COMMUNICATIONS

JANUARY

★ RADIO ENGINEERING
★ MODERNIZED RADIO TUBE SYMBOLS
★ PHASE MONITORS
★ 225.6-MC A-M RELAY TRANSMITTER
★ ANNUAL INDEX
★ AIRCRAFT COMMUNICATIONS

1944

WHY

AMPEREX

WATER AND AIR COOLED
TRANSMITTING AND RECTIFYING TUBES

Original ***Amperex*** design and construction refinements result in trouble-free performance of ***Amperex*** tubes . . . effecting natural economies in the operation of transmitting equipment. With replacements difficult to obtain, the extra hours of life inherent in ***Amperex*** tubes are often "priceless." To engineers, everywhere, this ***"Amperextra"*** factor of longevity is the major consideration.

HASTEN THE PEACE . . . BUY ANOTHER WAR BOND TODAY

AMPEREX ELECTRONIC PRODUCTS

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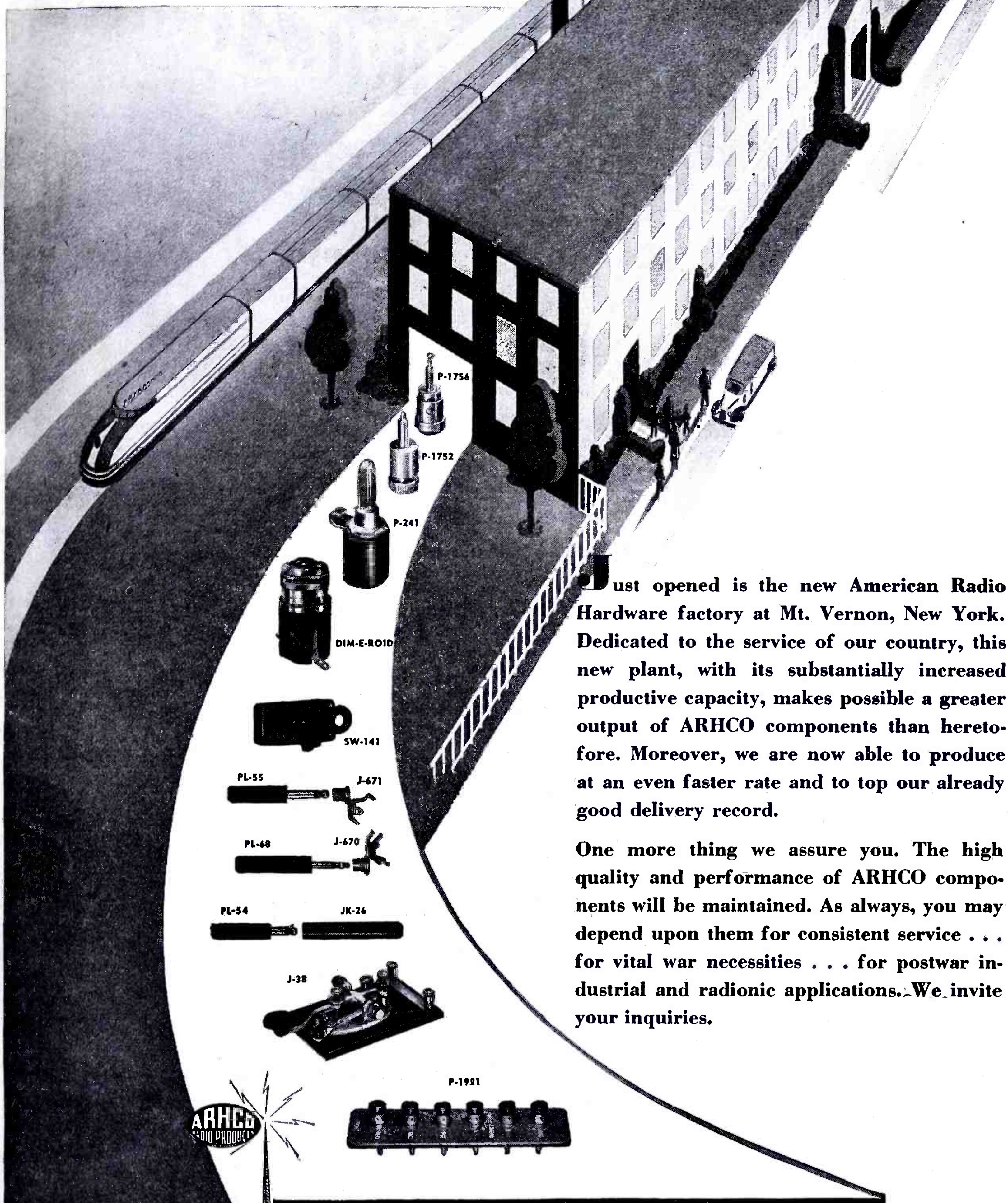
OUR *NEW* PLANT

steps up ARHCO production



Just opened is the new American Radio Hardware factory at Mt. Vernon, New York. Dedicated to the service of our country, this new plant, with its substantially increased productive capacity, makes possible a greater output of ARHCO components than heretofore. Moreover, we are now able to produce at an even faster rate and to top our already good delivery record.

One more thing we assure you. The high quality and performance of ARHCO components will be maintained. As always, you may depend upon them for consistent service . . . for vital war necessities . . . for postwar industrial and radionic applications. We invite your inquiries.

American Radio Hardware Co., Inc.

152-4 Mac Queston P'kway South • Mount Vernon, N.Y.

MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT

LEWIS WINNER, Editor
F. WALEN, Assistant Editor
A. D'ATTILIO, Assistant Editor

We See...

THE SKILL, PERSEVERANCE AND LOYALTY of radio operators received striking tribute in a recent steamship company advertisement titled "The Man We Take For Granted."

Said the ad: "He is the radio officer—the ears and voice of the ship. . . . In peace and war our seaborne commerce clears through his transmitters and receivers. . . . Emergencies affecting the very lives of passengers call for his skill. He is the one man besides the Captain, whose post and duty keeps him aboard ship, until the last moment. . . . No one lives closer to the high traditions of the sea than this *man we take for granted!*"

STATION LICENSES WILL HEREAFTER have a three-year life thanks to an amendment recently adopted by the FCC. Initial renewals will be hereafter for staggered periods, ranging from one year to two years and nine months. Thereafter all regular licenses will be for the full three-year period. This staggered method has been adopted to spread the work load, incident to examination of all applications for renewals over the three-year period.

It is interesting to note that in 1927, when the Federal Radio Commission was first organized, licenses were issued for only 60 days. In 1928, the normal license life was three months. In 1931, the license life was increased to six months, and in 1939 one-year licenses were issued. In October, 1941, the license period was increased to two years. That's progress!

YEAR-END REPORTS reveal that stations were really on the job all year long, notwithstanding material and manpower problems. The combined service delays were, in most instances, less than 1/10 of 1%. A proud record!

THIRTY-DAY DELIVERY SERVICE has been promised for the 893, 893R and 889 tubes. Let's hope the list expands. It looks as if it might!—L. W.

COMMUNICATIONS

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer. Registered U. S. Patent Office.
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JANUARY, 1944

VOLUME 24 NUMBER 1

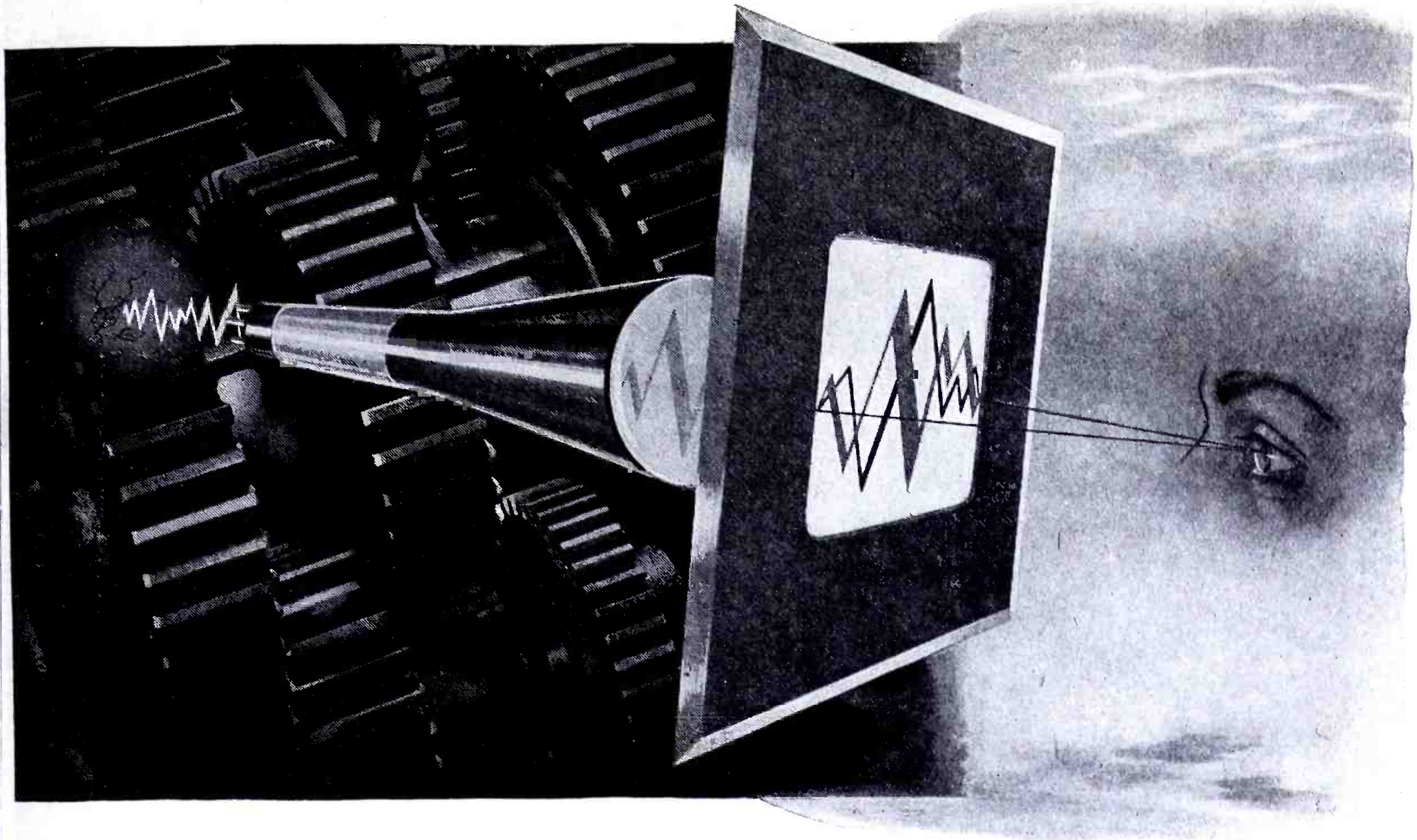
COVER ILLUSTRATION

Invasion communication beach party in training in the Mediterranean area. (*British Official Photo*)

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

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

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



Key to a world within a world

To inspect metal, judge its inner worth with the aid of electronics, is to add a vital chapter to war industry's book of knowledge. More, it is to write a preface to the mightier book of the future.

This same science of electronics, which finds the structural flaw in war metal, holds great possibilities whose commercial use awaits only the welcome day of peace.

Infinite additions to the knowledge, the safety, the comfort of modern man continuously reveal themselves in the quick flutter of the electronic tubes.

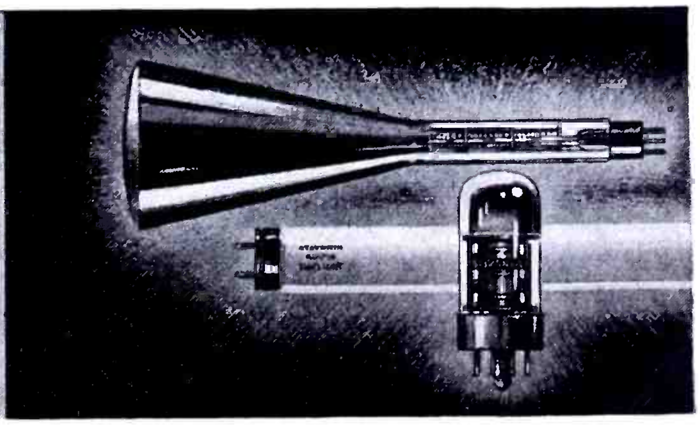
This is an inspiring reason why at Sylvania, in our work with electronics, as in everything else we do to widen the range of the eye and the ear, we set for ourselves a single goal — the highest standard known.

SYLVANIA ELECTRIC PRODUCTS INC.

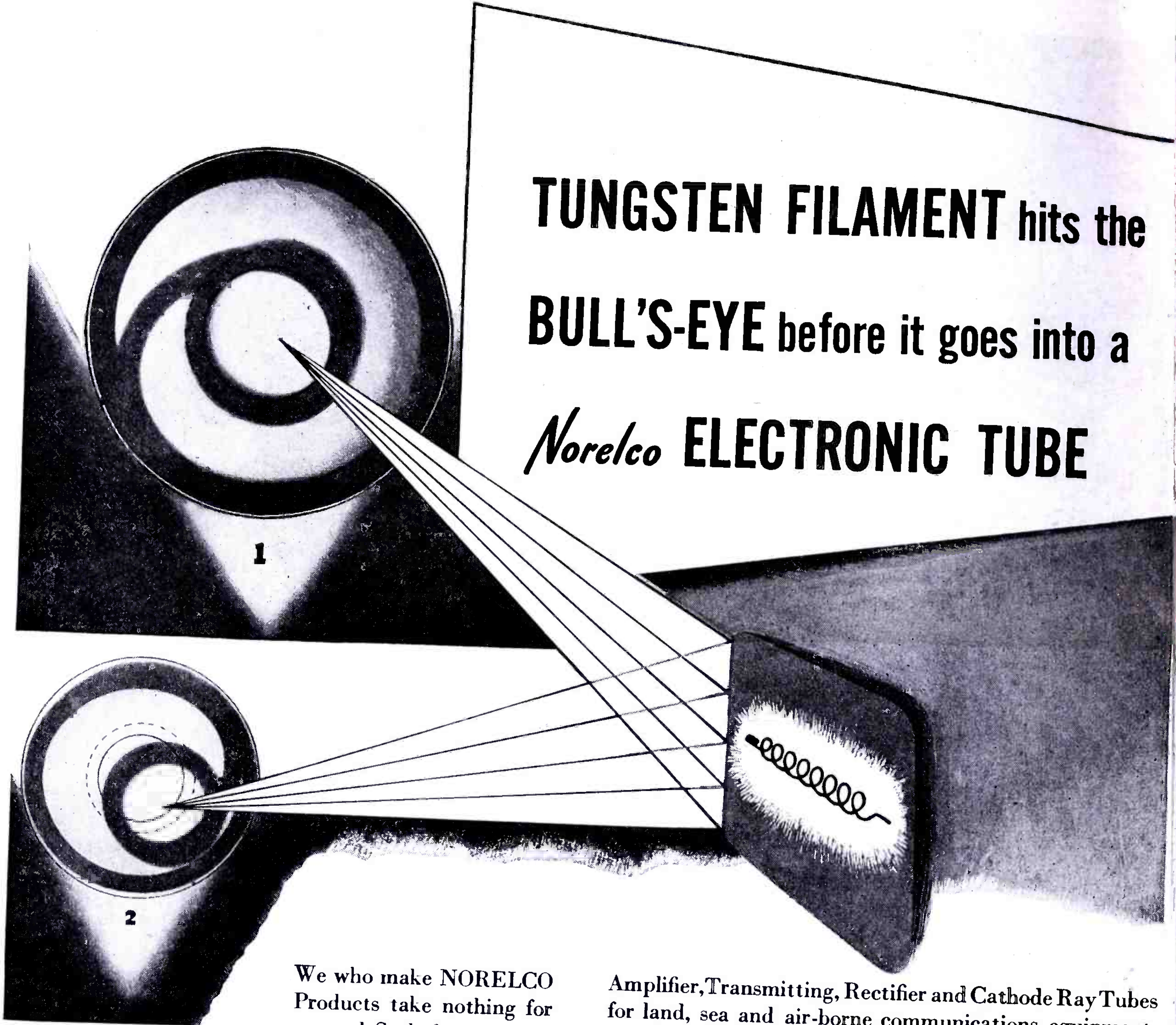
EXECUTIVE OFFICES: 500 FIFTH AVENUE, NEW YORK 18, N. Y.

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

AIDING THE HOME FRONTS "KNOW-HOW"—Sylvania Fluorescent Lamps and Fixtures give war workers the light they need to produce their armament miracles. Sylvania Radio Tubes bring the news of the world to the American family, keep our people mentally alert. Sylvania Incandescent Lamps economically protect the eyes of the American family. Indeed, the Sylvania name now, as always, means the ultimate in product performance.



TUNGSTEN FILAMENT hits the BULL'S-EYE before it goes into a Norelco ELECTRONIC TUBE



We who make NORELCO Products take nothing for granted. So, before tungsten filament coils are anchored to assemblies in tubes, they go into the limelight of a slide film projector. The projection beam is focused squarely through the dead center of the coil, and is projected against a screen on which a circle is painted.

A perfectly wound coil [*No. 1 above*] will cast its image on the screen coincident with the painted circle. An imperfectly wound coil [*No. 2 above*] *may* give adequate performance when assembled into certain types of electronic tubes—but since we who make NORELCO electronic products like to prevent possibility of failures before they get a start, we reject coils that do not meet our high standards of coil winding.

This is only one of the 61 inspections to which the various parts and assemblies of one type of NORELCO electronic tube is subjected before the final inspections in test operation.

Today, all our resources and experience are devoted to making the electronic tools and devices that will hasten Victory. Tomorrow, they will be free to serve industry in creating a new world.

For our Armed Forces we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes for land, sea and air-borne communications equipment.

