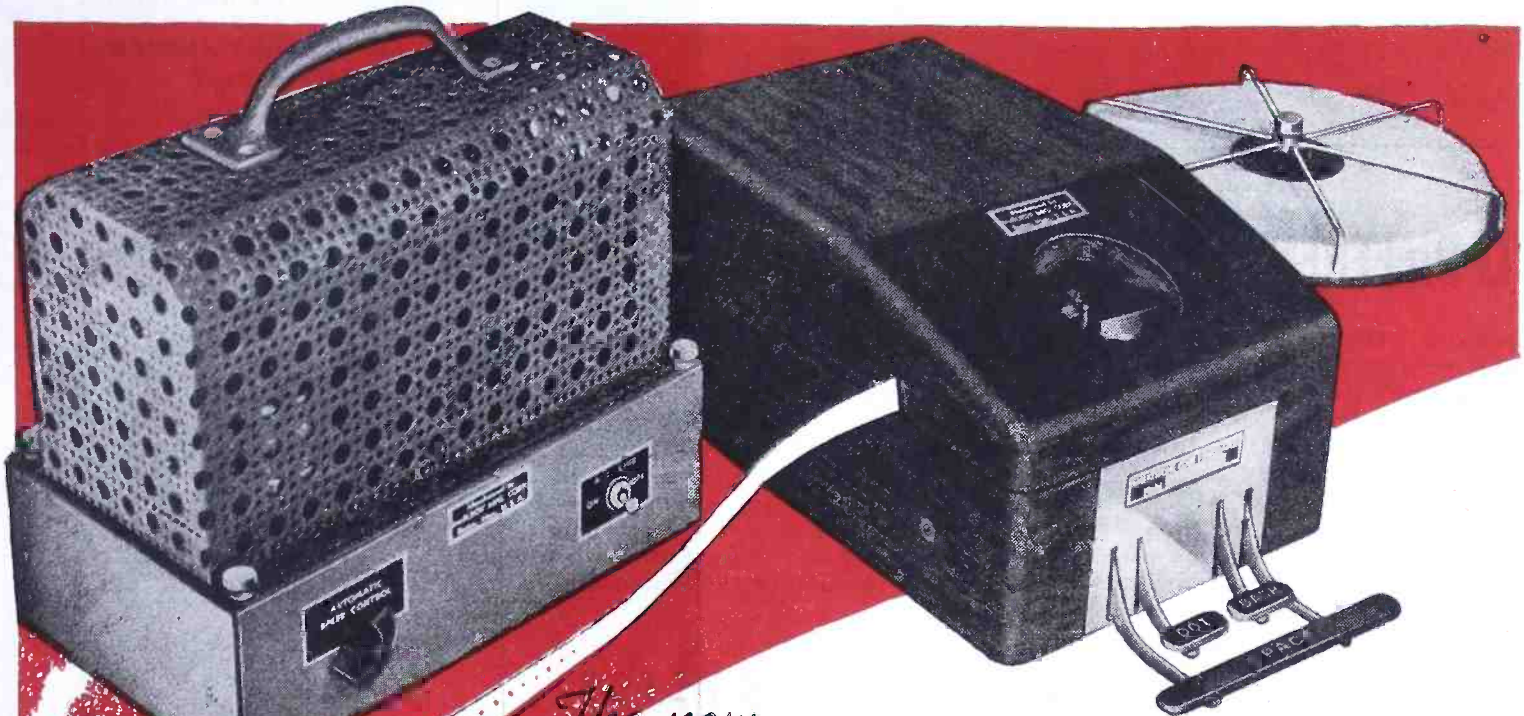
Hal Styles, chairman and co-founder of the VWOA Los Angeles chapter, who is running for Congress as a Democrat, representing the 15th Congressional district in California.

West Radio Equipment Company of Seattle, Wash. . . . H. H. Parker, who served for many years as secretary, continue to enjoy the healthful climate of Westchester County, N. Y. . . . E. K. Price is now stationed at the Naval Air Station, Floyd Bennett Field, Brooklyn, N. Y. . . . Edward G. Raser recently handled a get-together for the Delaware Valley Radio Association, N. J. . . . Lt. Cmdr. W. S. Rogers is now stationed in Boston. . . . Life member Colonel David Sarnoff is now overseas with the American Expeditionary Forces doing liaison work in communications for Supreme Allied Headquarters.

Lt. Comdr. Edw. Bennett is now stationed at Norfolk, Va. . . . Fred T. Bowen works out of San Francisco aboard a Navy cruiser. . . . Haven't heard from Leroy Bremmer, who is one of the pioneers of the Los Angeles chapter, lately. Let's read some of your experiences of the past few years LB. Should be printable now without disclosing anything to the enemy. . . . Arthur Cohen, one of the earliest of oldtimers, is now at the United States Embassay in Rio de Janeiro, Brazil. . . . Greetings to C. B. Cooper our latest life member. We'll have a write up about CB some time later when he furnishes the details. . . . Many months have passed since we've heard from George Street, chairman of the Honolulu chapter since its beginning. He seems to be maintaining interest in VWOA in those parts however, for we receive an occasional new member application from the Pacific. George has run some very excellent Hawaiian Dinner-Cruises in the past and with the large number of Army and Navy radiomen now in those parts he should be able to arrange a bang-up affair. . . . F. C. Dixon is with the communications department of Pan American Airways at Treasure Island, Calif. . . . Captain E. H. Dodd recently assumed the duties of Naval Postal Coordinator at San Francisco. . . . R. L. Duncan is stationed overseas in the Pacific with the Seventh Bomber Command. . . . A new and completely revised edition of Drew's *Questions and Answers for Commercial Radio Operating Exams* recently appeared. The author, our own veteran member, Charles E. Drew. . . . S. W. Fenton, formerly marine superintendent of Mackay Radio in San Francisco is now in the Washington office of Federal Telegraph and Radio Corporation. . . . Captain M. Fernandez is with the 20th Ferrying Group of the Army Transport Command at Nashville, Tenn.

Neville Miller, former NAB president wrote in recently, saying: "I certainly appreciate your thoughts of me and in turn I wish to express to you and the membership of the Association my sincere appreciation for all the kindnesses shown me while with the NAB. Here's hoping I shall have the pleasure of seeing you and the members of the Association many times in the future." Mr. Miller has recently accepted an important assignment with Governor Lehman's organization and will headquarter in Cairo, Egypt. Best of luck, NM. We in turn deeply appreciate your grand cooperation some of the details of which will make interesting reading in later years.

A highly RELIABLE, FAST and, when necessary, MOBILE adjunct to radiotelegraph communications!



The new

McELROY WHEATSTONE CODE TAPE PERFORATOR, PFR 443-A

Not only can the PFR-443-A, a proud McElroy achievement, be set up to operate immediately as a stationary unit, but it can be used with equal efficiency in moving vehicles. Requiring little or no maintenance, the PFR-443-A now provides high speed transmission where once it was impossible because of the bulky and complicated equipment required to perforate tape. With this unit, accurate tapes can be prepared for transmission at speeds up to 300 words per minute.

The McElroy PFR-443-A consists of two units. **The Keying Unit**, which is silent in operation, comprises two keys, space bar and punching mechanism. The **Electronic Unit**, which relieves the keying contacts of high current and voltage, is designed so that the tube and relay are separated from the mechanical section. Thus, the delicate electronic components are not subjected to jolts and jars.

Although the transmission of dots and dashes is automatic, the operation is similar to a semi-automatic (bug) key. A light touch actuates the punching mechanism for as long as either the key or space bar is depressed. Experienced operators can maintain, with ease, speeds of between 30 and 40 words per minute in all Morse combinations assigned to the Russian, Turkish, Greek, Arabic and Japanese alphabets and languages. This is a McElroy advantage not found on the keyboards of standard perforators manufactured in the U. S. or Great Britain.

McELROY ENGINEERS CREATE . . . DESIGN . . . BUILD. WE ARE NEVER SATISFIED WITH MEDIOCRITY

ARMY E NAVY

SUPPORT THE FIFTH WAR LOAN DRIVE

McElroy MANUFACTURING CORP.
82 BROOKLINE AVE., BOSTON, MASS.

NEWS BRIEFS

(*Continued from page 67*)

brochure: two tickets to the 194? World Series will be given by G. I. to the first ten people submitting the correct prediction on when the war will end.