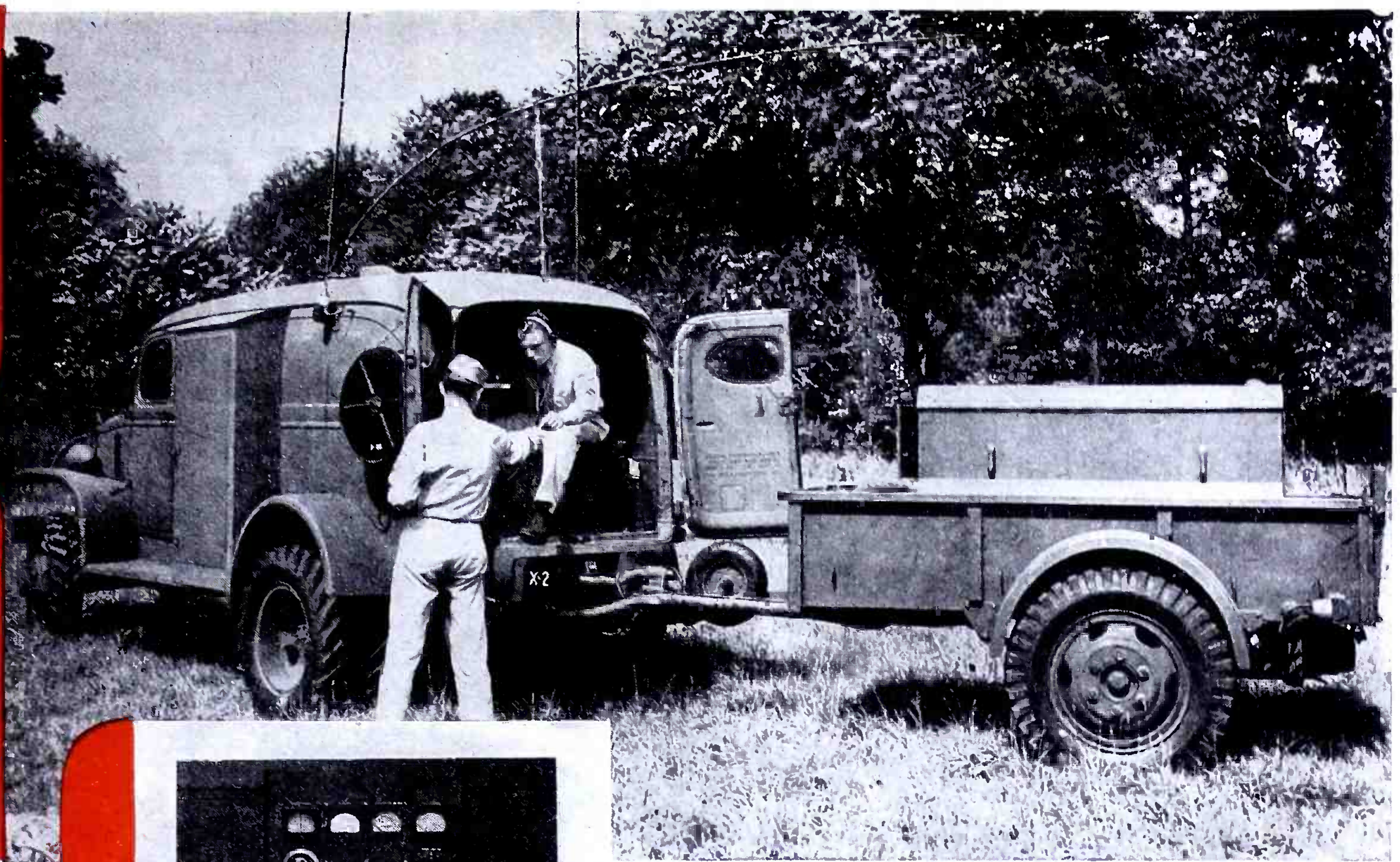
For our war industries we make Searchray (X-ray) apparatus for industrial and research applications; X-ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; High Frequency Heating Equipment; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine Wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies.

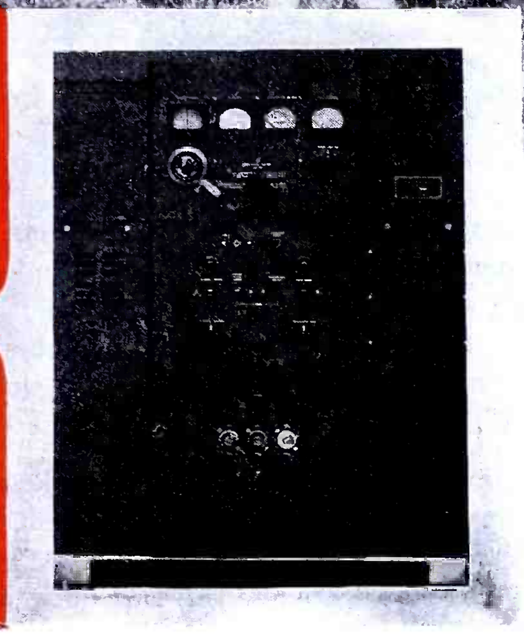
And for Victory we say: Buy More War Bonds.

★ ★ ★

Norelco

ELECTRONIC PRODUCTS by
NORTH AMERICAN PHILIPS COMPANY, INC.
Executive Offices: 100 East 42nd Street
New York 17, New York
Factories in Dobbs Ferry, N. Y.; Mount Vernon, New York (Philips Metalix Corporation); Lewiston, Maine (Elmet Division)





JOHNSON

Condensers
Tube Sockets
Couplings
Insulators

are used in the famous

HALLICRAFTER BUILT SCR-299

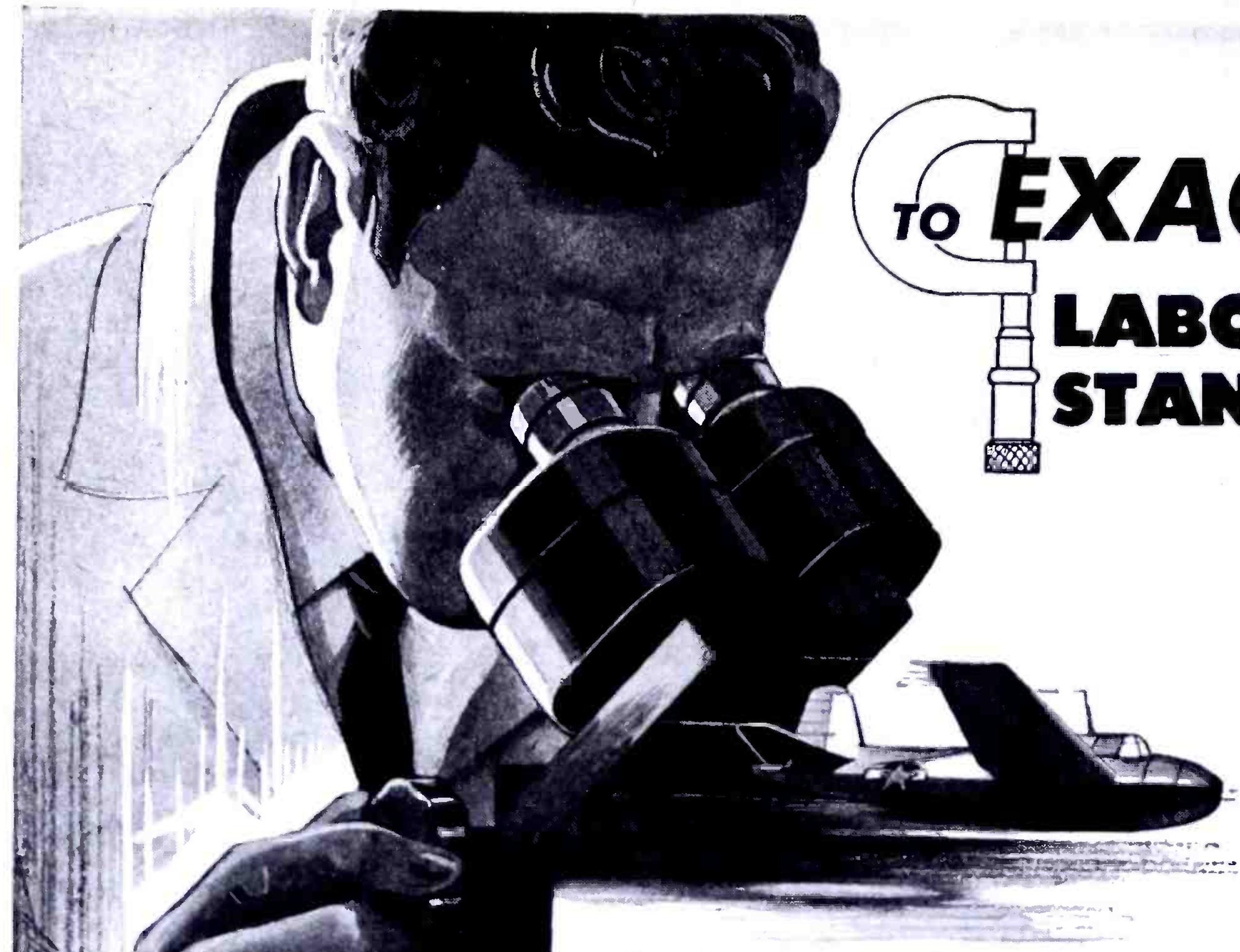
JOHNSON'S are proud of their part in furnishing many of the important components for this famous transmitter. They are proud to have been selected originally by HALLICRAFTERS to furnish these components for the HT-4—before the pressure of war made price unimportant. They are proud that this same HT-4 was used by the Signal Corps to become a part of the SCR-299—a tribute to the dependability of HALLICRAFTERS equipment and JOHNSON parts. They are proud to have been able to expand production to furnish all of these parts needed in the SCR-299 in addition to the vast numbers of parts needed by other manufacturers. And, we are proud that these are all standard parts made to the same specifications as our "ham" parts before the War.

Write for
CATALOG
967E

JOHNSON
a famous name in Radio

.. F. JOHNSON COMPANY • WASECA • MINNESOTA

TO EXACTING LABORATORY STANDARDS . .



Over the long period of years separating the past from the present, ECA has been called upon to tackle the development and production of innumerable types of specialized radio and electronic equipment. Consequently, our facilities are geared to exacting laboratory standards. We can handle the most delicate assignments with understanding care and painstaking skill.

Typical of the apparatus produced by ECA is this Rectifier Power Unit for general laboratory operation. Operating from a 105-125 volt, 50-60 cycle line, it delivers a maximum of 150 ma at 300 volts DC and has an open circuit voltage of 450 volts DC and 45 watts power output from 6.3 volts AC centertapped terminals. The hum voltage is 0.1% at 150 ma for all voltages above 150 volts. Continuous panel control of the DC output voltage is provided through a variable autotransformer.

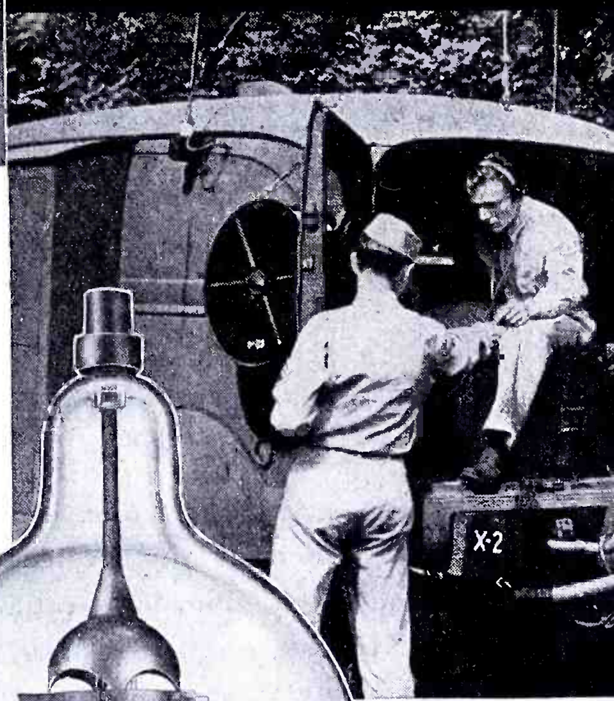
Did you read the list marked "Killed in Action" in your paper today? A pint of your blood might have saved the life of an American boy. Visit your local Red Cross Blood Bank . . . Do it now.

eca

ELECTRONIC CORP. OF AMERICA

45 WEST 18th STREET • NEW YORK 11, N. Y. • WATKINS 9-1870

Complete High Power Radio Transmitter and receivers mounted in light army truck. These transmitters are in service in all theatres of war and in most all branches of the army.



The radio amateur is fighting this war, too

The radio amateur is off the air as an amateur but he's still in radio. He's there in person and he's everywhere in the products created to satisfy his progressive demands. Many of the world's leading electronic engineers are radio amateurs and much of the equipment in use today by the armed services is a product of the great amateur testing grounds. Two outstanding examples are: the SCR-299 Transmitter and Eimac tubes.

The SCR-299 transmitter, designed by Hallicrafters, is an adaptation of the model HT-4 which is a 450 watt rig designed primarily for amateur use. Its characteristics and performance capabilities were such that it was easily adapted to military use and it is today seeing service throughout the world in all branches of the army. It is significant to note that Eimac tubes . . . created to satisfy the demands of the amateur...occupy the key sockets of the SCR-299. Yes, and Eimac Vacuum Tank Condensers, too, are in this now famous transmitter.

The SCR-299 offers a striking confirmation of the fact that Eimac tubes are first in the important new developments in radio...first choice of the leading engineers throughout the world.

Follow the leaders to **Eimac** REG. U. S. PAT. OFF. **TUBES**

ARMY NAVY E

EITEL-McCULLOUGH, Inc., SAN BRUNO, CALIF.

Plants at: Salt Lake City, Utah and San Bruno, California

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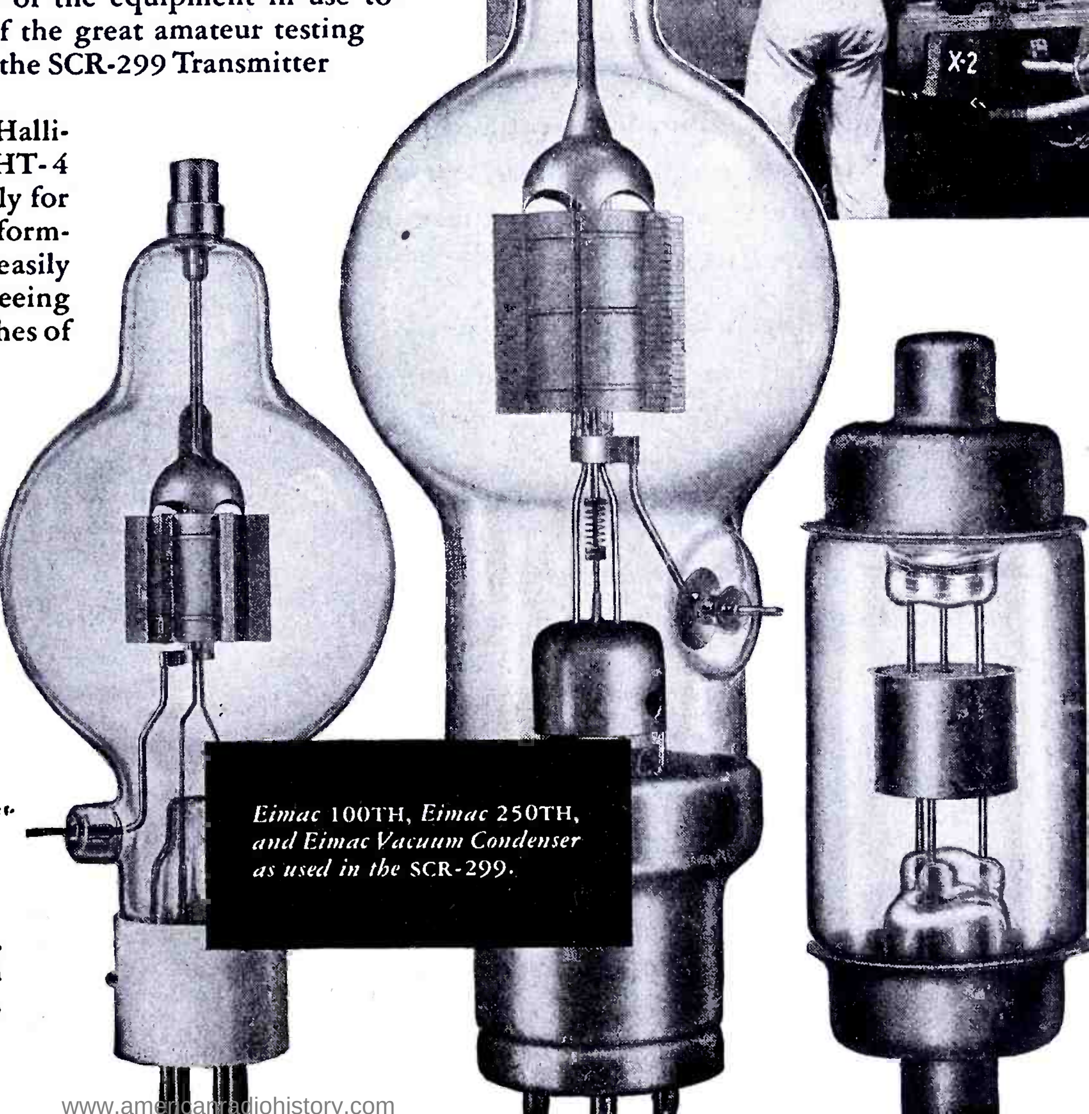


Eimac 100TH, Eimac 250TH, and Eimac Vacuum Condenser as used in the SCR-299.

Years of aircraft service have proved the reliability of Ohmite Units. Designed and built to withstand shock, vibration, heat and humidity . . . these Rheostats and Resistors "earned their wings" through consistent performances under all types of operating conditions.

They serve today in vital communications equipment as well as in instrument controls . . on land, sea and in the air . . . from the arctic to the tropics, from sea level to the stratosphere.

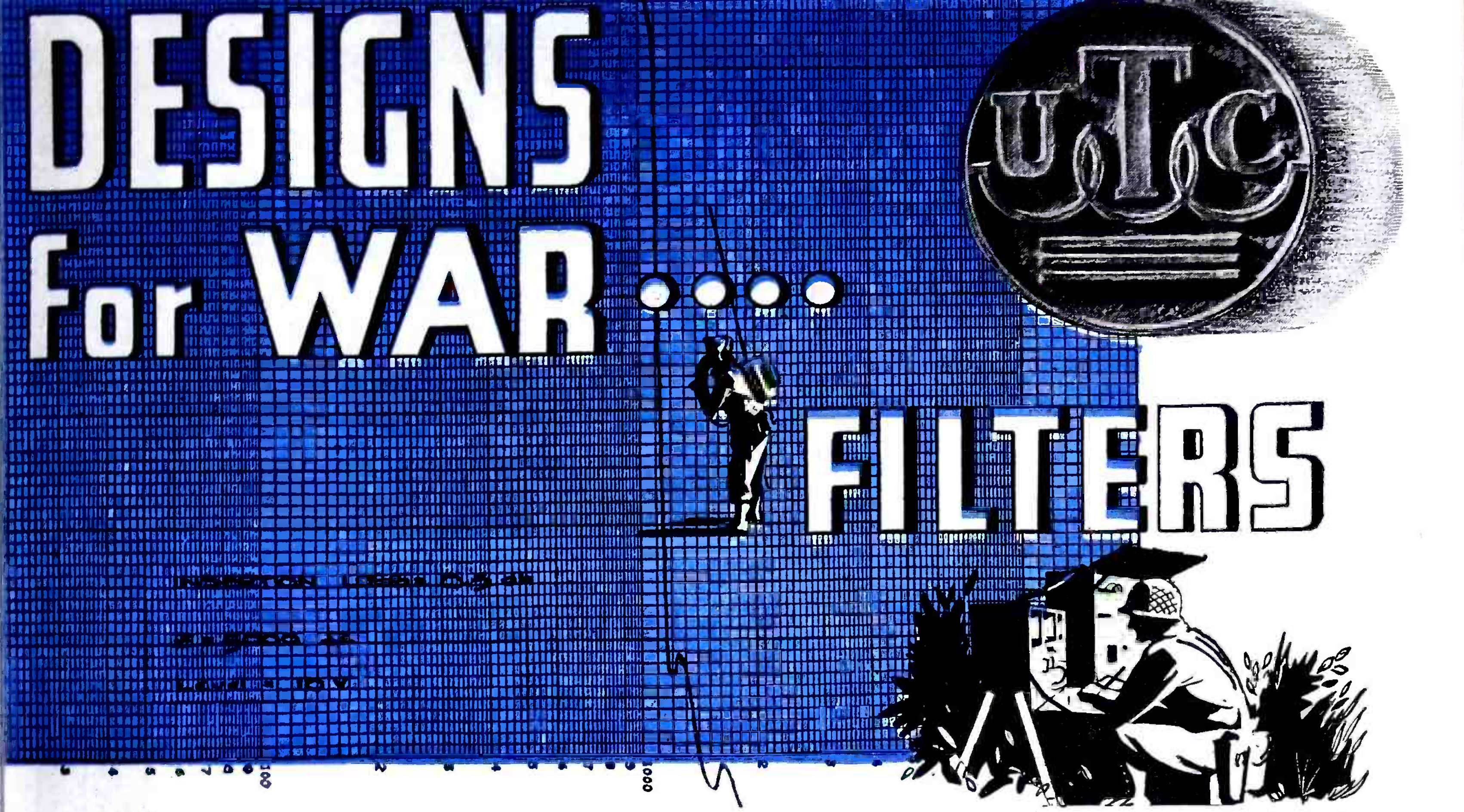
Ohmite Rheostats provide permanently smooth, close control. Ohmite Resistors stay accurate, dissipate heat rapidly, prevent burnouts and failures.

BE RIGHT WITH OHMITE
RHEOSTATS • RESISTORS • TAP SWITCHES

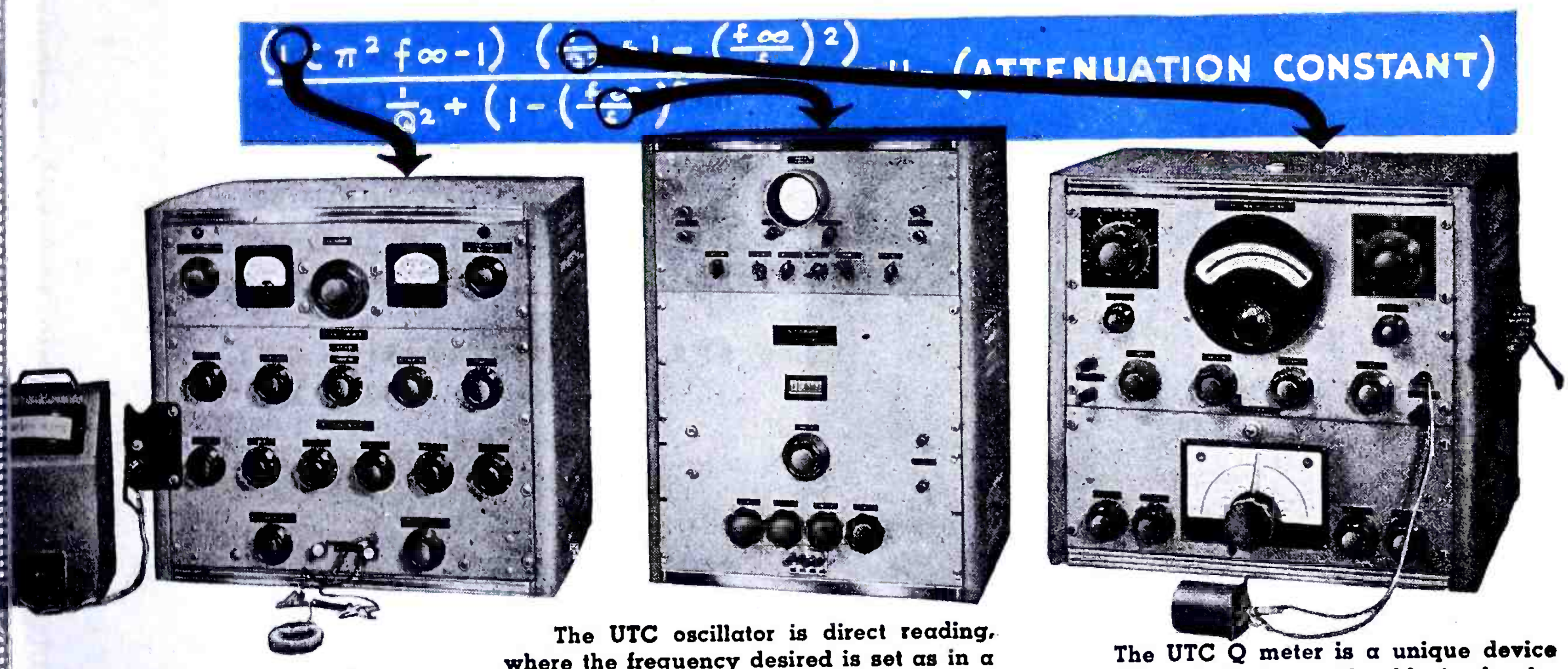
OHMITE MANUFACTURING COMPANY
4869 FLOURNOY STREET • CHICAGO 44, U.S.A.

Send for Catalog and Engineering Manual No. 40

Write on company letterhead for this helpful 96-page guide in the selection and application of rheostats, resistors, tap switches, chokes and attenuators.



Filter performance is dependent upon three major factors, basic design... Q of coil and capacitor elements... and precision of adjustment. The superiority of UTC products in this field has been effected through many years of research and development on core materials and measuring apparatus. We illustrate below a typical filter formula and some of the UTC apparatus used to determine quantitative and qualitative values:



The UTC inductance bridge is capable of four digit accuracy and covers a range from extremely low values to over 100 Hys. The effective resistance and inductance values are direct reading, eliminating the possibility of error in conversion.

The UTC oscillator is direct reading, where the frequency desired is set as in a four digit decade box, and is accurate within 1 cycle at 1,000 cycles. The range is 10 cycles to 100 kc. Accuracy of this type is essential with filters having sharp attenuation characteristics. This instrument is augmented by a UTC harmonic analyzer for the output measuring device.

The UTC Q meter is a unique device which has helped considerably in the development of the special core materials used in our filters. It is also of importance in maintaining uniform quality in our production coils. The Q is read directly and covers the entire range of possible Q factors over the entire audio frequency band.

UNITED TRANSFORMER CO.

150 VARICK STREET • NEW YORK 13, N. Y.

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

"Anybody Got a Stick of Gum?"

THAT last bump was *it.* The waist gunner picked himself up from the floor and clung to his gun as the huge ship was brought back into control. He took a quick look out, whistled softly and spoke through the Intercom to the rest of the crew.

"Somebody better hurry up with a stick of chewing gum before our left wing leaves us!"

★ ★ ★

The ability of our flying men . . . and our flying equipment . . . to "take it" is one of the major marvels of the war, and playing its full share in the success of our aerial forces is the Communications System. No place here for equipment that's merely *good.* It must be the *best,* for failure in Communication may be more serious than the failure of an engine or a landing gear.

It is to these superlative standards that Rola builds equipment for the Army-Navy Air Forces . . . highly specialized transformers and coils, supersensitive headphones, and other electronic parts having to do with Communications. And it is to these same standards that Rola will build its after-the-war products, whatever they may be. The ROLA COMPANY, Inc., 2530 Superior Avenue, Cleveland 14, Ohio.

ROLA

Let's do more in forty-four!

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

UNDER *ANY* TRYING CONDITION

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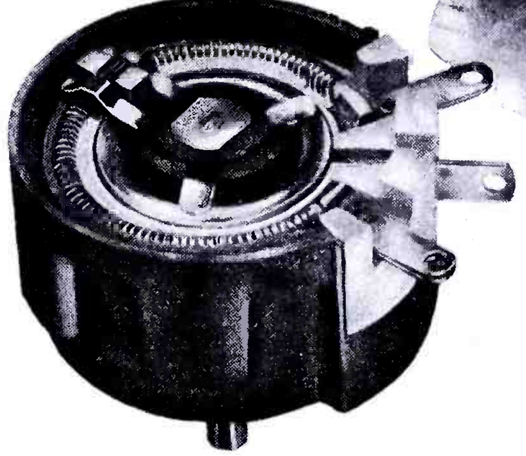
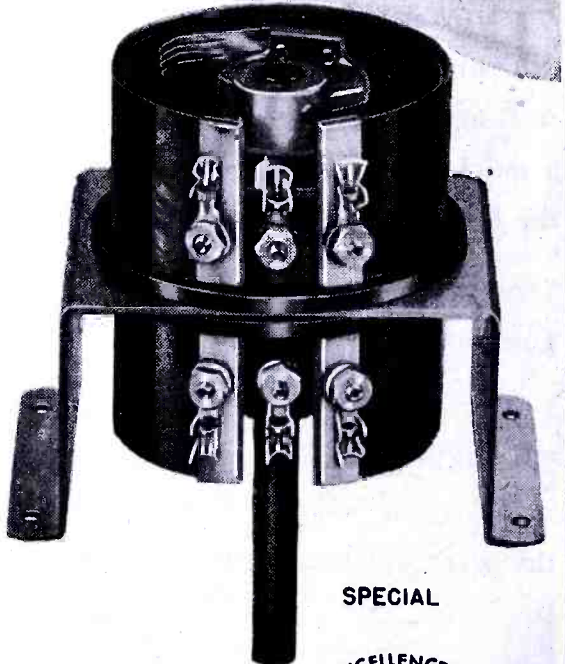


SPECIAL 25 AND 50 WATT



SPECIAL

UP A MOUNTAIN IN A TANK

HURTLING THROUGH SPACE IN A FORTRESS . . . . . .

WITHSTANDING THE GRUELLING PACE OF A WAR PLANT . . .

DeJur wire-wound potentiometers, in any assignment, fulfill their tasks capably and satisfactorily. The new line of these potentiometers covers a wide range of applications, for present and future use. Write for your copy of our "Special Bulletin", just off the press.

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

HELP SHORTEN THE WAR . . . BUY MORE WAR BONDS

DeJur-Amsco Corporation

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

SHELTON, CONNECTICUT

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

STARTING JANUARY 18TH

IT'S UP TO YOU!

STARTING January 18th, it's up to you to lead the men and women working in your plant to do themselves proud by helping to put over the 4th War Loan.

Your Government picks you for this job because you are better fitted than anyone else to know what your employees can and should do—and you're their natural leader. This time, your Government asks your plant to meet a definite quota—and to break it, *plenty!*

If your plant quota has not yet been set, get in touch now with your State Chairman of the War Finance Committee.

To meet your plant quota, will mean that you will have to hold your present Pay-Roll Deduction Plan payments at their peak figure—*and then get at least an average of one EXTRA $100 bond from every worker!*

That's where your leadership comes in—and the leadership of every one of your associates, from plant super intendent to foreman! It's your job to see that your fellov workers are sold the finest investment in the world. T see that they buy their share of tomorrow—of Victory

That won't prove difficult, if you organize for it. Se up your own campaign right now—and don't aim for any thing less than a 100% record in those *extra* $100 bonds

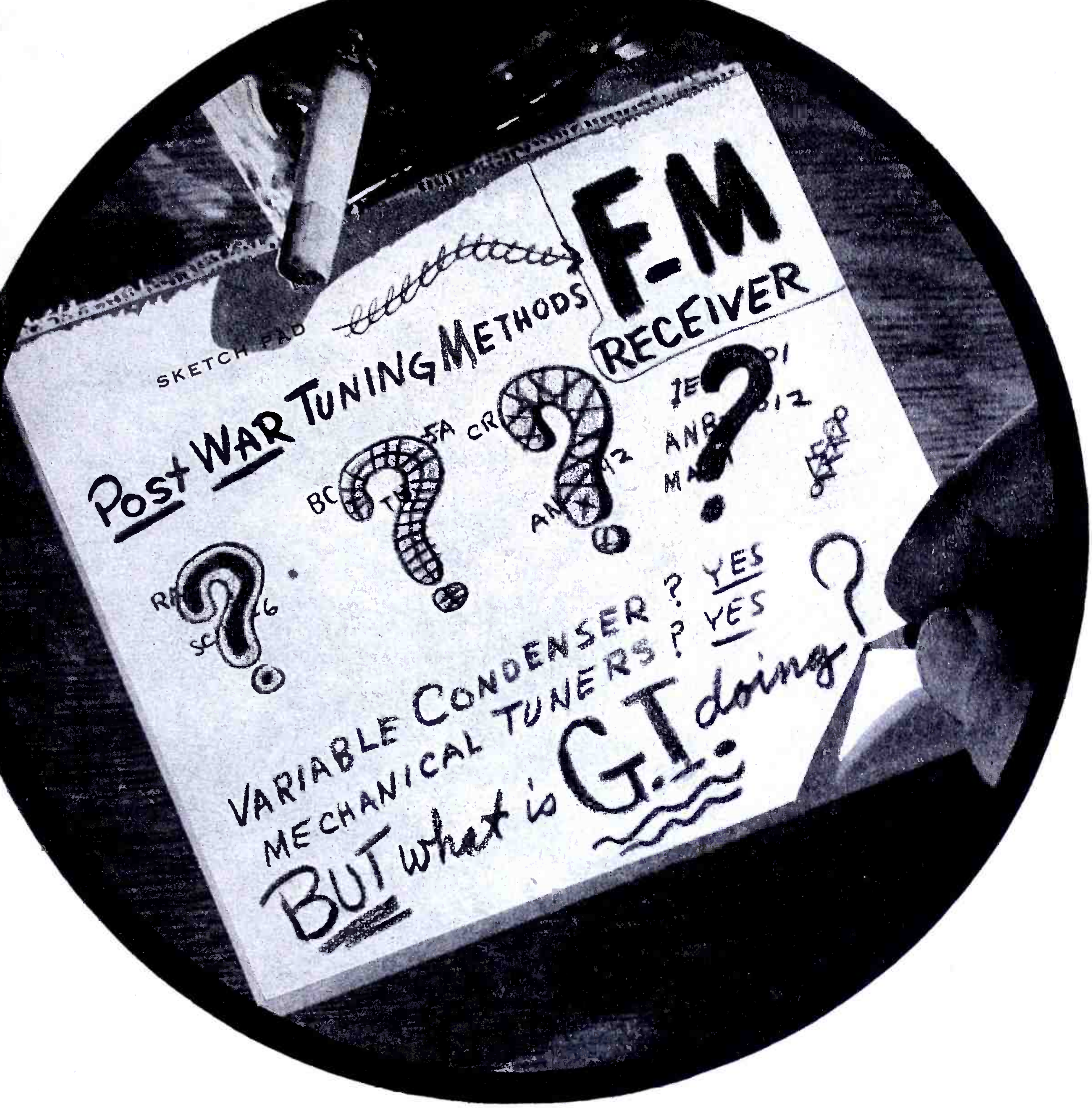
And here's one last thought. Forget you ever heard o "10%" as a measure of a reasonable investment in Wa Bonds under the Pay-Roll Deduction Plan. Today, thou sands of families that formerly depended upon a singl wage earner now enjoy the earnings of several. In suc cases, 10% or 15% represents but a paltry fraction of a investment which should reach 25%, 50%, or more!

Now then—Up and At Them!

***Keep Backing the Attack!*—WITH WAR BONDS**

This space contributed to Victory by COMMUNICATIONS

This advertisement prepared under the auspices of the United States Treasury Department and the War Advertising Council



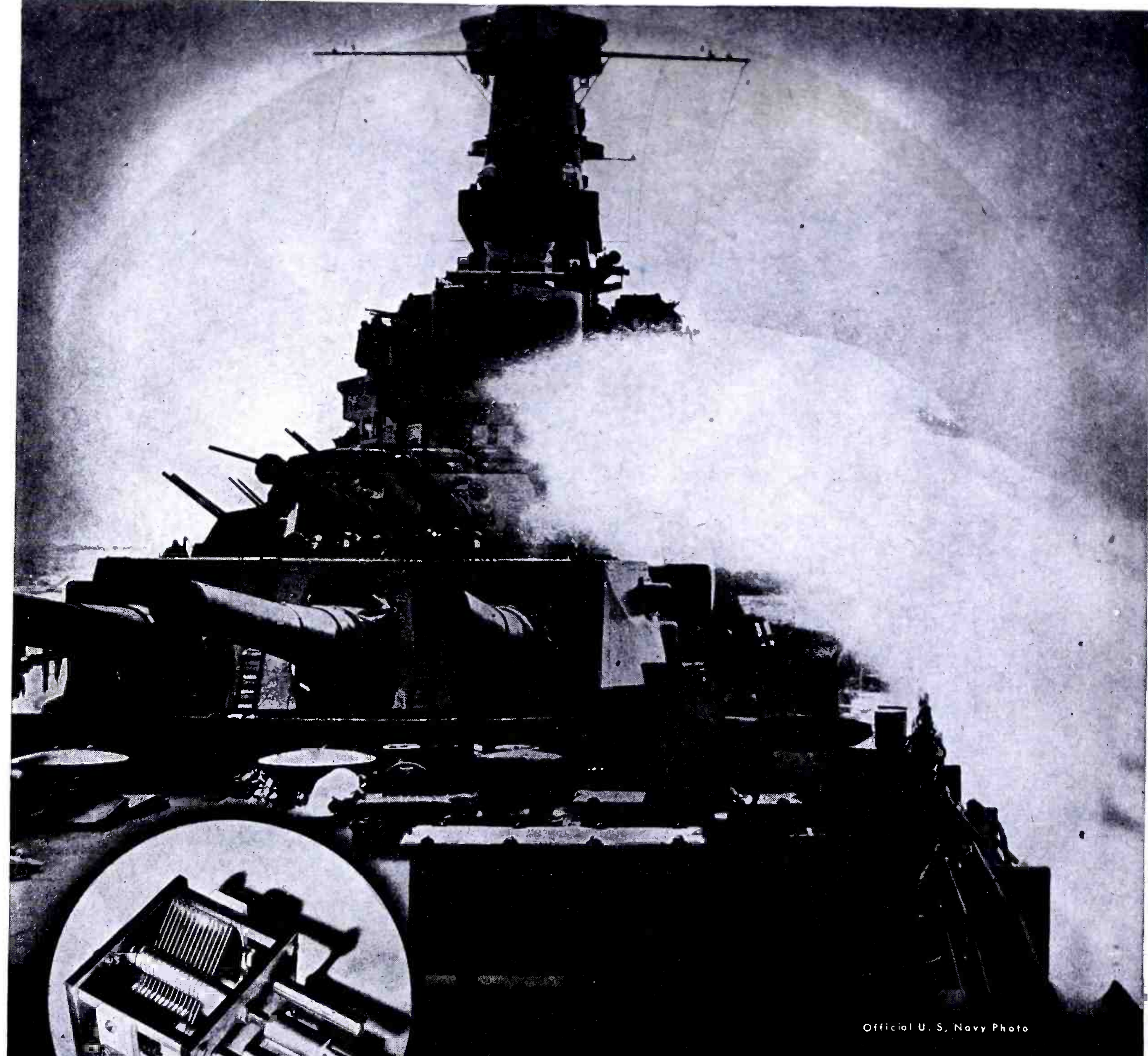
Naturally, we cannot answer all your questions right now. But it is certain that our production of tens of thousands of mechanical tuners and variable condensers to the precision standards required for military use will lead to many new postwar designs.