* * *

W. F. KEAN HEADS ANDREW COMPANY FIELD UNIT

A new division, providing field engineering and allocation service to the f-m and standard broadcast industry, has been inaugurated by the Andrew Company, Chicago. Walter F. Kean, formerly with Western Electric Company in charge of testing radio and radar projects, is in charge of the service.

* * *

CONTINENTAL-DIAMOND BULLETINS

A 12-page bulletin on the design and fabrication of laminated and molded phenolic plastics, and vulcanized fibre parts; and a 4-page folder on dilectene low loss u-h-f insulation, have been issued by Continental-Diamond Fibre Company, Newark 51, Delaware.

The phenolic plastics bulletin contains two articles, *Design Fundamentals for Phenolics* and *Fabricating Laminated Plastics and Vulcanized Fibre*, both of which are accompanied by photographs, diagrams, charts and tables. The dilectene folder gives a detailed story on this insulation plastic, its properties, fabrication, uses, and physical data.

Three other illustrated bulletins, Diamond Vulcanized Fibre, Dilecto, and Micabond, which describe Continental-Diamond non-metallics, have also been published.

* * *

THIRD WHITE STAR TO FEDERAL MANUFACTURING

The Federal Manufacturing and Engineering Corp., Brooklyn, New York, has been awarded with the third white star for their "E" flag.

* * *

TERRILL NOW FAIRCHILD SECRETARY

C. L. Terrill, vice president of the Fairchild Camera and Instrument Corp., New York, has been appointed secretary. The former secretary, James S. Ogsbury, Jr., is now in the Army.

* * *

DR. B. B. KNAPP, OF INT. NICKEL, PRESENTS COPPER DETECTION PAPER

A method for the rapid colormetric determination of copper in a nickel plating solution was described recently by Dr. B. B. Knapp, chemist of the Bayonne Laboratory of International Nickel Company, Inc. The method requires the use of the organic reagent dithizone, and embodies the mixed color principle, which nly involves matching the color of the nknown with that of a set of standards. 'he entire determination is carried out in test tube, and the copper content is ıeasured over the range of 0.004 to 0.5 ram per liter.

* * *

YLVANIA EXPERT ELECTED RINITY COLLEGE PRESIDENT

. Keith Funston, formerly director of urchases for Sylvania Electric Products, ıc., is the newly-elected president of 'rinity College, Hartford, Connecticut. ecently appointed a lieutenant comman-er in the U. S. Navy, Commander Fun-on has been given a leave of absence om Trinity for service with the Office f Procurement and Materiél, Industrial eadjustment Branch, in Washington,). C.

* * *

ORMICA BULLETIN

 32-page bulletin, *What Formica Is,* is eing distributed by the Formica Insula-ion Company, Cincinnati, Ohio. Photo-raphs and descriptive text detail the tory of formica, from its early labora-ory experimental procedures to the pres-nt process of manufacturing, molding nd machining this plastic material. For-nica's uses in radio, electrical, automo-ive, chemical, mechanical, and other in-ustries, are also given.

* * *

). F. JESTER OF MEISSNER 'ISITS WEST

)den F. Jester, vice president of the Meissner Manufacturing Company, Chi-ago and Mt. Carmel, Ill., has just com-leted a tour of radio dealers and dis-ributors in the middle, south and far vest. Mr. Jester surveyed the prospective narket for distribution of the new Meissner radio-phonograph, which is lated for production as soon as con-litions permit.

Frank C. Lee, furniture and industrial lesigner, has been commissioned by Meissner to design a series of cabinets to ouse the new radio-phonograph.

* * *

BRIDGE-CONTROLLED OSCILLATOR ANALYZED IN G. R. EXPERIMENTER

The May issue of the *General Radio Ex-perimenter* contains an analysis and cir-cuit diagram of the bridge-controlled os-cillator, by J. K. Clapp. Two other arti-cles, *Random Emission Compensation* and *Relative Humidity at Boston,* are also included in this issue.

* * *

AIRCRAFT ACCESSORIES ACQUIRES BESLER POWER BRAKE DIVISION

The power brake division of Besler Corporation has been acquired by Aircraft

(*Continued on page* 80)

THE INDUSTRY OFFERS . . .

FTR 200 KW STATIONS

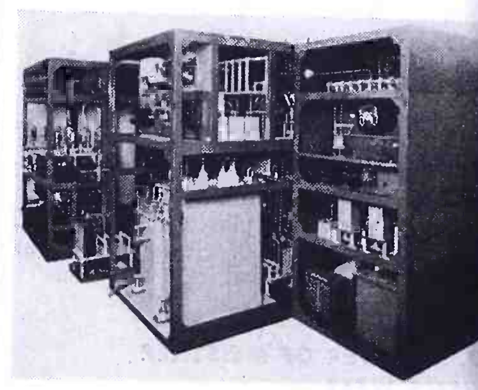
Short-wave transmitters of 200-kilowatt capaci are now being constructed for the Office War Information by Federal Telephone an Radio Corporation, Newark, New Jersey. The units, operating at two locations on the We Coast of the United States, will augmen existing radio coverage of the entire Pacif area, from Siberia to Australia and fro Hawaii to India.

It is planned to have the s-w stations operation early next fall under the supervisio of two of the major radio networks.

Peak input for the 200-kilowatt transmitt will be over 600 kva at 2300 volts.

Two audio amplifiers provide four push pull stages to supply audio driving power t the modulator grids. The driver stage ahea of the modulator is of the low-impedanc type. Alternating current filament operatic is used for all the tubes in the modulato unit, the starting current being limited b means of current-limiting reactors. The in dividual tubes of the modulator stage are oper ated from a single-phase filament supply fro a three-phase source. The six filament trans formers are connected to the three-phas source.

The plate supply rectifier is capable of deliver ing 600-kilowatts of direct current at 12,0 volts. A voltage regulator of the inductio type is used in the primary supply to thi rectifier so that the voltage may be varie from its maximum value to a value 35% lower Each of the plate supply rectifier rack mounts seven Federal 857 mercury-vapo rectifier tubes. Six of the tubes in each rac are used in a conventional three-phase, full wave circuit. The seventh tube on each rac serves as an installed pre-heated spare.



Amplifier and modulator sections of 200-kw FTR transmitter. Right to left: Three-stag a-f amplifier; 7000-v. rectifier and fourth a- stage unit; and 3000-v. bias rectifier an modulator.

* * *

SHALLCROSS FUNGUS-PROOF RESISTORS

Akra-ohm fixed wire wound resistors an switches, treated with anti-fungus material which meet Signal Corps specifications 71-2202 are now available from Shallcross Manufactur ing Company, Collingdale, Pa.

* * *

ALTEC-LANSING MULTI-CELLULAR SPEAKERS

A multi-cellular speaker, with high and low frequency units, that is said to require less than 1½ cubic feet of space, has been develope by Altec-Lansing Corporation, 1210 Taft Build ing, Hollywood 28, California.

In the horizontal plane the speaker is sai to deliver 12 times the area distribution at high frequencies as compared to the usual single unit speakers of comparable size. Its horizonta area of distribution is 60°. In the vertica plane, its area of distribution is 40°.

In the multi-cellular high-frequency horn the voice coil is wound with rectangular alumi num wire and operates in a magnetic field o very high flux density, which is supplied b a recently perfected type of permanent magnet The aluminum alloy metal diaphragm is sai to provide mass stiffness and high velocity o transmission speed at least five times greate than through paper cone material. This high requency unit is designed to operate as a iston up to frequencies above the limit of udibility. The high frequency horn is a multi-ellular unit having six cells in a 2 x 3 con-guration. Each cell covers a 20° solid angle, which means a combined area of distribution in he horizontal plane of 60° and 40° in the ertical plane. The high frequency horn is povered with a sound deadening material and hounted in the face of the low frequency unit. ower from the high frequency unit is supplied hrough the pole piece of the low frequency nit.

The three-inch voice coil of the low frequency nit is also wound with rectangular wire, and perates in a magnetic field of very high flux ensity, which is supplied by the newly per-ected type of permanent magnet. The low requency voice coil assembly is mounted in 15" stiff paper cone resonant at 38 cycles.

The input impedance of the duplex speaker is) ohms and a dividing network of the con-ant impedance type is used with a crossover requency of 1200 cycles for separating the ower for each unit. This crossover point per-its the horn to adequately load the high requency unit down to a point where little ower is being transmitted. It also eliminates ny tendency to produce distortion effects as ell as prevent damage to the high frequency nit.