ARMY E NAVY

PHONOGRAPH RECORD CHANGERS – HOME PHONOGRAPH RECORDERS – VARIABLE TUNING CONDENSERS – PUSH-BUTTON TUNING UNITS AND ACTUATORS

GENERAL INSTRUMENT CORPORATION

829 NEWARK AVENUE, ELIZABETH, N.J.


Official U. S. Navy Photo

COMMUNICATIONS

LEWIS WINNER, Editor

* * JANUARY, 1944 * *

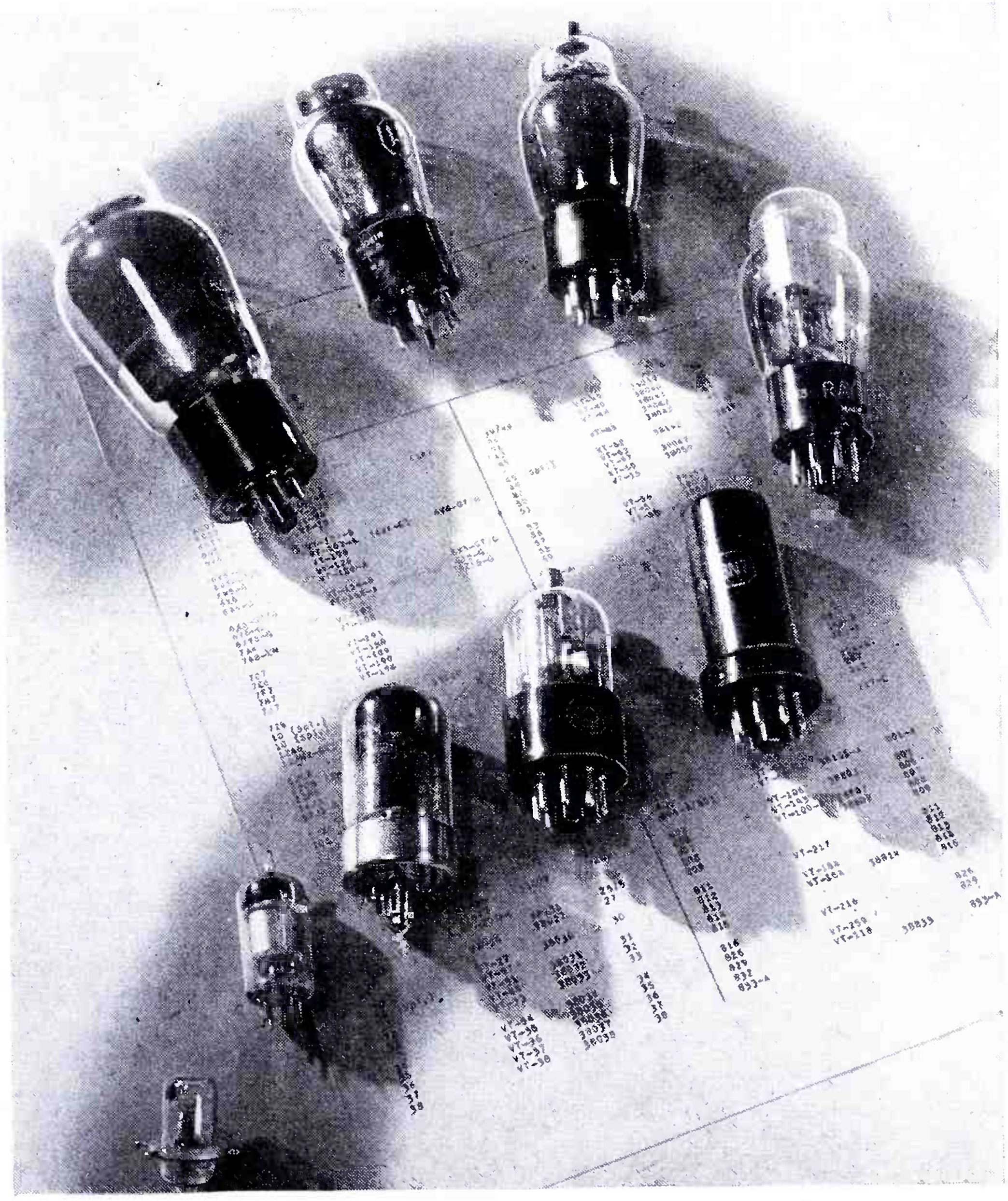
A MODERNIZED TUBE INDEX

Standardization of Vacuum Tube Nomenclature is Proposed in a New System Which Separates Designations Into Two Parts; a Serial Number Identifying Electrical Characteristics and a Group of Symbols Which Synthesize Physical Details

by J. R. SCHOENBAUM

Project Engineer

Curtiss-Wright Corp., Propeller Div.



IN the early days of radio it was possible for every one in the field to memorize the names and pertinent characteristics of all the vacuum tube types in existence. It very soon became apparent, however, that unless a standard system were established for naming new radio tube types as they appeared, confusion would result among the several manufacturers, to say nothing of the confusion of every one else. A very simple and admirable system of numbers was inaugurated which kept everybody happy, until the time was reached when there were more tubes than there was system. A more scientific method was then devised, which specified tubes by filament voltage, class of use and number of electrodes.

The flexibility of this arrangement became apparent upon the advent of metal tubes and octal bases, and the system was stretched and expanded to encompass also the glass versions of the metal tubes, the GT types, and acorns, miniatures and lock-in types. In the process, however, deviations gradually occurred, due to various exigencies, with the result that the system frankly broke down as a defin-

Symbol	Description
D	Diode
T	Triode, Amplifier
A	Power Triode
Q	Tetrode
B	Beam Power Tube
F	Pentode, Amplifier
P	Power Pentode
H	Hexode
S	Heptode
E	Octode
K	Converter
k	Mixer
R	Rectifier
RR	Doubler Rectifier
I	Magic Eye
V	Voltage Regulator
Vr	Resistor, Ballast
G	Gas Tube, Thyratron
L	Light Sensitive Cell
W	Light Source
N	Neon
C	Cathode Ray
J	Pilot Light
M	Mercury Rectifier
	Prescripts
g	Gaseous
m	Mercury
u	U-H-F Type
v	V-H-F Type
y	Anti-microphonic
x	Transmitter Types
Z	Secondary emission

Figure 1
Electrode and type symbols.

ing means, and as now in use serves to name new tubes without giving much of a hint as to their use. In addition, several branch systems were brought into play as whole new groups of tubes made their appearance.

Present Identification Difficulties

A situation now exists in which one well-known pentode type has twelve different names, due to various filament voltage requirements, basing arrangements and bulb shapes, with nothing to show in nine of the cases that the tube characteristics are the same (57, 77, 6J7, 6J7G, 6J7GT, 6D6, 6D7, 6W7G, 12J7GT/G, 1221, 1223). In the single-ended types, the 6SJ7, which one might identify as the counterpart of a 6J7 as regards operating characteristics, does not, however, belong to the same group, while the 6SF5 and its prototype, the 6F5, are alike. Additional difficulty in identification is encountered when one compares the 6C7 double-diode-triode with its single-ended counterpart, the 6SC7, which, unfortunately, is a twin-triode.

In the case of acorns, some miniatures and, indeed, some of almost every type, the abandonment of the system is complete, as illustrated by the use of the designation 1631 for the classic 6L6 supplied with 12-volt filament.

Characteristic	Used with Electrode Symbol	Digit 1st	2nd
Low mu	T and A		odd
High mu			even
Remote cut-off	Q, F, and IT	odd	odd
Semi-remote		odd	even
Sharp cut-off, r-f		even	odd
Sharp, audio		even	even
Half-wave	R	odd	odd
Full-wave		even	even
General Application	P and B		odd
R-F			even

Figure 2
Code for descriptive use of serial number digits.

Necessity of System

It has become clearly apparent that the many hundreds of radio and electronic tubes which are now in existence, and the thousands which will descend upon us in the future, are not going to be fitted into the several concurrent systems with which we are at present struggling. Obviously, a new system is in order.

Requirements

The general requirements of any system for naming and indexing vacuum tubes are quite definite. First, all present types must be accommodated; second, the structure of the method must allow for the introduction of all types and quantities of tubes, and, third, enough detail about the tube must be presented so that a person familiar with the nomenclature need not refer, except for specific design data, to any other source of information.

Of course, there are limits beyond which it is not practical to go.

Necessary Data

The most important things to know about a tube are: (1) the kind of tube it is, viz., rectifier, pentode, photocell, cathode-ray or triode-hexode converter; (2) the general characteristics of the type, such as low-mu or high-mu triode, or remote cut-off pentode, with some method of indexing which may be used to obtain the exact design data from a reference source; (3) the filament voltage at which the tube is intended to operate; (4) the application of the tube, insofar as indicated by the

Symbol	Description
A	Acorn
P	Miniature
L	Lock-in
K	GT
M	Metal Octal
G	Glass Octal
U	UV, UX, UY 4, 5, 6, 7
B	Bayonet (with subscript)
T	Screw thread (with subscript)
C	Cartridge
W	Wire Leads
	Subscripts
S	Single end
f	Filament only
F	Tapped filament
H	Tapped filament plus cathode
m	Miniature
c	Candelabra
l	Large, Mogul
N	No. of pins

Figure 3
Constructional tube type symbols.

electron emitter, whether direct fil[a]ment or heated cathode; and (5) physical information concerning th[e] structure of the unit, to differentia[te] between acorns, miniatures, metal a[nd] glass types, GT's, lock-in's, etc.

System Proposed

An analysis of the foregoing facto[rs] showed that a split or hyphenat[ed] number-letter code would probab[ly] solve the problem. Accordingly, [a] system encompassing this method w[as] evolved. The first section is compos[ed] of key letters designating the electro[de]

Old Type	New	Specification
27	T15-2U	Medium-mu amplifier triode, 2.5-volt indirectly heated cathode, U-type base.
ID8GT	DTP11-1FK	Diode, power pentode, medium-mu triode, 1-volt filament type, previous GT.
6SC7	TT12-6MS	Twin high-mu triodes, cathode type
12SC7	TT12-12MS	6.3- and 12-volt single-end metal
7F7	TT12-6L	6.3-volt lock in.
6U5	IT13-6G	Remote cut-off triode, magic eye indicator, 6.3-volt glass octal.

Figure 4
Comparison of old and new type designations.

structure, in combination with a number (two digits are sufficient for present purposes) which, in addition to acting as a number, also indicates certain features of the tube's characteristics. The first part of the tube-type designation would often cover a number of tubes having different constructional features, but which are similar electrically.

Second Section of Code

The second portion of the code details the nominal filament voltage, the type of electron emitter and the constructional type. A single cross-index has also been prepared. This lists all the variations in physical construction based on each kind of electronic characteristic, and shows all the electron types designed for each kind of envelope and application.

First Part of the Index Code

In Figure 1 we have a chart with a list of letter symbols that designate the various electrode structures. Most of the letters used have an obvious connotation with the accepted descriptions which they symbolize. The few which seem arbitrary were selected to avoid duplication. For example, Q for tetrode (quatre), S for heptode (seven), E for octode (eight) to avoid similarity to zero, P for miniature (peanut), etc. From this list a triode - hexode converter would be coded as KTH—. . . . Figure 2 illustrates the means for differentiating between low, medium and high-mu triodes, remote and sharp, cut-off pentodes and others. A duo diode high mu triode might then be coded DDT12—. . ., while a remote cut-off pentode could be F11—. . . . In addition to giving this much information about the tube, the first part of the hyphenated number acts to index the tube in reference manuals, from which may be obtained operating curves and other data.

Second Part of the Index Code

Figure 3 shows the letter symbols which represent the various tube constructions, and which are to be preceded by a number, indicating the nominal tube filament voltage. The letters are, in certain cases, followed by another letter, which may differentiate between standard metal and single-ended metal types, straight filament and indirect heater, or size of bayonet and screw bases. A 6-volt metal tube would be . . . .—6M, while a 3-volt former GT with a center-tapped filament would be referred to as . . .—3FK, or a bayonet type pilot as . . . .—7Bm.

In Figure 4 are synthesized several of the new designations broken down into their components, together with explanations and present type numbers. Figure 5 is an index of new type tube numbers against present types taken from a partial list of approved tubes. A cross-index is also presented. The serial numbers may seem to have many skips, but this is only because not every commercially made type is present on the list in Figure 5.

Discussion of System

Certain questionable details have arisen in connection with the system discussed above, notably the wide range of voltage covered by the nominal 1, 2 and 3-volt filament ratings. This could be solved through the use of the proper decimal in connection with the filament voltage number, in cases where confusion might otherwise result. But this has not been done in this index. Another debatable point concerns the advisability of indicating the number of base pins on type P tubes, and also in the grouping of UV, UX and UY types under one heading.

Duplication Problems

Some unfortunate cases of duplication in tube types which were made to provide alternate basing arrangements add to the complexity of our system. An example is given by the two tubes 5Y3G and 5Y4G. Their physical and electrical characteristics both are identical. The only difference is in the pin number to which the elements are connected. Thus an additional identifying number (—1) must be added to one of the tube type designations if both tubes are kept on our list.

Special Type Tubes

Another complication is added by the desirability of in some manner indicating tubes specially designed for high-frequency applications, or tubes specially selected as having low microphonic output. The method chosen supplies a prescript letter, as shown in the lower part of Figure 1.

System Advantages

While the full designations of a tube under the proposed system may frequently be more bulky than is customary in present usage, it should be noted that it is necessary to remember only the serial number of a tube in order to specify it completely.

Diodes	
uD11-1P	1A3
uD13-6A	9004
uD15-6A	9005
uD17-6P	9006
uD19-1L	1R4
uD19-6L	1203
uD19-1L	1294
uD19-6L1	7C4/1203A
Double Diodes	
DD22-6M	6H6
DD22-12M	12H6
DD22-6L	7A6
Half-Wave Rectifiers	
R11-6U	1v
R13-12U	12Z3
R15-7fU	81
R17-35L	35Z3-LT
R17-35K	35Z4-GT
R19-35HK	35Z5-GT/G
R19-45HG	45Z5-GT
R31-45P	45Z3
R33-2U	2X2/879
Full-Wave Rectifiers	
R22-5fU	80
R22-5fK	5Y3-GT
R22-5fGA	5Y4-G
R24-5fM	5W4
R24-5fK	5W4-GT/G
R26-6M	6X5
R26-6L	7Y4
R26-12L	14Y4
R28-6G	6ZY5-G
R40-6L	7Z4
R42-5G	5R4-GY
R44-28L	28Z5
Doublers	
RR22-25U	25Z5
RR22-25M	25Z6
RR22-25UA	25Y5
RR22-50K	50Y6-GT/G
RR24-50G	50Z7-G
RR26-117G	117Z6-G
Mercury Rectifiers	
mR22-2fU	82
mR24-5fU	83
Gas Rectifiers	
gR22-M	0Z4
gR22-G	0Z4-G
Medium-mu Triodes	
T11-1fG	1G4-GT/G
T13-1fG	1H4G
T13-1fU	30
T15-2U	27
T17-6U	37
T19-5fU	40
T21-2U	56
T21-6U	76
T21-6K	6P5-GT/G
T23-6M	6C5
T25-6M	6J5
T25-12M	12J5
T25-6L	7A4
T27-6M	6L5
T29-1fG	1E4-G
T29-1fL	1LE3
T31-6K	6AE5-GT/G
yT33-1U	864
uT35-6A	955
uT35-6P	9002
uT35-6L	1201
u237-1fL	1293

Figure 5

Cross reference indices of new and old designations. This cross reference is continued on pages 20 and 21. A cross index follows this listing on page 21. These lists are not complete, but cover most of the current types and for reference purposes include many obsolescent and little used tubes.