The speaker is available separately or mounted a walnut finished cabinet. The cabinet pro-ides eight cubic feet of air space. Special abinets for ceiling and sidewall mounting are vailable on request. A small compact 60 db ain amplifier with 15-watt output is also vailable for driving the speaker.

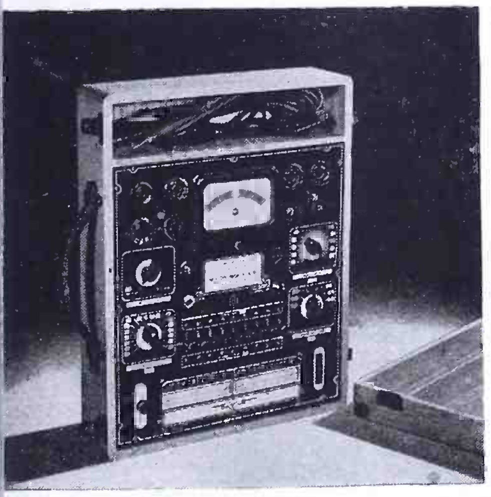
* * *

CP TUBE TESTER

tube tester, model 314, for testing octal, ctal, bantam jr., miniature, midget and all corn tubes has been produced by Radio City roducts Company, 127 West 26th St., New ork 1, N. Y. The filament voltage switch is esigned to test all present filament voltages om 1.1 to 117 volts.

Lever type switching individually controls ach tube prong, checks roaming filaments, ual cathode structures and multi-purpose tubes. eparate plate tests on diodes and rectifiers. leon short tests indicate leakage between any wo elements while the tube is hot. Rectangular eter, 4½", has "poor-good" scale.

Supplied in oak carrying case with handle r portable or counter use. Size, 14¼" x 13" x "; weight, 12¼ pounds.



* * *

GENERAL ELECTRIC FORMEX WIRE

ormex ribbon-rectangular magnet wire, avail-ble in shapes as thin as 0.004", has been an-ounced by G.E. The new Formex, being hade for the war program, is one-fourth the ze heretofore considered the low limit for hickness of this wire.

Because of its thinness, Formex ribbon-ectangular wire can be applied where round ire previously had to be used.

* * *

POTTER & BRUMFIELD RELAYS

Two relays, the KR, for applications where size nd weight are important factors, and the KL, ith approximately twice as much coil space nd a larger number of poles than the KR eries, are being made by Potter & Brumfield Mfg. Co., Inc., 104 North First Street, Prince-on, Ind. KL relays will operate on values as ow as .2 watt.

Unless otherwise specified, contacts are fine

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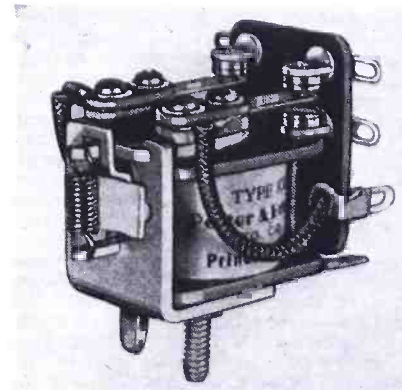
THE INDUSTRY OFFERS . . .

(*Continued from page 73*)

silver, rated at 3 amperes 110 v, 60 c, non-inductive. Contact arrangements up to and including double-pole double-throw. KRD-4 typ is 1 11/16" long, 1 ¼" high, 1 3/16" wide, no including mounting stud; weight, 1¾ to ounces. Designed to mount in two holes 7/16' center to center. One hole 3/16" diameter to accommodate a projecting lug and the othe approximately .140" diameter for a 6/32" mounting stud.

KLD-1 is 1 13/16" long, 1 13/16" high, 1 13/16' wide; weight 3½ to 4 ounces.



KR Relay

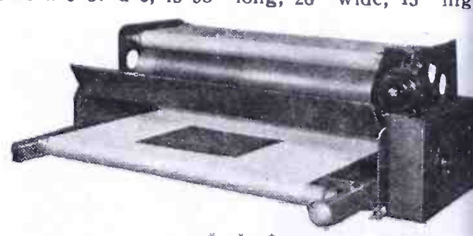
* * *

PECK AND HARVEY TABLE-TYPE CONTINUOUS PRINT DRYERS

An electrically heated dryer in two sizes handling blue or black and white prints of 26' and 44" width, has been announced by Peck and Harvey, 4327 Addison Street, Chicago 41, Ill.

In addition to standard heat regulation, the dryers, "B-8," are also equipped with variable speed drive motors and controllers. This is said to permit instantaneous speed changes over a range of 6" to 3½' a minute. On the 26" dryer 14 amperes are said to be consumed on 110 volts, 7 amperes on 220 volts; on the 44" dryer 23 amperes on 110 volts, 12 amperes on 220 volts.

The 26" dryer, 110 volt a-c or d-c, is 40' long, 28" wide, 13" high. The 44" dryer, 110 volt a-c or d-c, is 58" long, 28" wide, 13" high.



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KATOLIGHT REVOLVING FIELD GENERATORS

Revolving field generators, Katolight type, for 5, 10, 15 and 25 kw, in 4 pole (1800 rpm) and 5, 10 and 15 kw, 6 pole (1200 rpm) are now available from Kato Engineering Company Mankoto, Minnesota. Can be furnished as independent two-bearing generators suitable for belt or coupling drive or as single bearing generators designed to fit standard SAE engine bell housing. Voltage regulation is said to be approximately 10% with 2 cycle speed change.

Stator is built up of 26 gauge dynamo-grade core plate sheet steel laminations. Coils are form wound. Stators and rotors are preheated and dipped and baked in insulating varnish.

Rotor consists of pole pieces punched integral with each other from a single piece of 26 gauge dynamo-grade core plate sheet steel. Pole laminations are stacked under pressure and riveted together. Shaft is removable.

Cooling air of generator is supplied from a blower type cast aluminum fan of the split type which clamps onto the shaft. Machines are furnished with amortisseur or damper winding for parallel operation of two or more generators.

* * *

WHITE UNIVERSAL BRIDGE

A universal bridge affording measurement of resistance, capacity and inductance, is now available from W. R. White Research, 6 Boylston Street, Boston 15, Mass.

Resistance range is from 10^{-4} to 10^{10} ohms. Accuracy is said to be 1 ohm to 1 megohm within ½%, below 1 ohm and from 1 megohm to 100 megohms within 1%. Above 100 meg ohms the error is said to increase to 5%.

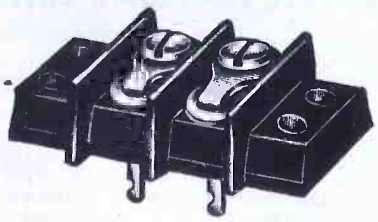
Capacitance range is from 10^{-6} to 100 microfarads. Accuracy is said to be 100 mmfd to

1 mfd within ½%; other ranges, within 2%.
Inductance range, with no d-c flowing, is from 10^{-6} to 100 henrys. Accuracy is said to be 100 mh to 1h, within 1%; other ranges, within 2%. With superimposed d-c, the range is .1 to 100 henrys; accuracy, within 2%.
Inductance of iron cored chokes and transformers can be measured with up to 500 ma of d-c flowing. Facilities for measurement of frequency, Q and power factor are included. The bridge contains a 1-megohm resistance decade in steps of one ohm.

* * *

JONES BARRIER TYPE TERMINAL STRIP

A barrier type terminal strip for connections both above and below the mounting surface has been designed by Howard B. Jones Co., 2460 W. George Street, Chicago 18, Illinois. It is identified as the "Y" type terminal. Mounts on standard barrier strips and permits a screw connection above the panel and a solder connection below.
The Y type terminal is made for the 140, 141 and 142 series barrier strips.
Bakelite body is of BM 120 compound according to Navy specifications 17P4 and the Y terminal is made of brass, tin plated.



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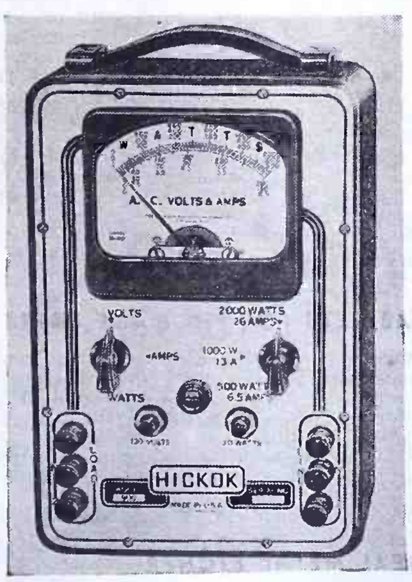
HICKOK VOLT-AMP-WATTMETER

A tester, model 900, that is said to operate at an extremely low range of 0-20 watts as well as the high range to 2000 watts has been produced by Hickok Electrical Instrument Company, 10529 Dupont Avenue, Cleveland 8, Ohio. Tests all electrical appliances from bell transformers and clocks to electric ironers and ranges operating on the 220 volt, three wire Edison system. Measures actual load values of volts, amperes, and watts. Overall dimensions are 9½" high, 6¾" wide, 3" deep; weight 8½ pounds; meter 4" square.



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DU MONT WIDE-RANGE OSCILLOGRAPH

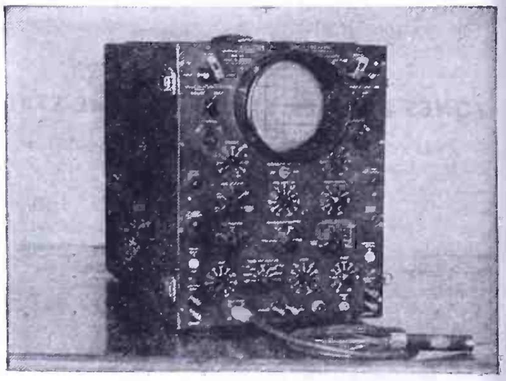
A portable oscillograph, model 248, suitable for lab or production-test purposes is now being produced by Allen B. DuMont Laboratories, Inc., Passaic, N. J. Oscillograph and a power supply are connected by a 6-foot plug-in shielded cable. The power supply weighs 80 pounds; oscillograph, 30 pounds. Units each measure 14"x18"x21".
This instrument reproduces either transient or recurrent phenomena. Also accommodates phenomena of inconstant repetition rate. The accelerating potential applied to cathode-ray tube is said to be great enough to permit study of extremely short pulses with low repetition rates. Timing markers are available for quantitative or calibration purposes.
Oscillograph also features wide band vertical axis amplifier usable to 10 mc. Delay network

(*Continued on page 76*)

THE INDUSTRY OFFERS . . . —

(*Continued from page 75*)

in vertical channel permits observation of entire wave shape of short-duration phenomena. Also has a trigger output signal for "synchroscope" application.



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TRIGNITROL ELECTRONIC SWITCH

An electronic switch designed to supersede mechanical switching on capacitor welders, has been developed by Electronic Power Company, Inc., 67 Seventh Avenue, Newark, N. J. The switch, known as the Trignitrol, is said to provide an instantaneous peaked discharge that welds with minimum damage to metal grain structure and no burning of surrounding metal. Further, the total capacitance required is substantially reduced.

The Trignitrol utilizes the Trignitron, a mercury pool conduction tube, fired capacitively by a low power trigger circuit. The control circuit must be reopened before the Trignitrol will recycle but speed of operation is only limited by the condenser recharging intervals.

Power supply is standard 110 or 220 volt, 60 cycle a-c.

This device and the Trignitron are licensed for exclusive use in welding equipment under the U. S. Pat. 2,287,541.

* * *

NIGG FASTENER STUD

A fastener stud with an adjustable range of nearly one-half inch, has been developed by Nigg Engineering Co., Covina, California.

The fastener stud is said to accommodate total sheet thicknesses from .021" to .500", yet locks and unlocks with only a quarter turn. The adjustment is controlled by a central screw which moves a sliding crosspin sleeve through a range of .471". The adjustment is made from the outside to any desired tension and locking torque.

All outside measurements of the fastener stud conform to standard dimensions, making it replaceable with all snap or spring type fasteners now in use.

Samples of the -5 oval and flush head and -7 flush head sizes and installation data are available to manufacturers.

* * *

CABINETS FOR PIN GAGE USERS

Cabinets furnished with precision pin sets, number drill, letter drill and fractional sizes, have been announced by United Precision Products Company, 3524 West Belmont Avenue, Chicago 18, Illinois.

Cabinets have drill sizes 1 to 60, letter drill sizes A to Z, (86 pins) and fractionals 1/64" to 1" in increments of 1/64".

Size, 9⅞" wide, 15½" long and 4½" high.

* * *

IDEAL METAL ETCHER

A 4-ounce metal etcher has been developed by the Ideal Commutator Dresser Company, 4025 Park Avenue, Sycamore, Illinois.

Depth of mark is controlled by etching heat and speed of writing. Four etching heats are 120, 240, 420 and 700 watts.

In addition to the standard four-ounce etching tool, a small two-ounce tool is also available for marking thin delicate parts. Overall size, 7¼"x5⅛"x8½"; weight 16 lbs.

* * *

FEDERAL U-H-F SIGNAL GENERATORS

U-H-F laboratory type signal generators for from 7.6 to 330 megacycles have been announced by Federal Mfg. & Engineering Corp., 211 Steuben Street, Brooklyn 6, N. Y. Frequency calibration is said to be accurate to plus or minus 2%; voltage output is said to be controlled by calibrated attenuator network for control of from 1 to 20,000 microvolts.

Output is arranged so that an internal source of modulation at a frequency of 1,000 cycles may be used. Or, by use of an incorporated switching arrangement, external sources of nodulation may be used between 30 cycles and),000 cycles, adjustable from 0 to 60%, in-icated by a direct-reading modulation meter.

Circuit-switching device is said to make it ossible to modulate the generator from an ex-ernal source, with a pulse modulation having eep wave fronts and extending in rapidity o pulses of about 20 microseconds.

Stabilized power supply incorporated in the nit for operation at either 115 volts or 230 olts a-c; 40 to 60 cycles, single phase.

Enclosed in walnut cabinet, weighs less than pounds. Supplied with 3 foot coaxial output ıble of 75 ohms impedance; fixed 10:1 attenu-ion reduction unit, special terminal unit, dapter plug, line cord, extra blank plug-in oil form, spare pilot lamps, fuses, and one set 4 operating tubes. Models are known as 04-CS1 and 804-CS2.

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HARCO STEEL ANTENNA TOWERS

Four-foot square steel sections for antenna ower use, have been designed by the Harco teel Construction Company, Elizabeth, New ersey.

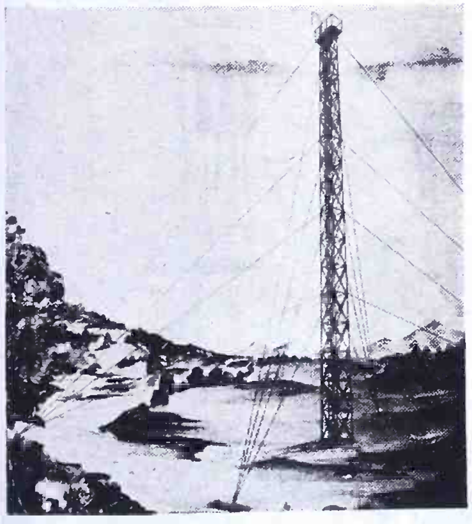
The four-foot sections are six feet in height, ach six-foot sectional square weighing 112 ounds.

A thirty-foot tower weighing 596 pounds, less he base, ladders, boom and platform, occupies packing space of only eight cubic feet. A fty-foot tower, 998 pounds, occupies fourteen ubic feet and a one-hundred foot tower, weigh-ng 2154 pounds, occupies thirty cubic feet.

Three men can erect the thirty-foot tower in wo hours, according to Harco experts.

Each Harco tower includes in its equipment, ase, fittings, turnbuckles, guys, ground an-hors, boom, winch, platform, platform frame. The top platform measures four by eight feet.

The towers, known as Bantam King, are said o be suitable supports for f-m and u-h-f adiators, rotary or stationary beam and array ntennas, etc.



* * *

NYLON SHEETS

Nylon sheets, recently produced by DuPont, have been fabricated into special coil supports by Frintloid Inc., of 91 Mercer Street, New York 12, N. Y. It is expected that when the upply of Nylon becomes sufficient for all needs, t will make its appearance in the form of ods, sheets and tubes.

* * *

RCA MULTIPLIER PHOTOTUBES AND HI-MU TRIODES

A 9-stage, electrostatically focused, ultraviolet-sensitive multiplier phototube, 1P28, and a miniature duplex-diode high-mu triode, 6AQ6, have been made available by the RCA Victor division of RCA.