Medium-mu Duo-Diode Triodes

DDT11-1U	1B5
DDT11-1fG	1H6-G
DDT13-2U	55
DDT13-6U	85
DDT13-6G	6V7-G
DDT15-6M	6R7
DDT15-6MS	6SR7
DDT15-6L	7E6
DDT15-12MS	12SR7
DDT17-6MS	6ST7

Medium-mu Twin Triodes

uTT11-3FL	3B7
uTT11-3FL	1291
TT13-6G	6C8-G
TT15-6G	6F8-G
TT15-6L	7N7
TT15-6KS	6SN7-GT
TT15-12KS	12SN7-GT
TT17-12K	12AH7-GT
uTT19-6P	6J6
uTT21-6MU	1642

High-mu Triodes

T12-6M	6F5
T12-6K	6F5-GT/G
T12-12K	12F5-GT
T12-6MS	6SF5
T12-6L	7B4
T14-6G	6K5-G

Diode High-mu Triodes

DT12-1fK	1H5-GT/G
DT12-1fL	1LH4

Duo-Diode High-mu Triodes

DDT12-2U	2A6
DDT12-6U	75
DDT12-6MS	6SQ7
DDT12-12MS	12SQ7
DDT12-6L	7B6
DDT14-6G	6T7-G
DDT14-6M	6Q7
DDT14-6K	12Q7-GT/G
DDT16-6L	7C6

Twin High-mu Triodes

TT12-6MS	6SC7
TT12-12MS	12SC7
TT12-6L	7F7
TT14-6K	6SL7-GT
TT14-12K	12SL7-GT

Remote Cut-Off Tetrodes

Q11-1fK	1D5-GT
Q13-2U	35

Sharp Cut-Off Tetrodes

Q22-3fU	22
Q24-2U	24A
Q26-1fU	32
Q28-6U	36

Remote Cut-Off Pentodes

F11-1fP	1T4
F13-1fK	1P5-GT
F15-1fU	34
F17-1fU	1A4-P
F17-1fG	1D5-GP
F19-2U	58
F19-6U	6D6
F19-6G	6U7-G
F31-6U	78
F31-6M	6K7
F31-6G	6K7-G
F31-12K	12K7-GT
F33-6MS	6SK7
F33-6L	7A7
F33-12MS	12SK7
F33-12L	14A7/12B7
F35-6L	7B7
F35-6G	6S7-G
F37-6L	7H7
F39-6MS	6AB7/1853
F51-6MS	6SS7
F53-6U	39/44
uF55-6A	956
uF55-6P	9003

Diode Remote-Pentodes

DF11-6MS	6SF7
DF11-12MS	12SF7

Duo-Diode Remote-Pentode

DDF11-6L	7E7

Triode Remote-Pentodes

TF11-6U	6F7
TF11-6G	6P7-G
TF13-12K	12B8-GT
TF15-25K	25B8-GT

Semi-remote Pentodes

F12-1fL	1LC5
F14-1fK	1N5-GT
F14-1fL	1LN5
F16-6MS	6SG7
F16-12MS	12SG7

Duo-Diode Semi-remote Pentodes

DDF12-2U	2B7
DDF12-6U	6B7
DDF12-6M	6B8
DDF12-6G	6B8-G
DD12-12M	12C8
DDF14-6L	7R7

Sharp-Audio Pentodes

F22-2U	57
F22-6U	77
F22-6M	6J7
F22-6K	6J7-GT
F22-6U	6C6
F22-6G	6W7-G
F22-6L	7C7
F22-12K	12J7-GT
yF22-6M	1630
F26-6MS	6SJ7
F26-6KS	6SJ7-GT
F26-12KS	12SJ7-GT
F26-12MS	12SJ7

Diode, Sharp-Audio Pentodes

DF22-1fP	1S5
DF24-1fL	1LD5

Sharp r-f Pentodes

F21-1fP	1L4
F23-1fU	1B4-P
F23-1fK	1Eg-GP
F25-2U	15
vF27-6L	1231
vF29-6L	7G7/1232
F41-6MS	6SH7
F41-12MS	12SH7
F43-6MS	6AC7/1852
vF45-6P	6AG5
F47-6L	7L7
F49-6L	7V7
vF61-6L	7W7
uF63-6A	954
uF63-6P	9001
vF63-6L	1204

Duo-Diode Sharp r-f Pentodes

DDF21-1fU	1F6
DDF21-1fG	1F7-G

Diode-Triode, Sharp r-f Pentode

DTF21-3FK	3A8-GT

Low-mu Power Triodes

A11-5U	71A
A13-7fU	50
A15-7fU	10
A17-2fU	45
A19-1fU	31
A21-2fU	2A3
A21-6fU	6A3
A21-6G	6B4-G
vA23-6P	6C4

Low-mu Twin-Power Triodes

AA11-6U	6E6
vAA13-3fP	3A5
AA15-6K	1635

Gain Triode, Low-mu Power Triodes

tA11-6U	6B5
tA11-6G	6N6-G
tA13-25U	25B5
t13-25G	25N6-G

High-mu Power Triodes

A12-2fU	46
A14-2fU	49
A16-6K	6AC5-GT/G
A18-25K	25AC5-GT/G

High-mu Twin-Power Triodes

AA12-1fK	1G6-GT/G
AA14-1fG	1J6-G
AA14-1fU	19
AA16-2U	53
AA16-6U	6A6
AA16-6M	6N7
AA16-6K	6N7-GT/G
AA18-6G	6Z7-G
AA20-6G	6Y7-G
AA20-6U	79

Beam Power Tubes

B11-1fK	1Q5-GT/G
B11-3FK	3Q5-GT/G
B11-3FL	3LF4
B13-3FL	3D6/1299
B15-1fK	1T5-GT
B17-6M	6L6
B17-6G	6L6-G
B17-12M	1631
B19-6M	6V6
B19-6K	6V6-GT/G
B19-6L	7C5
B21-6G	6Y6-G
B21-25G	25C6-G
B23-6L	7A5
B23-35L	35A5
B25-25M	25L6
B25-25K	25L6-GT/G
B25-50K	50L6-GT
B25-12M	1632

Rectifiers (Beam Power)

RB11-32K	32L7-GT
RB13-70K	70L7-GT
RB15-117K	117L7/M7-GT
RB15-117K1	117P7-GT
RB17-117K	117N7-GT

Twin Beam Power Tube

BB11-28L	28D7

Power Pentodes

P11-1fK	1A5-GT
P11-1fL	1LA4
P13-1fP	1S4
P13-3FP	3S4
P15-3FP	3A4
P17-1fK	1C5-GT
P19-1fL	1LB4
P21-3FP	3Q4
P23-1fU	1F4
P23-1fG	1F5-G
P25-1fG	1G5-G
P27-1fG	1J5-G
P29-1fU	33
P31-2U	2A5
P31-6U	42
P31-6M	6F6
P31-6G	6F6-G
P33-2fU	47
P33-2U	59
P35-6fU	6A4/LA
P37-6U	41
P37-6K	6K6-GT/G
P37-6L	7B5
P39-6P	6AK6
P41-6G	6G6-G
P43-6U	38
P45-6U	89
P47-12FU	12A5
P49-25U	43
P49-25M	25A6
P51-25G	25B6-G

Diodes; Power Pentodes

DP11-1fG	IN6-G

Rectifier; Power Pentodes

RP11-12U	12A7
RP13-25K	25A7-GT/G

Twin Power Pentodes

PP11-1fG	1E7-G
PP13-12K	12L8-GT
PP15-12K	1644

R-F Power Pentodes

P12-6MS	6AG7
vP14-12L	1284

Converter Pentagrids

KS11-1fK	1A7-GT/G
KS11-1fL	1LA6
KS13-1fL	1LC6
KS15-1fK	1B7-GT
KS17-1fP	1R5
KS19-1fU	1C6
KS19-1fG	1C7-G
KS21-1fU	1A6
KS21-1fG	1D7-G
KS23-2U	2A7
KS23-6U	6A7
KS23-6M	6A8
KS23-6G	6A8G
KS23-6G1	6D8G
KS23-6L	7B8
KS23-6ML	7B8-LM
KS23-12K	12A8-GT/G
KS25-6MS	6SA7
KS25-6L	7Q7
KS25-12MS	12SA7

Triode-Hexode Converters

KTH11-6M	6K8
KTH11-6G	6K8-G
KTH11-12K	12K8

Triode-Heptode Converters

KTS11-6G	6J8-G
KTS11-6L	7J7

Octode Converter

KE11-6L	7A8

(Mixers) Pentagrids

kS11-6M	6L7
kS11-6G	6L7-G
kS11-6M1	1612

(Magic Eye) Remote Cut-Off Triodes

IT11-6U1	6AB5/6N5
IT13-6U	6U5/6G5

(Magic Eye) Sharp Cut-Off Triodes

IT22-2U	2E5
IT22-6U	6E5
IT22-12G	1629

Twin Magic Eye Tubes

II21-6G	6AD6-G
II23-6G	6AF6-G

• • •

CROSS INDEX

1A3	uD11-1P
1A4P	F15-1fU
1A5-GT	P11-1fK
1A6	KS21-1fU
1A7-GT	KS21-1fK
1B4-P	F23-1fU
1B7-GT	KS15-1fK
1C5-GT	P17-1fK
1C6	KS19-1fU
1C7-GT	KS19-1fK
1D5-GP	F17-1fG
1D5-GT	Q11-1fK
1D8-GT	DTP11-1fK
1E5-GP	F23-1fK
1E7-G	PP11-1fG
1F4	P23-1fU
1F5-GT	P23-1fK
1F6	DDF21-1fU
1F7-G	DDF21-1fG
1G5-G	P25-1fG
1G6-GT	AA12-1fK
1H5-GT	DT12-1fK
1H6-G	DDT11-1fG
1J6-G	AA14-1fG
1L4	F12-1fP
1LA4	P11-1fL
1LA6	KS11-1fL
1LB4	P19-1fL
1LC5	F12-1fL
1LC6	KS13-1fL
1LD5	DF24-1fL
1LE3	T29-1fL
1LH4	DT12-1fL
1LN5	F14-1fL
1N5-GT	F14-1fK
1N6-G	DP11-1fG
1P5-GT	F13-1fK
1Q5-GT/G	B11-1fK
1R5	KS17-1fP
1S4	P13-1fP
1S5	DF22-1fP
1T4	F11-1fP
1T5-GT	B15-1fK
2A3	A21-2fU
2A5	P31-2U
2A7	KS23-2U
2B7	DDF12-2U
2E5	IT22-2U
2X2/879	R33-2U
3A4	P15-3FP
3A5	vAA13-3FP
3A8-GT	DTF21-3FK
3LF4	B11-3FL
3Q4	P21-3FP
3Q5-GT/G	B11-3FK
3S4	P13-3FP
5T4	R48-5fU
5U4-G	R46-5fG
5V4-G	R60-5G
5W4	R24-5fM
5W4-GT	R24-5fK
5Y3-GT	R22-5fK
5Z3	R46-5fU
5Z4	R62-5M
6A3	A21-6fU
6A4/LA	P33-6fU
6A6	AA16-6U
6A7	KS23-6U
6A8-G	KS23-6G
6A8-GT	KS23-6K
6AB5/6N5	IT11-6U1
6AB7/1853	F39-6MS
6AC5-GT/G	A16-6K
6AC7/1852	F43-6MS
6AD6-G	IT21-6G
6AF6-G	II23-6G
6AG5	vF45-6P
6AG7	P12-6MS
6AK6	P39-6P
6B4-G	A21-6G
6B5	TA11-6U
6B7	DDF12-6U
6B8	DDF12-6M
6B8-G	DDF12-6G
6C4	vA23-6P
6C5	T23-6M
6C6	F22-6U
6C8-G	TT13-6G
6D6	F19-6U
6D8-G	KS23-6G1
6E5	IT22-6U
6E6	AA11-6U
6F6	P31-6M
6F6-G	P31-6G
6F7	TF11-6U
6F8-G	TT15-6G
6G6-G	P41-6G
6H6	DD22-6M
6J5	T25-6M
6J5-G	T25-6G
6J6	uTT19-6P
6J7	F22-6M
6J7-GT	F22-6K
6J8-G	KTS11-6G
6K6-GT/G	P37-6K
6K7	F31-6M
6K7-G	F31-6G
6K8	KTH11-6M
6K8-G	KTH11-6G
6L5-G	T27-6G
6L6	B17-6M
6L6-G	B-17-6G
6L7	kS11-6M
6L7-G	kS11-6G
6N7	AA16-6M
6P7-G	TF11-6G
6Q7	DDT14-6M
6R7	DDT15-6M
6R7-GT	DDT15-6K
6S7-G	F35-6G
6SA7	KS25-6MS
6SC7	TT12-6MS
6SF5	T12-6MS
6SF7	DF11-6MS
6SG7	F16-6MS
6SH7	F41-6MS
6SJ7	F26-6MS
6SK7	F33-6MS
6SL7-GT	TT14-6KS
6SN7-GT	TT15-6KS
6SQ7	DDT12-6MS
6SR7	DDT15-6MS
6SS7	F51-6MS
6ST7	DDT17-6MS
6U5/6G5	IT13-6U
6U7-G	F19-6G
6V6	B19-6M
6V6-GT/G	B19-6K
6W7-G	F22-6G
6X5	R26-6M
6X5-G	R26-6G
6Y6-G	B21-6G
6Z7-G	AA18-6G
6ZY5-G	R28-6G
7A4	T25-6L
7A5	B23-6L
7A6	DD22-6L
7A7	F33-6L
7A8	KE11-6L
7B4	T12-6L
7B5	P37-6L
7B6	DDT12-6L
7B7	F35-6L
7B8-LM	KS23-6ML
7C5	B19-6L
7C6	DDT16-6L
7C7	F22-6L
7E6	DDT15-6L
7E7	DDF11-6L
7F7	TT12-6L
7G7/1232	vF29-6L
7H7	F37-6L
7J7	KTS11-6L
7L7	F47-6L
7N7	TT15-6L
7Q7	KS25-6L
7R7	DDF14-6L
7V7	F49-6L
7W7	vF61-6L
7Y4	R26-6L
7Z4	R40-6L
10	A15-7fU
12A5	P47-12FU
12A6	DD24-12M
12A7	RP11-12U
12A8-GT/G	KS23-12K
12AH7-GT	TT17-12K

(*Continued on page* 76)

EXPERIMENTAL 225.6-

by W. L. WIDLAR

Development Engineer
Bird Engineering Co.

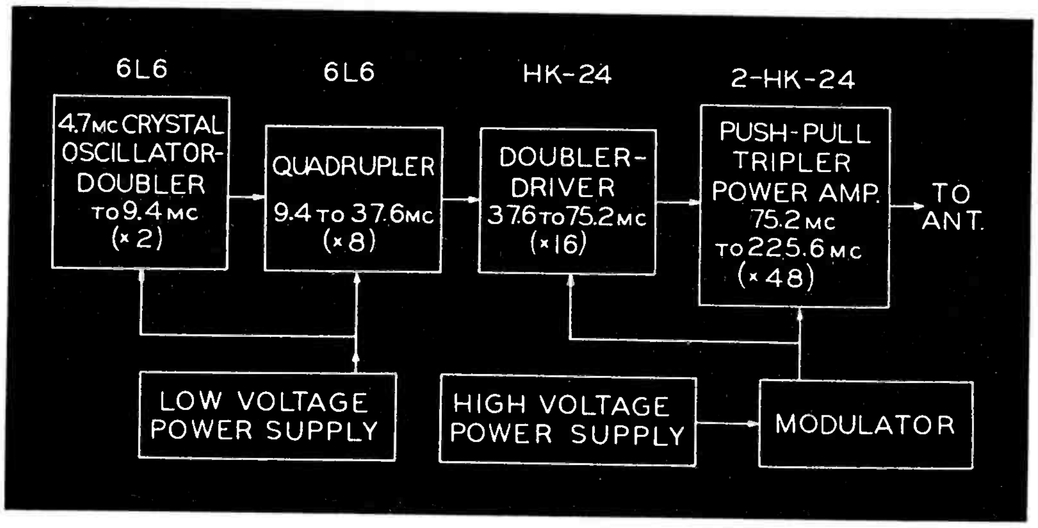


Figure 1
Block diagram of the 225.6-mc transmitter using frequency multiplication.

FREQUENCY multiplication offers an effective means of obtaining high transmitter efficiency, particularly on u-h-f for relay work. Accordingly, to conduct relay experiments on u-h-f, a transmitter encompassing this mode of design was built. The transmitter, shown in block diagram form in Figure 1, was designed for use on 225.6 mc.

The r-f section of the transmitter employs but five tubes. The frequency of a 4.7-mc crystal is multiplied 48 times to 225.6 mc.

Operation of Transmitter

A schematic diagram of the r-f section of the transmitter is shown in Figure 2. The 4.7 mc crystal oscillator functions when power is applied, regardless of the tuning of its 9.4-mc plate circuit. When the oscillator is operating, a small reading is obtained on the grid milliammeter. As each successive multiplier stage is resonated to its operating frequency, the direct current flowing in the grid return circuit will increase the milliammeter reading. Resonance of the 75.2-mc doubler-driver plate circuit is obtained by adjusting its plate resonance and the resonance of the grid circuit of the tripler-amplifier at the same time.