The 1P28 has the same size and general appearance as the 931-A but is constructed with a special glass bulb which transmits radiant energy in the ultraviolet region down to about 2000 angstroms.

The 6AQ6 is similar to the metal type 6Q7, but requires only half the heater current and has appreciably lower grid-cathode and plate-cathode capacitances. Designed for use as a combined detector, amplifier, and automatic-volume-control tube.

* * *

GIRDLER H-F HEATER

Automatic high frequency equipment for pre-heating of plastic preforms has been produced by the Thermex division of the Girdler Corporation, Louisville, Kentucky. Known as the 2-P Thermex, it operates at 25 to 30 megacycles. Using 230-volt, 60-cycle, single phase current this model is said to have an output in excess of 3400 btu per hour. Measures 28" x 28", 47" high; weighs 614 pounds.

Closing of preform drawer turns on the power and timer. At the end of the prescribed time, which may be anywhere from 5 to 10 seconds up to 2 minutes, a red indicating light goes out, operator removes tray, and unloads preforms into mold cavities.

* * *

EUTECTIC WELDING ROD

A gas welding rod, 195, for repairing zinc base die castings, is now being marketed by Eutectic Welding Alloys Company, 40 Worth Street, N. Y. 13, N. Y.

The rod has a lower melting point and a still lower bonding temperature than the original alloy. The improved rod is said to be easier to build up with, and matches the hardness of the die castings.

* * *

S-D IMPULSE-INITIATED TIMER

An impulse-initiated timer, 3½"x3⅝"x3¾", has been introduced by Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.

Known as the type PSEH-1 timer, it is made in both a-c and d-c types. The adjustable timing range is 20-to-1, and the mechanism is immediately recycling. A built-in double-pole,

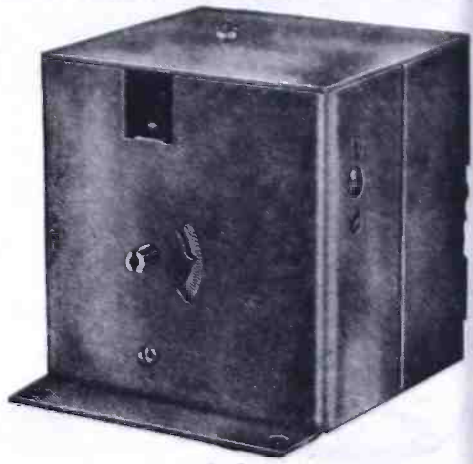
(*Continued on page 78*)

THE INDUSTRY OFFERS . . .

(*Continued from page 77*)

double-throw auxiliary relay provides a variet of circuit arrangements common to, or isolate from, the control circuit.

Timers can be supplied for a-c operation o 110 v, 60 cycles or 25 cycles; 220 v, 60 cycles o 25 cycles; or for d-c operation at any specifie voltage from 6 to 120 volts.



* * *

FTR 25-KW INDUCTION HEATING UNI

A 25-kw Megatherm induction heating uni particularly adapted to high speed inductio surface hardening of such parts as bearing sur faces, cam faces and gear tooth contours, ha been introduced by the Industrial Electronic Division, Federal Telephone and Radio Corpora tion, Newark, New Jersey.

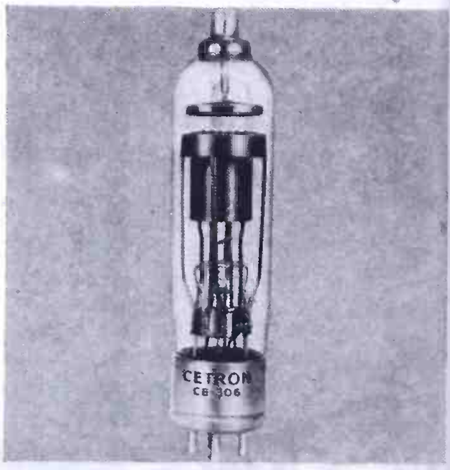
The unit is designed to deliver 25 kw o output continuously at frequencies adjustabl within a 2 to 5-million cycle range. The powe factor of Megatherm is said to be 95%.

The unit measures 4'x4'x7'.

* * *

CONTINENTAL CE-306

A gas-filled grid control tube, CE-306, has bee announced by the Continental Electric Com pany, Geneva, Illinois. The control tube o thyratron is rated at 6 amperes continuou load; peak forward volts (max.) 750; peak in verse volts (max.) 1250. Height is 9½" diameter, 2".



* * *

TRAV-LER CHEST SET

A chest set consisting of a chest unit, equippe with a switch; junction box; two cotton web bing straps; and two cords for connecting throat or a lip mike to a transmitter, is bein manufactured by the Trav-ler Karenola Radi & Television Corporation, 1036 West Van Bure Street, Chicago, Illinois.

The chest unit has a toggle switch whic has three positions—on, off, and momentaril on.

The cord which connects to the microphon is a two-conductor stranded copper wire cor and has a JK-48 jack on one end. The othe cord which is plugged into the transmitter i three-conductor tinsel cord with a PL-58 plu on one end.

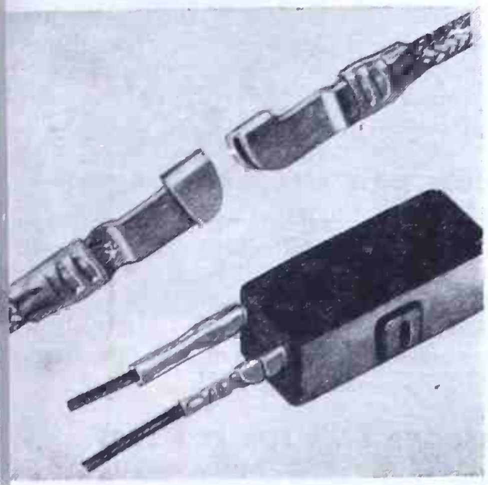
* * *

AMP KNIFE-DISCONNECT TERMINAL

Solderless knife-disconnect terminals for con nection and disconnection to contacts of smal switches have been produced by Aircraft Marine Products, Inc., 1591F North Fourt Street, Harrisburg, Pa.

Switches with tabs extending from contact to which external connections are soldered ma be converted to disconnection switches by re placing the contact members with members mbodying knife-disconnect ends instead of oldering tab.

Switches which have screws or binding posts r external connection may be converted by stening on these screws a disconnect tab designed to fit the particular application.



* * *

EFFERSON FLUORESCENT LAMP ALLASTS

luorescent lamp ballasts for either bottom or d leads are being manufactured by Jefferson lectric Company, Bellwood, Illinois. Insulated ushings set at an angle protect the leads in ther case. A two-lamp 40-watt size is now in roduction with other popular capacities available in the near future.

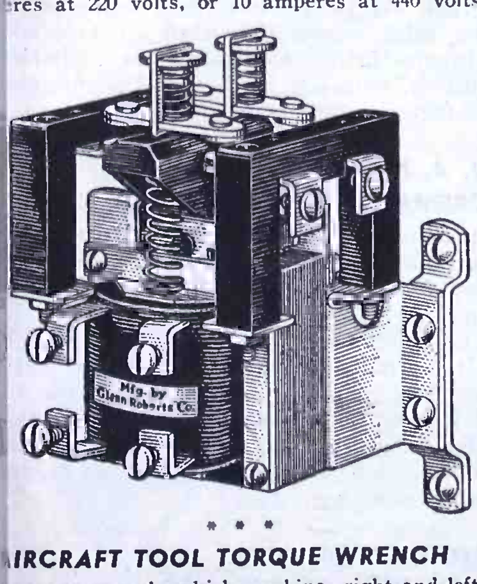
* * *

LENN-ROBERTS RELAY-CONTACTORS

relay-contactor for heavy-duty circuit control has been developed by Glenn-Roberts Company, (Electronics Division), 1009 Fruitvale venue, Oakland 1, California.

In the unit, a vertical solenoid, actuated by coil mounted on a relay core frame, operates moulded bridge carrying heavy-duty spring-aded contact bars on which silver alloy concts are mounted. Matching silver-alloy concts are mounted on a double-break wiping ction. The contact-carrying bridges are so esigned that additional decks may be inrporated. Units for normally closed, norally open or double-throw operation.

Single or dual-voltage operating coils for all andard voltages are available. Standard units e rated at 30 amperes at 110 volts, 20 amperes at 220 volts, or 10 amperes at 440 volts.