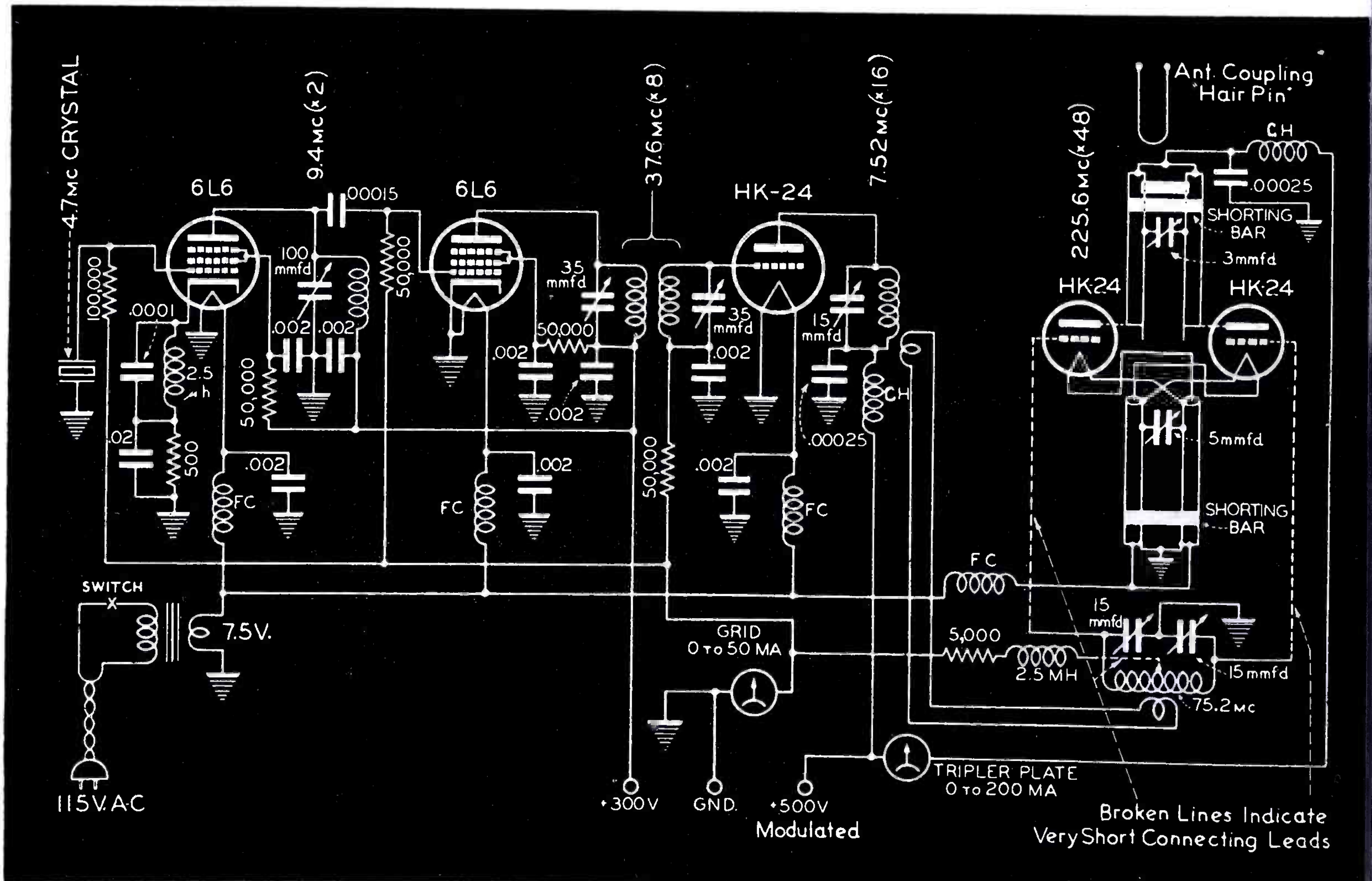


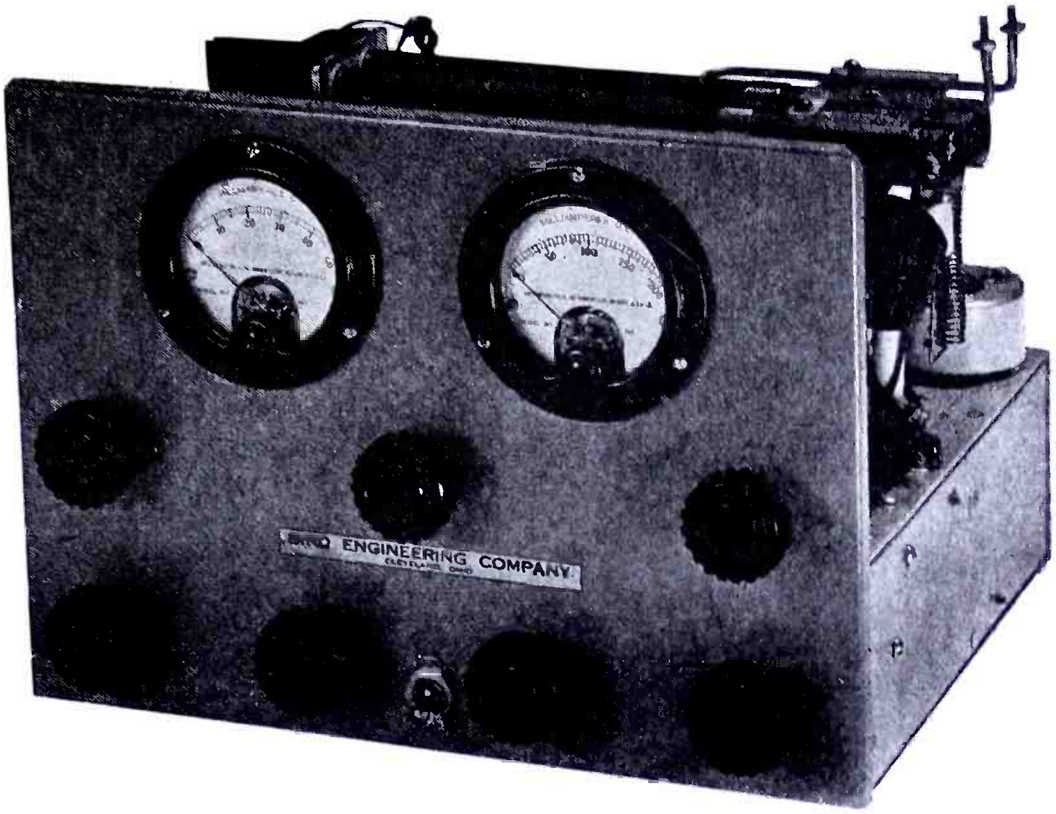
Figure 2
R-f section of the 225.6-mc a-m transmitter.

MC A-M RELAY TRANSMITTER

•

ont view of the amplitude modulation trahigh-frequency relay unit using but five tubes in the r-f section.

•



/hen resonance of both circuits ocırs, a maximum reading is obtained ı the grid meter.

llament Filters

The filament chokes (*fc*) and their ssociated bypass condensers conibute to the efficiency and stability f the transmitter by restricting the rculation of stray r-f energy. The lament chokes are designed with the roper resistance to provide 6.3 volts › the tube filaments with filament ower supplied by a 7.5-volt transormer.

25.6-MC Regenerative Tripler

The operation of the push-pull ipler-amplifier is quite interesting. t shows evidence of regeneration /hen in operation. The plate and lament resonant lines are in close roximity and in inductive relation; ıe filament line is beneath the plate ne and is transposed.

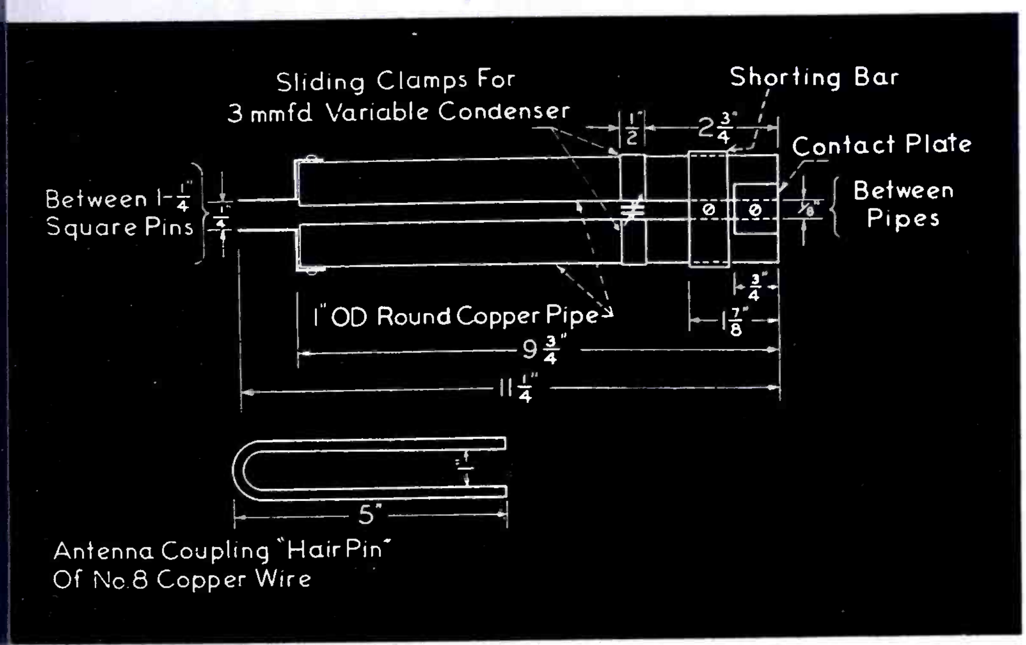
Due to the arrangement of plate nd filament lines, the tripler comrises a neutralized harmonic-ampliier. Many experimenters have realized hat harmonic-amplifiers, when neuralized, afford better tube efficiency. n the usual unneutralized triode harnonic-amplifiers, the feedback through he grid-plate capacity is, of course, degenerative. It is degenerative because the harmonic feedback provides a capacitive reactance in the grid circuit. If an inductive reactance should prevail, the feedback would then be regenerative. The latter condition occurs in this u-h-f relay transmitter. Thus by varying the reactance of the harmonic feedback in the grid circuit, any degree of regeneration or degeneration is possible.

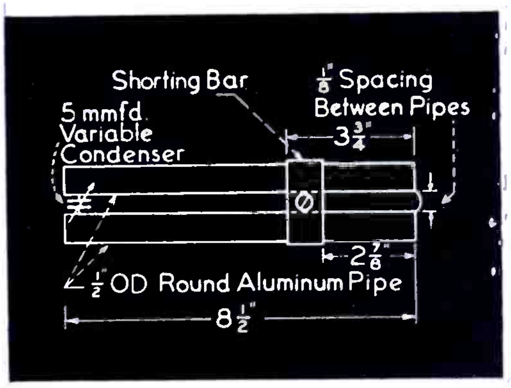
Tripler Tuning

Tuning of the tripler is accomplished by adjusting the shorting bars on the filament and plate lines, with 75.2-mc excitation applied. Resonance is indicated by a minimum plate current dip of the tripler plate-circuit milliammeter. These adjustments are made with the resonant line tuning condensers set at half their capacity. The condensers are then adjusted for fine tuning and serve as a convenient means of compensating for changes in loading and small circuit changes due to temperature variations. The variable condenser on the filament line is a regeneration control. The physical proportions of the filament and plate lines are shown in Figures 3 and 4.

Resonant Line Peculiarities

Incidentally resonant line circuits





•

Figures 3 (left) and 4 (above)
Figure 3 illustrates the physical proportions of the plate line. The filament line physical proportions are shown in Figure 4.

•

operate differently from conventional coil and condenser circuits in that they react in opposite fashion to identical treatment. This may be interesting to experimenters who are familiar with self-supporting coils that can be adjusted to resonate at a lower or higher frequency by decreasing or increasing the spacing between turns. When the turns of a coil are spaced close together, it will resonate at a lower frequency than when the turns are spaced apart. The reverse of this is true with resonant line circuits. When the lines are spaced close together the circuit will resonate at a *higher* frequency than when space between lines is increased.

Cascade Modulation

An unusual feature of the transmitter is the cascade modulation of the double-driver and the push-pull tripler-amplifier. Cascade modulation of the two stages permits the application of a higher percentage of modulation with a low value of excitation to the tripler, than could be obtained by modulating the tripler alone.

Driver and Tripler Phasing

To take full advantage of cascade modulation, the modulated stages must be correctly phased at audio frequencies. In the 225.6-mc transmitter, the correct phasing of the driver and tripler was complicated by the presence of stray r-f (inductive coupling, with rf coupling link removed) between the 75.2-mc driver plate-tank circuit and the 75.2-mc tripler grid-tank circuit. This stray coupling occurred in spite of the fact that the two circuits are separated eight inches and are located so that the aluminum chassis shields one circuit from the other, (Figure 5a).

Radio Frequency Phasing

To avoid loss of excitation, because of the stray coupling, it was necessary that a r-f coupling link be installed between the two circuits, so as to be in series-aiding to the stray coupling. This condition was determined by trial. That is, we first observed the tripler grid current. Then we transposed the r-f coupling link and reversed the direction of coil winding in the driver plate or tripler grid-tuned circuits. This procedure is illustrated in Figure 5b and 5c. The condition providing maximum tripler grid current proved to be the correct on[e].

Audio Frequency Phasing

If the modulated excitation from th[e] driver is out of phase with the triple[r] at audio frequencies, severe down[-]ward modulation will result. Whe[n] this occurred in this transmitter th[e] two stages were properly phased b[y] reversing the r-f coupling link polarit[y] and the winding direction of one coi[l] in the 75.2-mc driver to tripler coup[-]ling circuit. This reversal establishe[d] the two stages in phase at audio fre[-]quencies and maintained the excita[-]tion in series-aiding to the stra[y] coupling.

Results

With an output power of 10 watts this transmitter has provided excel[-]lent signals under a variety of condi[-]tions. Listening tests on the 225.6 mc operating frequency indicated com[-]plete freedom from ignition, electrica[l] appliance, power circuit and atmos[-]pheric disturbances. In addition, test[s] were conducted during violent thunder[-]storms. Uninterrupted communicatio[n] was carried on over a 30-mile pat[h] during such storms, while strong loca[l] broadcast-band signals were blotte[d] out completely.

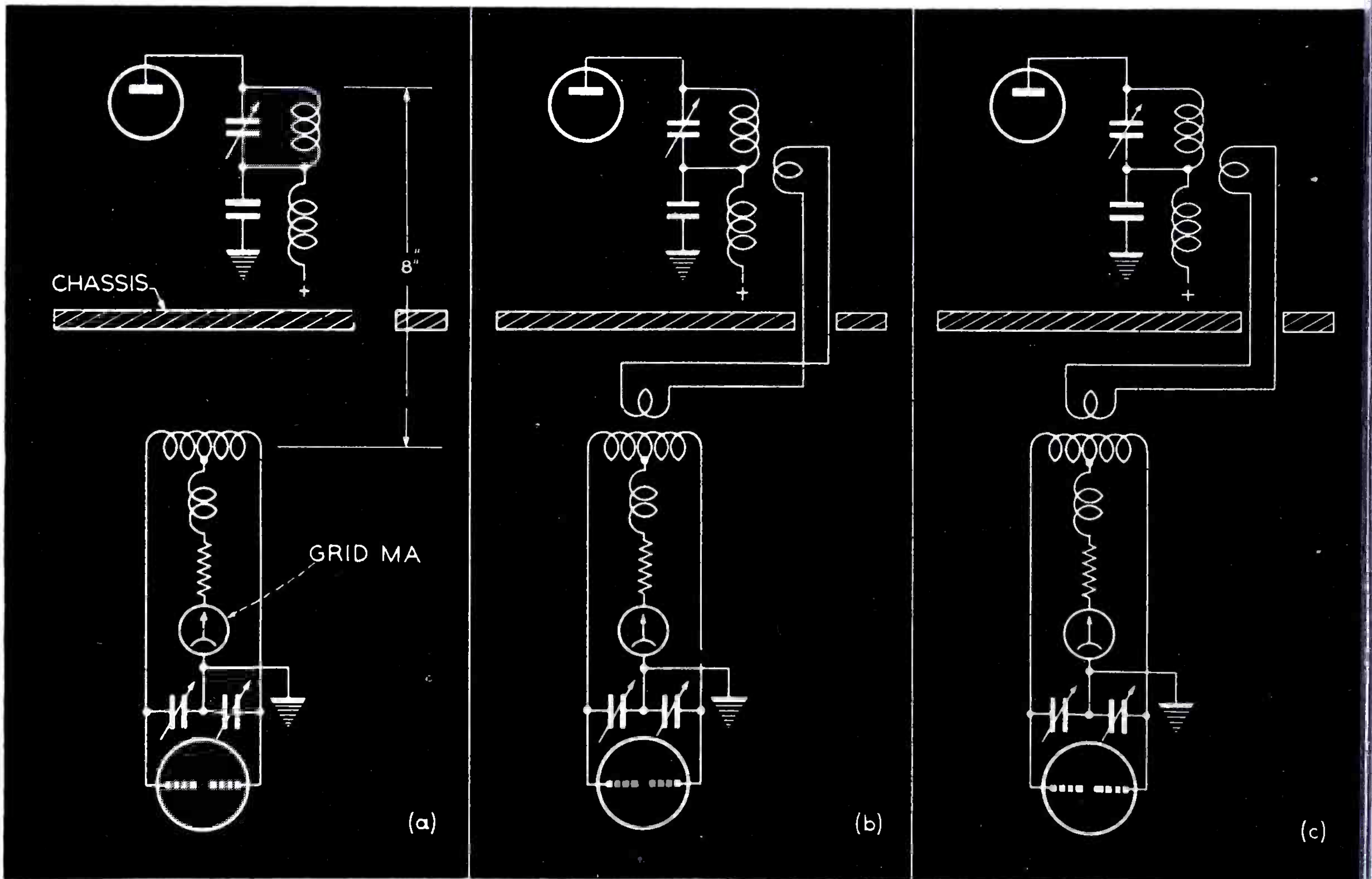
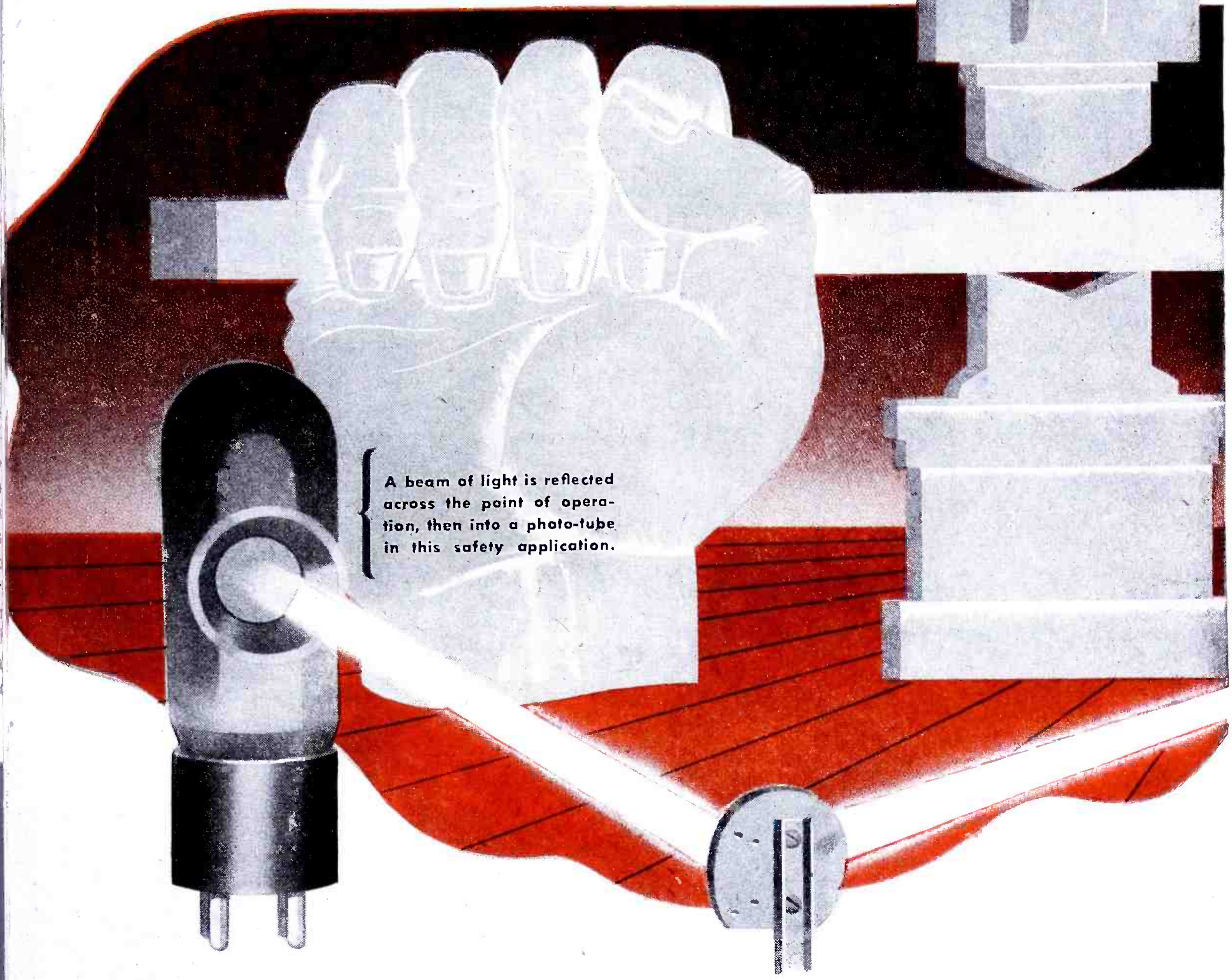


Figure 5
At (a) is illustrated a condition for stray r-f coupling between 75-mc tuner circuits. Tripler grid circuit is shown. In (b) we have transposed link, while in (c) is shown a plate coil winding reversal.

wherever a tube is used...