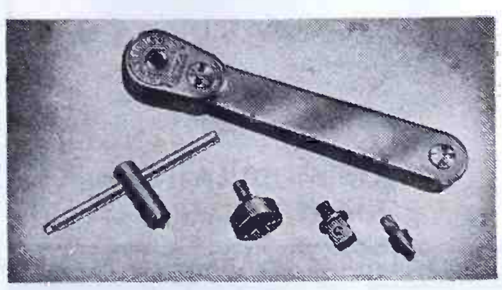
* * *

IRCRAFT TOOL TORQUE WRENCH

torque wrench, which combines right and left-and torque in one wrench, has been developed y Aircraft Tools, Inc., 750 East Gage Avenue. os Angeles 1, California.

The wrench is full ratchet so that when desired tension is reached, positive break-away occurs one notch at a time. Torque is set in specified inch pounds.

Handle is chromium-plated, Zamak die cast to fit hand. Weight, 11½ ounces.



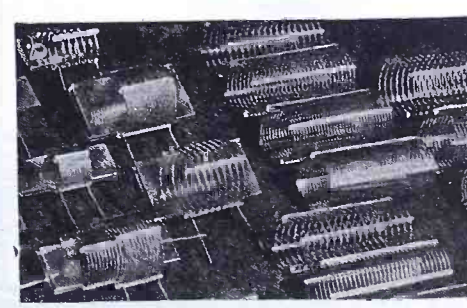
* * *

B-W MINIATURE H-F INDUCTOR COILS

Miniature air inductor coils for h-f applications have been introduced by Barker and Williamson, 235 Fairfield Ave., Upper Darby, Pa.

Regularly supplied in diameters from ½" to 1¼".

Any type of mounting can be supplied. Can be equipped with fixed or variable, internal or external coupling links. There are 5 standard diameters and each diameter is available in any winding pitch from 44 to 4 turns/inch, or less if required. Wire sizes range from 14 to 28, and almost any desired type of wire can be supplied.



NEWS BRIEFS

(*Continued from page 71*)

Accessories Corporation, Kansas City, Kansas. Operations of the Besler brake division are being moved from Emeryville to Burbank, California, and will be incorporated with AAC's power controls division.

* * *

COLE NOW RMA DIRECTOR

S. I. Cole, president of Aerovox Corporation of New Bedford, Massachusetts, has been elected a director of the Radio Manufacturers Association, parts division, for a two-year term. Mr. Cole was a member of the Executive Committee of this division during 1943.

* * *

SECOND STAR FOR RCA LABS

RCA Laboratories, Princeton, New Jersey, has received a second white star for its Army-Navy "E" flag.

* * *

DEE BREEN APPOINTED LITTELFUSE WESTERN S-M

Dee Breen, plant production manager for Littelfuse, Inc., 4757 Ravenswood Avenue, Chicago 40, has been promoted to the post of western division sales manager, with headquarters at the company's plant in El Monte, California. Mr. Breen was formerly connected with the Chrysler Corporation, and the Army-Navy Electronic Production Agency.

Dee Breen, left, Western division sales manager, and T. M. Blake, secretary and treasurer, Littelfuse, Inc.

* * *

BAILEY NAMED OPERADIO SALES ENGINEER

Frank A. Bailey has been appointed to the sales engineering staff of Operadio Manufacturing Company, St. Charles, Illinois, to assist in the field engineering of factory equipment.

* * *

N. A. PHILIPS ORGANIZATIONAL BOOKLET

A 28-page illustrated booklet describing activities and products, has been issued by the North American Philips Company, Inc., 100 East 42 Street, New York 17. The booklet lists the company's plants in Mt. Vernon and Dobbs Ferry, New York and Lewiston, Maine, and relates the activities of these plants in their production of piezoelectric quartz crystals, electronic tubes, special communications devices, and other items.

* * *

ROSTRON OF RCA COMMUNICATIONS DIES

John B. Rostron, vice president and traffic manager of RCA Communications, Inc., died recently. Mr. Rostron was a veteran of fifty-two years service in international communications, the past twenty-four of which were with RCA.

* * *

FRAME AND PITTS JOIN HOFFMAN RADIO

Allen Frame, formerly with the Army Signal Corps as resident inspector-in-in-charge of the Universal Microphone Company, and Vaughn M. Pitts, vice president of the Standard Parachute Company of San Diego, have joined the staff of Hoffman Radio Corporation, Los Angeles. Mr. Frame becomes special assistant to the company's chief inspector; Mr. Pitts, the company's cost accountant.

* * *

HIGGINS AD DIRECTOR FOR COLLINS

Alfred K. Higgins has been appointed director of the advertising department at Collins Radio Company, Cedar Rapids, Iowa. Mr. Collins was previously associated with N. W. Ayer & Son and Young & Rubicam.

* * *

WRGB TELEVISION REVIEW ISSUED BY G. E.

A 24-page booklet, *Television at WRGB*, has been released by General Electric Company, 1 River Road, Schenectady, New York. Highlights of G. E.'s television history from 1926 to today are covered, along with a discussion of WRGB's engineering and programming techniques, and a brief comment on the future of television.

* * *

TWO-WAY F-M TRAIN RADIO INSTALLED BY GALVIN

Marion Bond of the Motorola engineering staff and Ernest R. Dahl, engineer for the Rock Island Railroad, were commended recently for their successful installation of two-way f-m radio on the Rock Island trains. The equipment was designed and built by Galvin Manufacturing Corporation.

* * *

MICROCOPY TRANSLITE HI-REDUCTION MICROFILM PROCESS

A *translite hi-reduction* process for microfilming engineering drawings, records, documents, maps, or other valuable papers, has been developed by Microcopy Corporation, 2800 West Olive Avenue, Burbank, California. The process is described in a bulletin, *Hold Everything*, recently released by the company. Also described is the new Microcopy multiple-magnification viewer which enlarges the microfilm reproductions for reading.

* * *

MAGAZINES, INC., TO REPRESENT CARTER MOTOR

The Carter Motor Company, 1608 Milwaukee Avenue, Chicago, recently appointed Magazines, Inc., of Chicago to act as public relations counsel. Carter is planning a campaign devoted to postwar uses of portable hand generators.

* * *

FTR BOOK ON WORLD BROADCASTING SYSTEM PROPOSAL

A 40-page book entitled *Beyond Our Shores the World Shall Know Us*, discussing the promotion of better world understanding through international

(*Continued on page 82*)

NEWS BRIEFS

(*Continued from page 81*)

broadcasting, is being distributed by the Federal Telephone & Radio Corporation, 67 Broad Street, New York 4, New York. The book describes and illustrates a proposal, submitted to U. S. government authorities a few years ago, for the establishing of an American short-wave super-broadcasting system consisting of 12 200-kw stations, capable of complete world coverage. Frequencies of 6 to 21 mc are recommended.

Federal's purpose in publishing this book is indicated in their belief that comprehensive broadcasting facilities are essential to the promotion of American prestige abroad.

* * *

F. C. ESTEY JOINS BURTON BROWNE

F. Clifford Estey is now with Burton Browne Advertising, 150 East Superior Street, Chicago, as assistant to Burton Brown. Before coming to BBA, Mr. Estey was assistant general manager for American Zinc Products Company, and previous to this, sales engineer of the radio division of Aluminum Company of America, assistant to the president of United Reproducers Corporation, and assistant to Powell Crosley.

* * *

WESTINGHOUSE PLASTIC DEVELOPMENTS

A moisture-proof plastic, Fosterite, which seals parts against harmful moisture, was recently given a first public showing in New York City by Westinghouse specialists.

The plastic was named for Newton C. Foster, 29-year-old Westinghouse chemist, who developed it after several years of intensive research.

Fosterite requires no liquid solvent which would evaporate during the heat-

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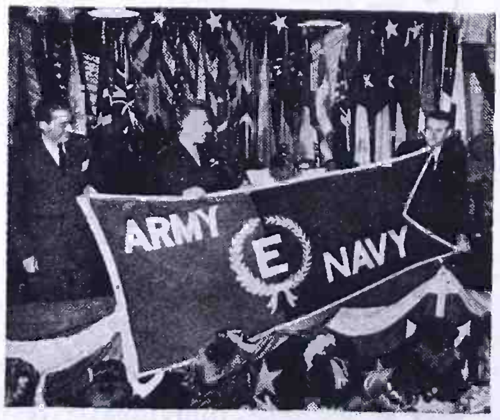
LEWYT WINS "E"



The Lewyt Corporation, 60 Broadway, Brooklyn 11, N. Y., have been awarded the Army-Navy "E." Presentation of the award was made by Col. W. E. Richards, Air Corps, U. S. Army, to Alex M. Lewyt, president of Lewyt Corp.

ing process and cause tiny cracks to appear. To demonstrate the plastic's waterproof qualities, the Westinghouse experts submerged a Fosterite control transformer completely in a jar of water. An electric light bulb attached to the transformer continued to glow brightly.

Forming of heated laminated plastics into complicated shapes with a new material, Micarta 444, was also demonstrated.

The new plastic was shown to be as tough and reliable after it has been shaped, as before. A one-inch square bar of the material will stand a tensile "pull" of 13,000 pounds and can carry a compression load of 30,000 pounds without cracking. At temperatures as high as 170 degrees Fahrenheit it will not wilt and even gains in impact strength.

* * *

DR. POWER RETURNS TO CONSULTANT DUTIES

Dr. Ralph L. Power has returned to his offices at 407 Van Nuys Building, Los Angeles, after service since 1942 with the San Francisco Signal Corps Inspection Zone. Dr. Powers has been a radio consultant for more than a decade.

* * *

LEWYT BROCHURE

A 48-page loose-leaf book describing products and projects completed during 50 years of manufacturing has been published by Lewyt Corporation, 60 Broadway, Brooklyn 11, N. Y.

Described and illustrated are departments devoted to product engineering, tools and dies, machine work, sheet metal, welding techniques, electrical and mechanical products, etc.

* * *

EBEL OPENS CONSULTING OFFICE

A. James Ebel, chief engineer of WILL, University of Illinois, has entered the consulting engineering practice with an office at 1113 West Washington Street, Champaigne, Illinois. He will specialize in a-m/f-m broadcast activities.

* * *

IRE-RMA MEETING IN NOVEMBER

The annual Rochester Fall Meeting of the RMA Engineering Department and the Institute of Radio Engineers will be held on November 13 and 14 at the Sagamore Hotel, Rochester, New York.

* * *

STEVENSON NAMED SECRETARY OF UTAH

William J. Stevenson, general counsel for Utah Radio Products Company, 816 Orleans Street, Chicago 10, has been appointed secretary of the company.

MULTIVIBRATORS

(*Continued from page* 40)

and *n* are small whole numbers. In the laboratory this ratio has been made as small as 1 to 50. For practical purposes the product *m* times *n* will never exceed 10. In most cases the multivibrator frequency will be a direct submultiple of the controlling frequency, i.e., $m = 1$.

The synchronizing voltage may be introduced almost anywhere in the circuit. For purposes of discussion, suppose it is introduced in series with the grid of V_1. The grid voltage may then be as shown in Figure 5. Conduction would normally have transferred at time *B*. Now, however, it transfers at time *A*. If the next transfer of conduction comes at the same phase of the control cycle but 3 cycles later, the ratio $m/n = 1/3$. If the control had skipped a multivibrator cycle, the ratio $m/n = 2/3$. If the control voltage is increased, there will be some voltage at which the ratio changes. In general, as the control voltage increases, the product *mn* decreases.

A satisfactory means of designing a controlled multivibrator is to design the multivibrator with a natural frequency slightly less than the controlled frequency. Then we can find experimentally the upper and lower values of control voltage to give the desired frequency; we can operate halfway between these limits.

Principal applications of multivibrators are to obtain a series of accurate frequencies for calibration purposes and to obtain accurate time standards. For instance, a multivibrator controlled at 50 kilocycles by a 500-kilocycle crystal oscillator has harmonics at 50, 100, 150 kc, etc., all as accurate as the original crystal frequencies. By cascading multivibrators each controlling the following one, it is possible to reduce a crystal frequency to an audio frequency and use this to drive, for instance, a synchronous clock. By proper attention to the design of the crystal oscillator, this clock may be made to vary less than half a second a day.

Bibliography

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Hull, L. M., and J. K. Clapp, *Convenient Method for Referring Secondary Frequency Standards to a Standard Time Interval,* IRE Proc., pp. 252-71; Feb. 1929.

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Terman, F. E., *Radio Engineers' Handbook,* McGraw-Hill Book Co.

F-M/A-M ANALYSIS

(Continued from page 36)

rating, since in f-m it is not necessary to account for peak power.

F-M transmitter design, therefore, allows the use of smaller components for the same power output, as compared with a-m, and smaller installed tube capacity in the modulator stage as well. This makes for more economical operation and greater equipment dependability, since there are no peaks of amplitude modulation to overload the components. As a matter of fact, in the Armstrong modulator practically all the tubes used in the modulator unit are of the receiver type.

In f-m transmitter design it is possible to apply 60-cycle a-c, single phase, directly to the filaments of the class C amplifiers following the modulator, and the noise level can be kept within limits without the use of inverse feedback.

Inverse Feedback

In many high power a-m transmitters it is usually necessary to employ considerable inverse feedback over the power stages to maintain the noise level within the limits prescribed by the FCC. In the higher powered f-m transmitters now in operation, no inverse feedback is used anywhere. And the noise level, without feedback, is regularly measured as better than 60 to 70 db below the carrier level.

Generally, less power can be used in f-m than in a-m to effectively cover the primary service area of a station. In a-m broadcasting the primary service area is determined by the 500-microvolt per meter contour. In f-m broadcasting the primary service area is determined by the 50-microvolt per meter contour. This is due to the fact that less field voltage is required to develop a satisfactory signal at the receiver output in view of the absence of a-m noise which any a-m transmission system must override. Thus, less transmitter power can be generally used to efficiently service a given area, except of course, in mountainous areas.

F-M has worked up to the second and third horizons, due to slight refraction of the wave along the earth's surface. Lower power consumption from the power line was another economy factor noted during the study. Only 109 kw are required for the 50-kw amplifier such as the G.E. type. This results in smaller and less expensive transformer substation equipment at the transmitter.

Another economical factor is the smaller water cooling system required for the r-f stages. This is due to lower

(Continued on page 86)

(Continued from page 85)

plate dissipation when operating tubes at class *C* telegraph ratings.

The distortion, noise, and frequency response characteristics of a given f-m transmitter was found to hold constant over a longer period than these same constants in an a-m unit. This is because no peak power is present to overload, heat up, and change the electrical values of circuit components; also, because no inverse feedback is necessary to reduce distortion and noise level.

In one 40-kw f-m installation we found that no distortion, noise or frequency response measurements had been made for fifteen months. This was due to the pressure of important research work that was assigned to the staff. But, notwithstanding the fact that the transmitter kept a schedule every day during this period, the characteristics had not appreciably changed during all these months, and when measurements were made, it was still delivering a high fidelity signal into the turnstile well within the FCC performance requirements. This does not imply that routine quality measurements should not be made on f-m transmitting equipment, but it does indicate the dependability of the equipment and its circuits.

There are 85 a-m stations operating in the United States on the frequency of 1400 kc; 81 of these stations are 250-watt outlets, and 4 operate with 100-watt outputs.

The FCC-allocation plan for such local stations is based upon the following signal-strength data:

Time	Signal (microvolts/m)	Range miles	Possible Interference at that Range (microvolt signals)
Day	500	13	25
Night	4000	4.8	200

This data was taken from FCC records and assumes an antenna height of 331 feet. The FCC mileage separation for allocation purposes is 173 miles.

In comparison, a 250-watt f-m station with a single bay antenna 331 feet high, would have a corresponding *day* and *night* range of 29 miles to the 50-microvolt-per-meter contour. An f-m signal of 50-microvolts per meter is considered equal or better than a 500-microvolt-per-meter a-m signal.

The range of a-m station interference is variable over wide limits with time of day, time of night, seasons of the year, and conditions of the ionosphere (sun spots, northern lights, etc.). This is not true for f-m transmission. The necessary signal-to-noise or interference ratio for clear reception is 100 to 1 in a-m, and only about 2 to 1 in f-m.

Another interesting fact disclosed was that an f-m link between transmitter and studio can be used to advantage by both a-m and f-m stations. With low power (about 25 watts in the average installation) and with a directional receiving and transmitting antenna of small physical size (but with a power gain of 10 to 1 in the forward direction), which makes the 25 watts equivalent to 250 watts of power in the useful direction, wire lines can be eliminated connecting these points, and with higher fidelity transmission than can be had economically with line transmission. Such a system won't go out in storms, and is far more dependable than wire links.