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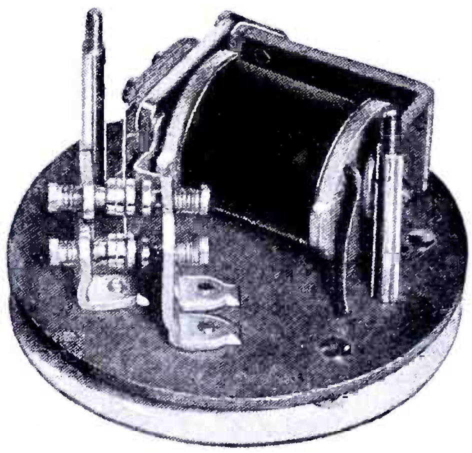

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IRE WINTER TECHNICAL MEETING

Thursday, January 27 (Joint AIEE-IRE Session . . . At Engineering Societies Building, 33 West 39th Street, New York City)

2:00 P.M. "A Short-Cut Method of Estimating TIF of Power Systems with Rectified Load"; *C. W. Frick, General Electric Company.*

"Crossbar Toll Switching System"; *L. G. Abraham, A. J. Busch,* and *F. F. Shipley, Bell Telephone Labs, Inc.*

"Automatic Ticketing of Telephone Calls"; *O. A. Friend, Bell Telephone Labs, Inc.*

"Electronically Controlled Dry-Disc Rectifier"; *Allen Rosenstein,* and H. N. Barnett, *Signal Engineering Products Company.*

"Rectifier Circuit Duty"; *C. C. Herskind, General Electric Company.*

8:00 P.M. "Enemy Communication Equipment"; *Major General R. B. Colton, Signal Corps, U. S. Army.*

Friday, January 28th (IRE Technical Meeting . . . Hotel Commodore, New York City)

8:00 A.M. Registration

10:00 A.M. Opening of Meeting by Dr. B. E. Shackelford, chairman.

10:10 A.M. "Electronic Tin Fusion"; *H. C. Humphrey, Westinghouse Electric and Mfg. Company.*

10:35 A.M. "The Amplidyne System of Control"; *M. A. Edwards and K. K. Bowman, General Electric Company.*

11:15 A.M. Two-group technical session.

Group A

11:20 A.M. "Joint Army and Navy Tube Standardization Program"; *Lt. C. W. Martel, U. S. Army* and *J. W. Greer, USN.*

11:40 A.M. "A New Studio-to-Transmitter Antenna"; *M. W. Scheldorf, General Electric Company.*

12:00 Noon. "Orthicon Cameras in Television Studio Work"; *H. R. Lubke, Don Lee Broadcasting System.*

Group B

11:20 A.M. "The Limitations Imposed by Quantum Theory on Resonator Control of Electronics"; *L. P. Smith, RCA.*

11:40 A.M. "The Piston Attenuator"; *H. A. Wheeler, Hazeltine Electronics.*

12:00 Noon. "Equivalent Circuits for Discontinuities in Transmission Lines"; *J. R. Whinnery, General Electric Company.*

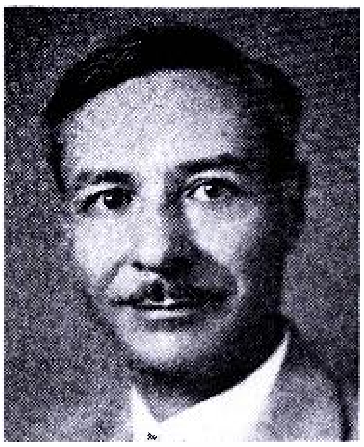
Group A

2:00 P.M. "The Modification of Noise by Certain Non-Linear Devices"; *Dr. D. O. North, RCA.*

IRE MEDAL OF HONOR TO PRATT

Haraden Pratt, vice-president and chief engineer, Mackay Radio and Telegraph Company and vice-president of the Federal Telephone and Radio Corporation, has been awarded the Medal of Honor by The Institute of Radio Engineers for distinguished service in the field of radio communication.

Mr. Pratt, who is secretary and past president of The Institute of Radio Engineers, also is the Institute's delegate to the Radio Technical Planning Board.



2:20 P.M. "Some Experiments Relating to the Statistical Theory of Noise"; *C. M. Burrill, RCA.*

Group B

2:00 P.M. "Transmission Line Analogies of Plane Electromagnetic Waves"; *Dr. A. B. Bronwell, Northwestern University.*

2:20 P.M. "Equivalent Circuit of the Field Equations of Maxwell"; *Gabriel Kron, General Electric Company.*

"A New Approach to the Solution of High Frequency Field Problebs"; *J. R. Whinnery and Simon Ramo, General Electric Company.*

"AC Network Analyzer Studies of Electromagnetic Cavity Resonators"; *J. R. Whinnery, C. Concordia, W. Ridgway* and *Gabriel Kron, General Electric Company.*

2:40 P.M. "Intermittent Behavior in Oscillators"; *W. A. Edson, Bell Telephone Laboratories.*

3:00 P.M. "The Work of the Radio Technical Planning Board," A Symposium; *Haraden Pratt, Mackay Radio,* chairman.

Speakers

Dr. W. R. G. Baker, RTPB chairman.

F-M BROADCASTERS MEETING

FM Broadcasters, Inc., will hold its fifth annual meeting at the Commodore Hotel, New York City, on January 26 and 27.

Scheduled to speak at the meeting are Walter J. Damm, Philip Loucks, C. M. Jansky, Jr., Major Edwin H. Armstrong, Dr. W. R. G. Baker, and FCC chairman Fly.

Dr. A. N. Goldsmith, chairman c Panel 1; Spectrum Utilizatio
Dr. C. B. Jolliffe, chairman c Panel 2; Frequency Allocation.
R. M. Wise, chairman of Panel 3 High Frequency Generation.
H. S. Frazier, chairman of Pan 4; Standard Broadcasting.
C. M. Jansky, Jr., vice chairman c Panel 5; Very High Frequenc Broadcasting.
D. B. Smith, chairman of Pan 6; Television.
J. V. L. Hogan, chairman c Panel 7; Facsimile.
Haraden Pratt, chairman of Pan 8; Radio Communication.
E. W. Engstrom, chairman c Panel 9; Relay Systems.
W. P. Hilliard, chairman of Pan 10; Radio Range, Direction, an Recognition.
D. W. Rentzel, chairman of Pan 11; Aeronautical Radio
C. V. Aggers, chairman of Pan 12; Industrial, Scientific an Medical Equipment.
D. E. Noble, chairman of Pan 13; Police Emergency Service.

7:00 P.M. Banquet. *George Lewi* Master of Ceremonies.

Saturday, January 29th (IRE Technica Meeting . . . Hotel Commodore, Ne York City)

9:30 A.M. "Design Technique Versu Service Requirements"; *I. W Stanton, RCA.*

9:50 A.M. Subject to be announced *A. Stringer, RCA.*

10:30 A.M. "Engineering Work of th Federal Communications Commis sion", A Symposium; *Professor H M. Turner,* chairman.

Speakers

"General Introduction"; *E. K. Jet FCC Chief Engineer.*
"Timely Broadcast Matters"; *G. Adair, assistant chief engineer an chief of the Broadcast Division o the Engineering Department.*
"Police and Aviation and Maritime Services"; *W. N. Krebs, chie of the Safety and Special Service Division.*
"International Point-to-Point an Allocation Problems"; *P. F. Si ing, chief of the International Divi sion of the Engineering Depart ment.*

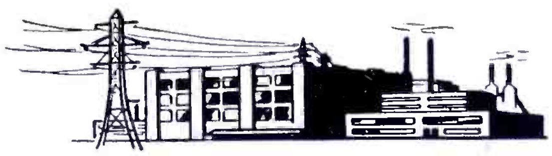
2:30 P.M. "Organization of Radio Re search, Development and Produc tion in Great Britain; *F. S. Barto British Air Commission.*

3:15 P.M. "Peace, War, and Futur Application of Radio in China" *T. M. Liang, Chinese Supply Mi sion.*

3:45 P.M. "Standardization of Servic Equipment"; *Commander A. Chamberlain, U. S. Navy.*

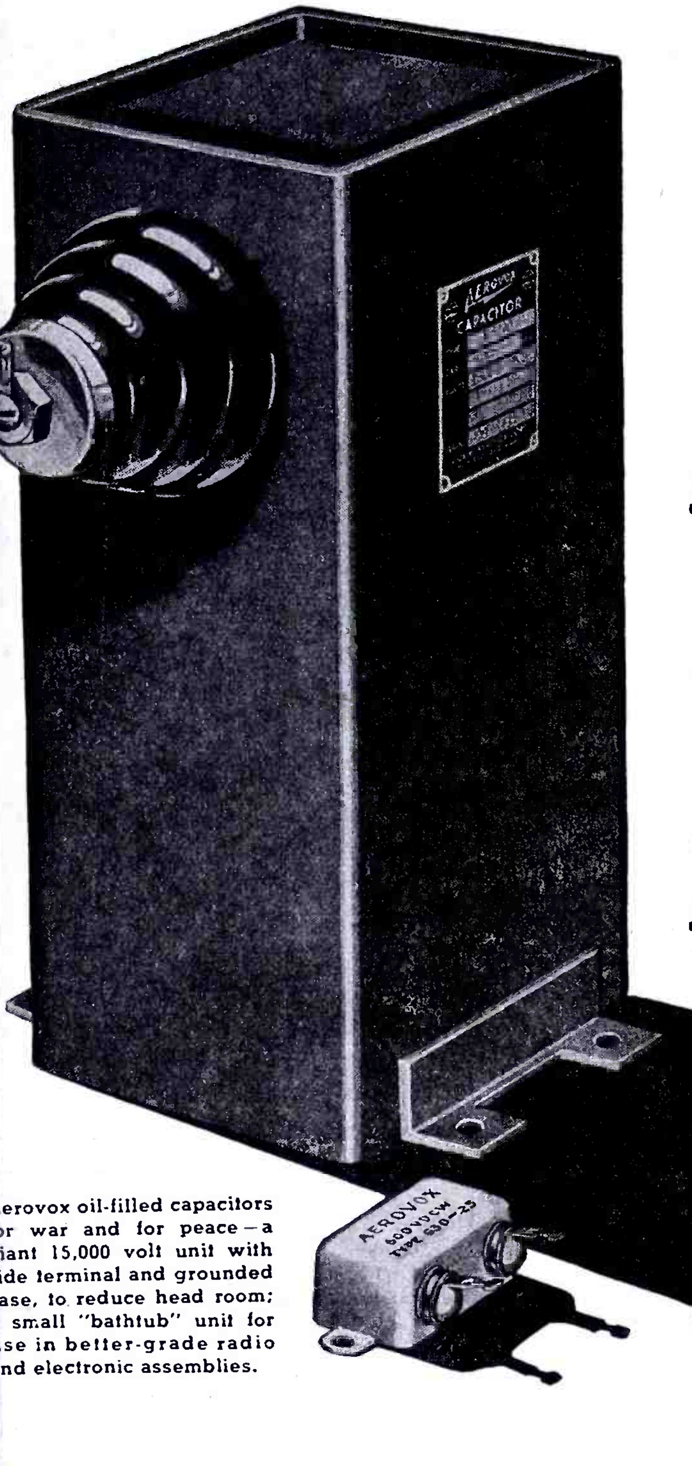
TODAY...

Aerovox Capacitors Go to War



TOMORROW...

Aerovox Capacitors Help Build Peacetime Progress



erovox oil-filled capacitors or war and for peace—a iant 15,000 volt unit with ide terminal and grounded ase, to reduce head room; small "bathtub" unit for se in better-grade radio nd electronic assemblies.

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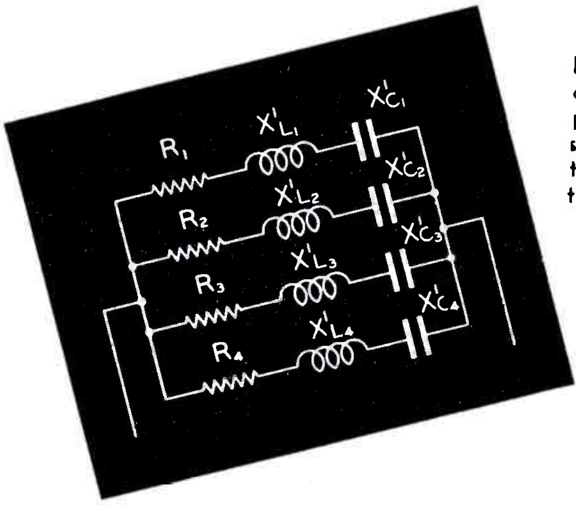
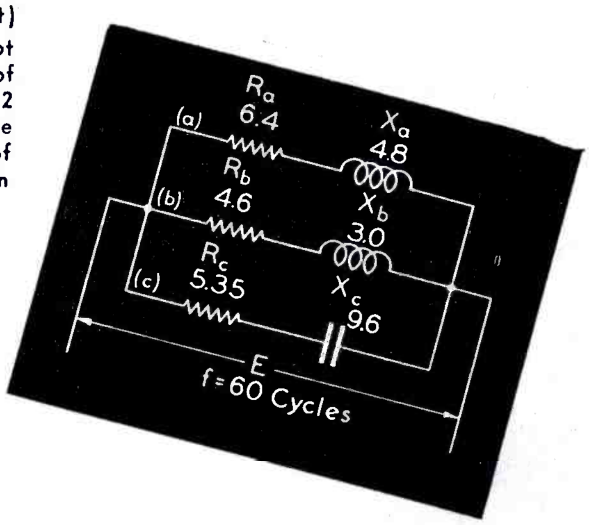


Figures 1 (left) and 2 (right)
In Figure 1 appears a concept of the elementary theory of parallel circuits. Figure 2 shows circuit used to determine the equivalent impedance of three branches as described in the *N* diagram, Figure 4.



NOMOGRAM
FOR SOLVING PARALLEL CIRCUIT PROBLEMS

by SGT. BON L. WONG
Weather Inf. Branch, AAF

THE various methods, such as admittance and graphic, for solving a parallel circuit consisting of two or more branches are usually tedious and time consuming. Moreover, the possibility of introducing a mathematical error is great as there are many steps involved in each case. It is the purpose of this nomogram to present a method through which the determination of the equivalent impedance in rectangular coordinates of any parallel circuit can be greatly simplified.

Referring to Figure 1 and recalling from the elementary theory of parallel circuit, we have the following equations:

$$Z_1 = R_1 + j\,(X'_{L_1} - X'_{C_1}) = R_1 + j\,X_1,\ \text{if}\ X'_{L_1} > X'_{C_1} \quad (1)$$

$$Z_2 = R_2 + j\,(X'_{L_2} - X'_{C_2}) = R_2 + j\,X_2,\ \text{if}\ X'_{L_2} > X'_{C_2} \quad (2)$$

$$Z_3 = R_3 + j\,(X'_{L_3} - X'_{C_3}) = R_3 - j\,X_3,\ \text{if}\ X'_{L_3} < X'_{C_3} \quad (3)$$

$$Z_4 = R_4 + j\,(X'_{L_4} - X'_{C_4}) = R_4 - j\,X_4,\ \text{if}\ X'_{L_4} < X'_{C_4} \quad (4)$$

For Z_1 and Z_2 in parallel,

$$Z_0 = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{(R_1 + jX_1)(R_2 + jX_2)}{(R_1 + jX_1) + (R_2 + jX_2)} \quad (5)$$

$$= \frac{(R_1^2 + X_1^2)\,R_2 + (R_2^2 + X_2^2)\,R_1}{(R_1 + R_2)^2 + (X_1 + X_2)^2}$$

$$+ j\,\frac{(R_1^2 + X_1^2)X_2 + (R_2^2 + X_2^2)X}{(R_1 + R_2)^2 + (X_1 + X_2)^2}$$

For Z_2 and Z_3 in parallel

$$Z_0 = \frac{Z_2 Z_3}{Z_2 + Z_3} = \frac{(R_2 + jX_2)\,(R_3 - jX_3)}{(R_2 + jX_2) + (R_3 - jX_3)} \quad (6$$

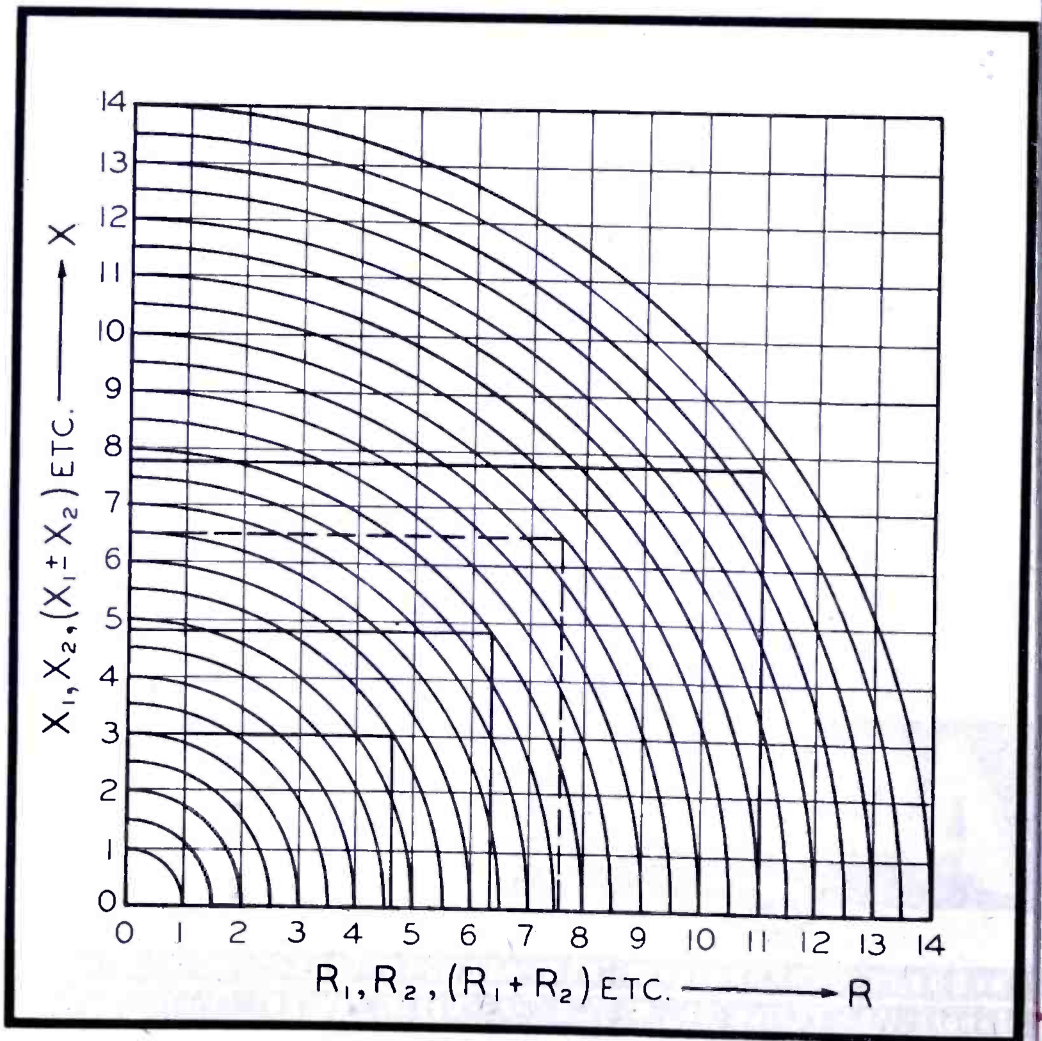


Figure 3
The Z diagram.