Incidentally, due to the absence of peak power at high percentage modulation in f-m, coaxial lines, connecting the transmitter output with the antenna system, can be of smaller diameter. This is an advantage when considering installation costs, particularly if the antenna is some distance from the transmitter building.

High gain f-m antenna systems have been developed. These permit lower installed transmitter power. For instance, a four-bay G.E. f-m circular antenna, also known as the *doughnut* antenna, has a power gain of 4.26, which means that if 10,000 watts of installed transmitter power are provided, the station employing this four-bay antenna system would have a power output equivalent to 42,600 watts. The single-bay antenna of this type has a power gain of .841, the two-bay antenna a power gain of 2.0, and the eight-bay antenna of this type has a power gain of 8.71. With antennas of such power gain, economies can be effected in installation costs. For instance, a 10-kw G.E. f-m transmitter sold for $23,000 before Pearl Harbor,

(*Continued on page* 88)

A-M/F-M ANALYSIS

(*Continued from page 87*)

and a four-bay G.E. circular antenna sold for $6,000. However, if 10-kw of f-m power were required for a given installation, it might be well to buy a 3-kw transmitter at $12,833 since, when employing the $6,000 four-bay antenna with a power gain of 3.47, only $18,833 would be invested, as compared with $23,000 for the ten-kw transmitter and a simple antenna of the Franklin type.

FCC V-H-F BURST TESTS

(*Continued from page 61*)

as compared with the bursts in the f-m band.

Report to RTPB

In accordance with a commitment made when the FCC met November 17, 1943, with representatives of the Radio Technical Planning Board, the Interdepartment Radio Advisory Committee, and the Board of War Communications to discuss organization and procedure to be followed in postwar planning, the Commission has made a preliminary report on bursts in the f-m band to the RTPB.

Commission engineers are continuing their observations and it is hoped data will be obtained which may serve as a basis for approximating the amplitudes and numbers of the bursts to be expected at various distances from a transmitter at any given time. This determination involves not only a long-time measurement of burst amplitudes from f-m stations, but measurements as well of the path lengths and directions of arrival of the signals, in order to identify the medium causing the bursts.

CATHODE-RAY TUBES

(*Continued from page 46*)

wide range; time lag can be in the order of a few microseconds up to a matter of minutes. In the so-called fast screens, blue (calcium tungstate) gives a time lag in the order of microseconds. Green (zinc orthosilicate) screens provide decay periods in the order of milliseconds and are termed medium persistence screens; this is also true for white screens. For television, a mixture of zinc sulphide and zinc beryllium silicates is usually used. The first material gives a blue fluorescence and the second provides yellow fluorescence; together they produce white. Here, it is important that persistence of each color be nearly the same so there will be no separation of color which would show as a yellow or blue after-trace.

Zinc orthosilicate can also be treated with other activating agents to increase the decay period. Such mixtures make the screen more suitable for photographic work. Decay periods can thus be increased four to five times that of normal medium persistence screen characteristics.

There are various methods used for applying screens. The settling technique is perhaps the oldest. It involves placing a liquid in the tube, then pouring in a second solution having the fluorescent material in suspension. Then, after the powder is deposited the solutions are syphoned off and the tube is baked. The settling process is slow and must be conducted in a vibration-free location, otherwise the powder will be deposited unevenly.

Another method for applying screen material, that is commonly used in Europe, coats the inner face of the tube with a binder solution and then dusts on the fluorescent powder while the tube is being rotated. The excess powder is then poured out. Instead of applying the powder in bulk, a dust gun can be used. This results in a more uniform coat of fluorescent material.

High Pressure Liquid Sprays

A third method of applying the screen to a tube makes use of a high pressure liquid spray. This is a rapid process and lends itself well to mass production. The complete interior of the glass envelope is coated and then the excess fluorescent material is wiped out so as to leave only the end of the tube covered.

Efficiency of screens depends to a great extent on density or opaqueness. The electron beam does not penetrate the fluorescent material but only activates the inside surface. Therefore, the intensity of the trace on the face of the tube is less than that on the inside. Thickness of the fluorescent coating affects transmission to the outer surface. Thus the transmission factor must be kept low and within fixed limits (50 to 60%). If this factor goes above 60%, the glow from the cathode can be seen through the screen. This is objectionable when viewing waveforms or patterns.

Uniformity of Screens

Screens must also be uniform and free from blemishes, otherwise the pattern or picture will be marred. Since the fluorescent coating is very sensitive after the first application, subsequent treatment must be carefully controlled so that burning and discoloration will not result. Pattern marks are very easily burned in most screens. This results from permitting the electron beam to remain in one position for too long a period. For this reason, extreme care must be taken to avoid this in processing and in use.

[*To be continued*]

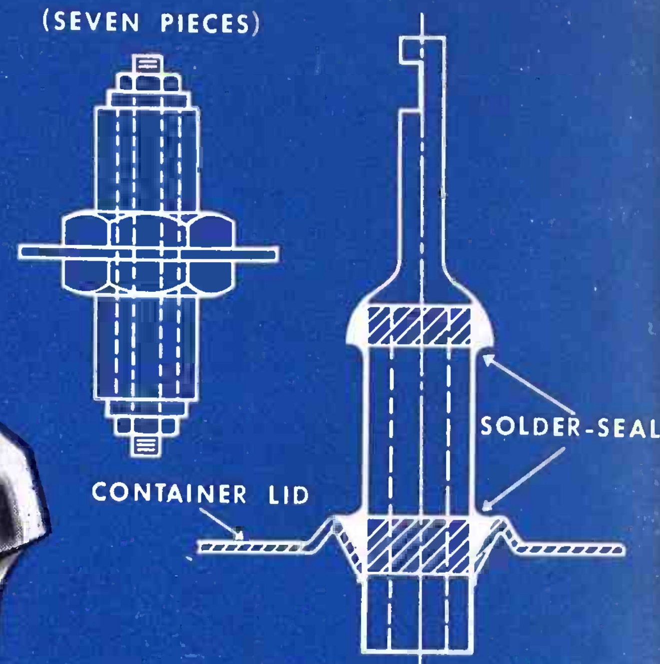
ADVERTISERS IN THIS ISSUE*

COMMUNICATIONS—JULY, 1944

*Due to paper restrictions several advertising pages had to be omitted from this issue.

HERMETIC SOLDER-SEALING MAKES PRESTITE TERMINAL BUSHING

Leakage-proof



Westinghouse Solder-Sealed PRESTITE Terminal Bushing, S # 1309164.

ACTUAL SIZE

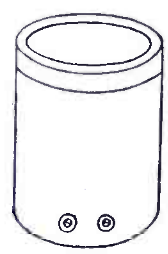
High altitudes . . . humidity condensation . . . thermal shocks . . . cannot affect the performance of Solder-Sealed apparatus. The 100% hermetic bond assured by the metal-to-PRESTITE seal assures trouble-free service of terminal bushings.

The bushing consists of a PRESTITE tube on which are Solder-Sealed a terminal cap and a stud. Similar bushings are available without hardware for Solder-Sealing to other parts on the manufacturer's own production line.

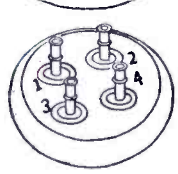
Solder-Sealed PRESTITE assemblies offer immediate help to manufacturers in many available standard forms. They also open up many new and added possibilities in postwar uses. For complete information, send for booklet B-3244. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N.

J-05142

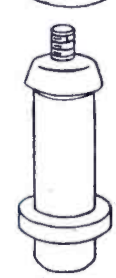
Other PRESTITE methods of taking leads through partitions



APPARATUS ENCLOSING SOLDER-SEAL BUSHING—combination insulator, cover and terminal board—has a hollow construction which permits placing small devices inside.



SOLDER-SEAL ASSEMBLY—for vibrator packs, but can be used in similar apparatus, combining jack and terminal board.



SOLDER-SEALED BUSHING—for use with thicker gage covers of larger size transformers and capacitors. Bushing is Solder-Sealed to a metal ring which is soldered to the container cover.

PRESTITE is a dense nonporous ceramic compacted under high pressure and vacuum by the patented PRESTITE method of manufacture. This eliminates minute air pockets in the material, thus minimizing distortion in voltage gradients and eliminating internal corona discharges. PRESTITE is impervious to moisture and all chemicals except hydrofluoric acid. The quality of PRESTITE is consistently uniform, thus eliminating the need for the exaggerated safety factors common in other ceramics.

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