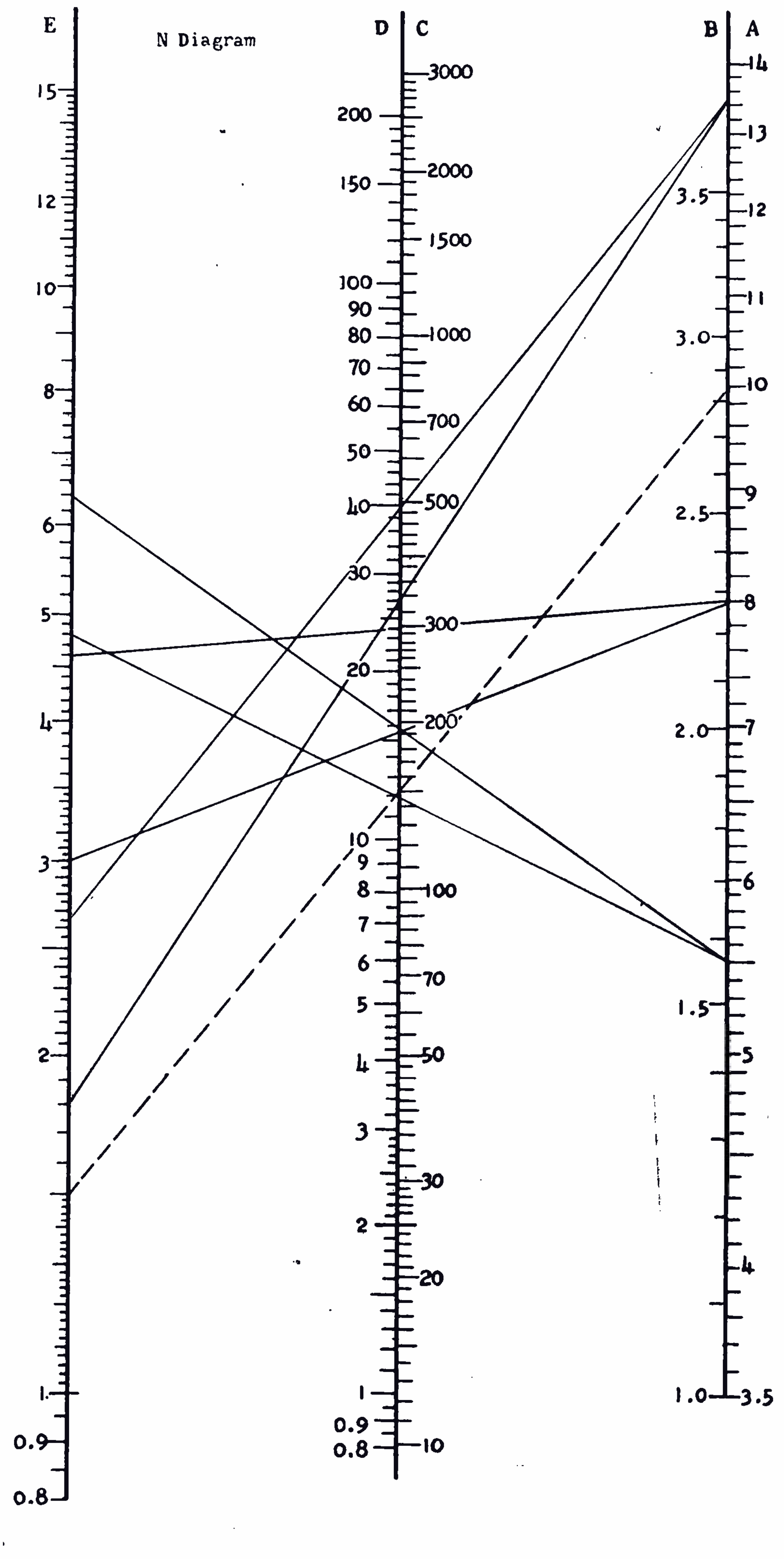


Figure 4

N Diagram

$$= \frac{(R_2^2 + X_2^2)\,R_3 + (R_3^2 + X_3^2)\,R \ldots}{(R_3 + R_2)^2 + (X_3 - X_2)^2}$$

$$+ j\,\frac{-(R_3^2+X_3^2)X_2+(R_2^2+X_2^2)X \ldots}{(R_2 + R_2)^2 + (X_3 - X_2) \ldots}$$

For Z_3 and Z_4 in parallel

$$Z_0 = \frac{Z_3 Z_4}{Z_3+Z_4} = \frac{(R_3 - jX_3)\,(R_4 - jX \ldots}{(R_3 - jX_3) + (R_4 - jX \ldots} \quad (7 \ldots$$

$$= \frac{(R_3^2 + X_3^2)\,R_4 + (R_4^2 + X_4^2)\,R \ldots}{(R_3 + R_4)^2 + (X_3 + X_4)^2}$$

$$- j\,\frac{(R_3^2+X_3^2)\,X_4 + (R_4^2 + X_4^2)\,X \ldots}{(R_3 + R_4)^2 + (X_3 + X_4)^2}$$

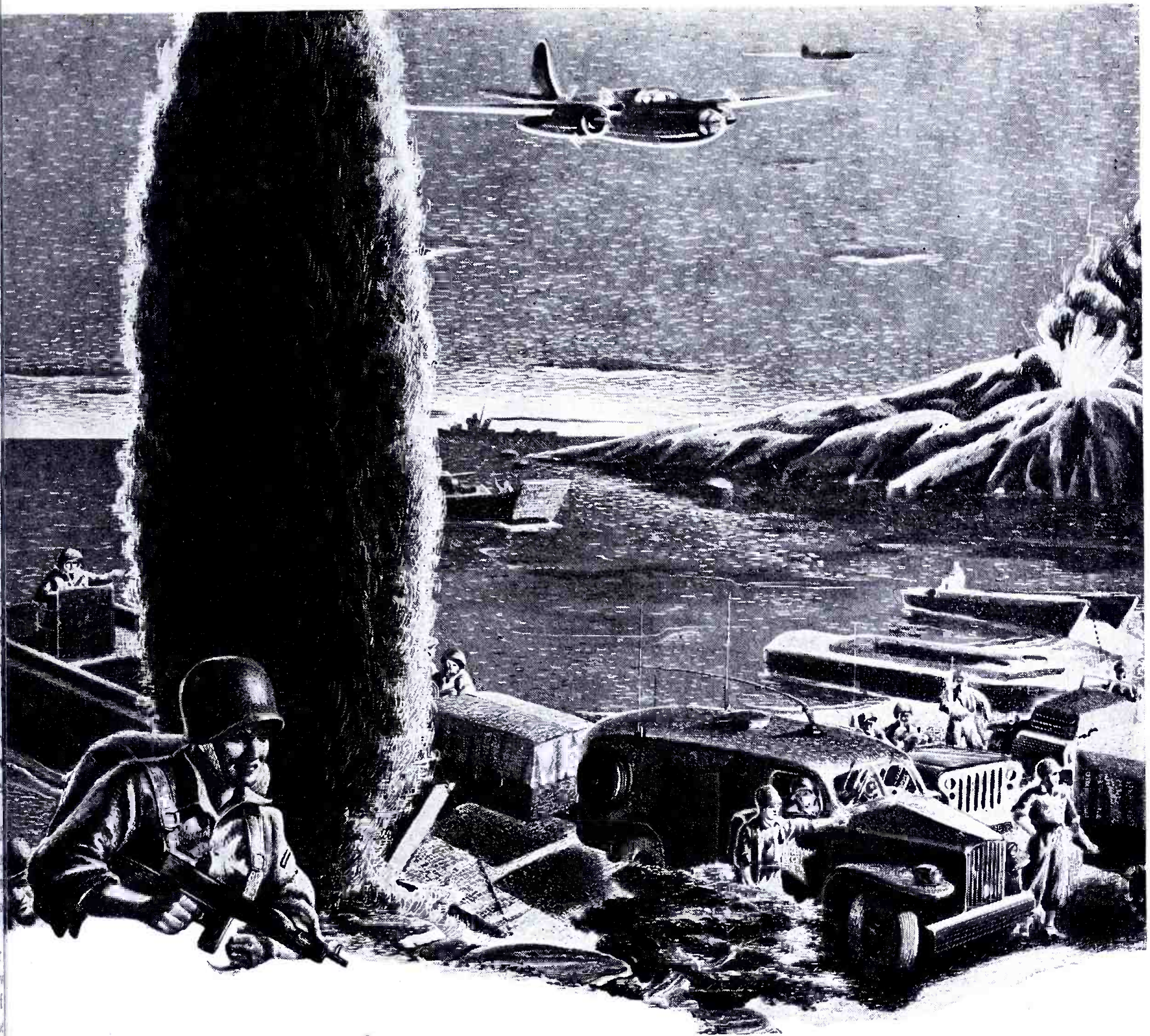
It should be pointed out that equa- tions for $Z_{1,3}$, $Z_{2,4}$, and $Z_{1,4}$ can al- be written but are not needed, sin- they are similar to $Z_{2,3}$. Consequentl- equations *5*, *6* and *7* are the gener- solutions of parallel combination - two resistance-inductive branches, - resistance-inductive branch and a r- sistance-capacitive branch, and two r- sistance-capacitive branches, respe- tively.

By inserting proper subscripts to t- constants of an equation representi- the equivalent impedance of tw- branches, the resulting equation tak- the form of equations *1*, *2*, *3* or - This and another equation of either - single branch or the equivalent of tw- branches will be the final solution of - network of three or four branche- We follow the same procedures if the- are more than four branches.

Attention is called to the fact th- equations *5* and *7* are identical exce- for the sign of the second terms a- are always inductive and capaciti- respectively. However, equation - could be either inductive or capaciti- depending upon the numerical valu- of the constants of the two branch- in question.

An inspection of the terms on t- right hand side of the equal sign - equations *5*, *6*, and *7* shows but a fe- simple steps of mathematical oper- tions. Moreover, there are comm- terms in the numerators as well as - the denominators. It is therefo- rather easy to get the final result - merely drawing a few straight lin- connecting the given constants on a- propriate scales. The *Z* diagram - primarily used for determining t- square root of the sum of two squar- while the *N* diagram is for multiplic- tion and division. Whenever *A*, *B*, -

(*Continued on page* 77)



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PHASE MONITORS

by DR. VICTOR J. ANDREW

Andrew Company

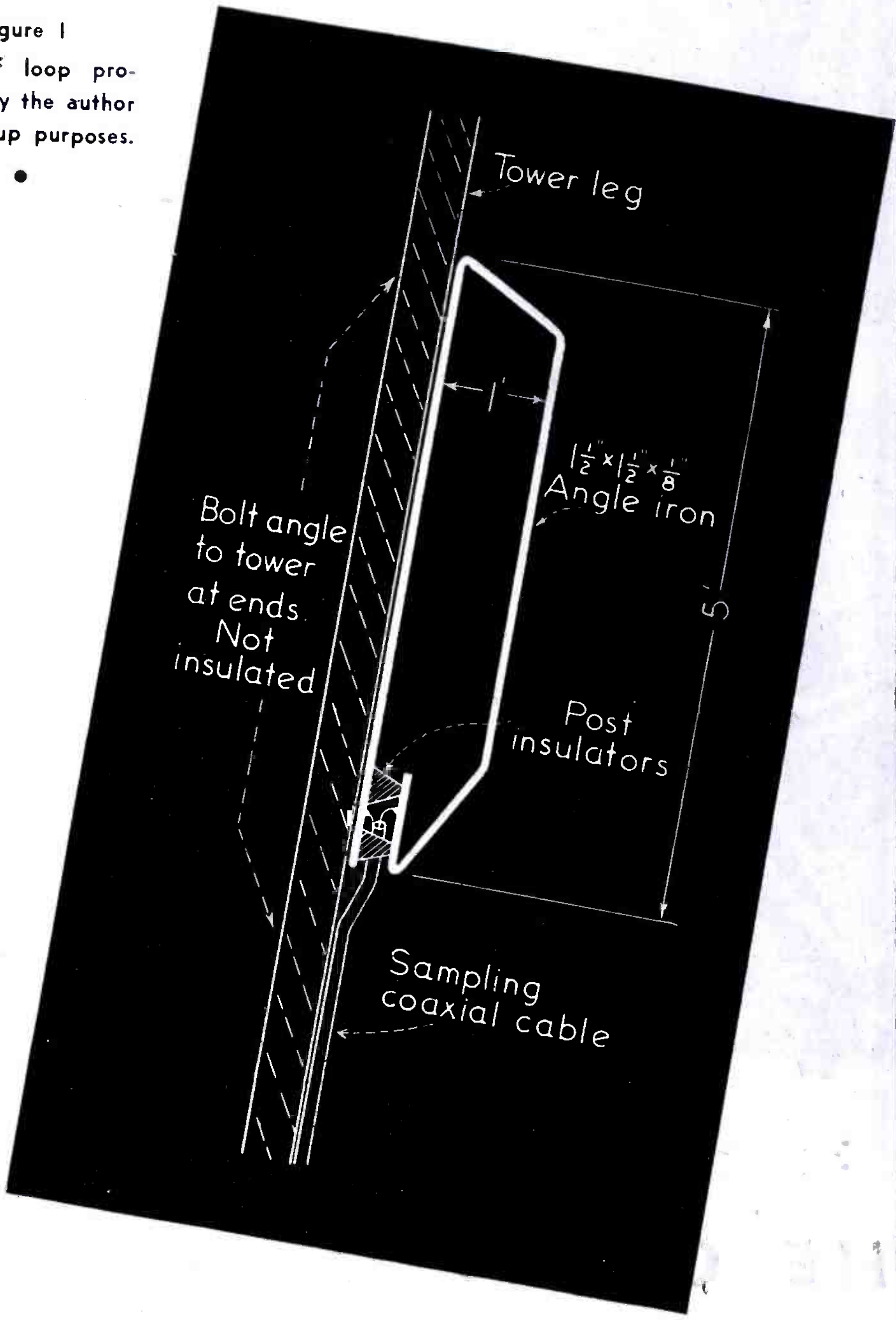

Figure 1
Type of loop proposed by the author for pickup purposes.

THE intent of the phase monitor is to give an absolute reading of the phases of the radiated field. Some people have used monitors as comparison devices only to indicate changes in phase. The instrument also has its greatest utility during tuning of the antenna system, rather than as a routine operation instrument. The accuracy is believed to be in the order of 2°.

Place of Sampling

With a series-fed tower of not over a quarter-wavelength (physical height) a sample can be taken in the antenna lead within the antenna tuning house. The sample must be taken by a transformer with an electrostatic shield, so that the voltage of the lead does not influence the reading. The entire transformer (primary and secondary) is housed in a metal box, so that it will not be influenced by the electromagnetic field of nearby inductances.

In series-fed antennas of greater than quarter-wavelength height, the phase rotation of the current at different points on the tower commences to play an appreciable part. The pickup loop is therefore mounted at the point of greatest current, below the top of the tower. This point is not critical. A minimum height of 50 feet above ground for the loops was maintained on a Wincharger tower. In tests all loops were at the same distance from the top of their towers, though the towers were of different heights.

On a shunt-excited tower the sampling loop must be mounted a substantial distance above the feed wire. Five times the tower diameter should suffice. Incidentally, in our tests shunt excitation of broadcast towers has been found to be impractical.

Symmetry

To get absolute measurement of phase it is necessary to make the different sampling loops and their transmission lines identical. Extra line from the nearer towers may be coiled without appreciably affecting its length.

Design of Pickup Loops

The phase shift between the current in the tower and in the sampling line should be kept identical for all towers. Accordingly, the voltage picked up by the loop should not be varied. If the size of the loop is varied, the change in inductance gives objectionable phase shift. The monitor must permit the necessary adjustment of input voltage, and this adjustment must not shift phase.

Pickup Loop Application

Ordinarily, no tuning device is used in our pickup loops. If such a device is used, it may be adjusted with a bridge to identical tuning in the different loops. If it is merely tuned to maximum output, an objectionable phase shift may occur. For example, if the output is left 1% down by mistuning on one side, the phase will be shifted by 12°.

By carrying loops near tower members we have noted that the field creases rapidly as we come close the tower leg. The greatest pick is obtained by using the tower me ber itself as one side of the loop. T is not very desirable, however, as rusty joint might later introduce sistance which would introduce major phase shift.

Figure 1 illustrates the type of lo found quite effective. It is formed one piece. Brass bolts are brazed i the metal for connections, to prev poor connections resulting from r

Pickup loops which were insula from the tower have never been u because we have anticipated that el trostatic pickup on them might in ence readings. However, our calcu tions of the possible magnitude this influence have indicated that would not be serious.

Chemistry is but one of the many sciences which are collaborating at National Union in the work of producing better electronic tubes for today's vital war assignments. Indeed, our chemists are playing a decisive role in making National Union Tubes *measure up* to the precise standards of scientific instruments.

Thanks to chemical research, we know for example that not only must the formula of a tube's emission coating be *right,* but also the application and processing methods must be rigidly controlled.

To effect such control our chemists, in cooperation with the engineers of our Equipment Division, designed, built and put into production a new type automatic coating machine. Operating in an air-conditioned chamber, this equipment provides exact control of both the coating operation and the chemical processing of the emission coating—free from all extraneous elements.

The fact that tube manufacture *is* such a many-sided scientific job—is a subject to keep in mind when making post-war plans. If you have electronic tube problems—*count on* National Union.

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T H.

(PART ONE OF A TWO-PART PAPER)

by PAUL B. WRIGHT

Communications Research Engineer

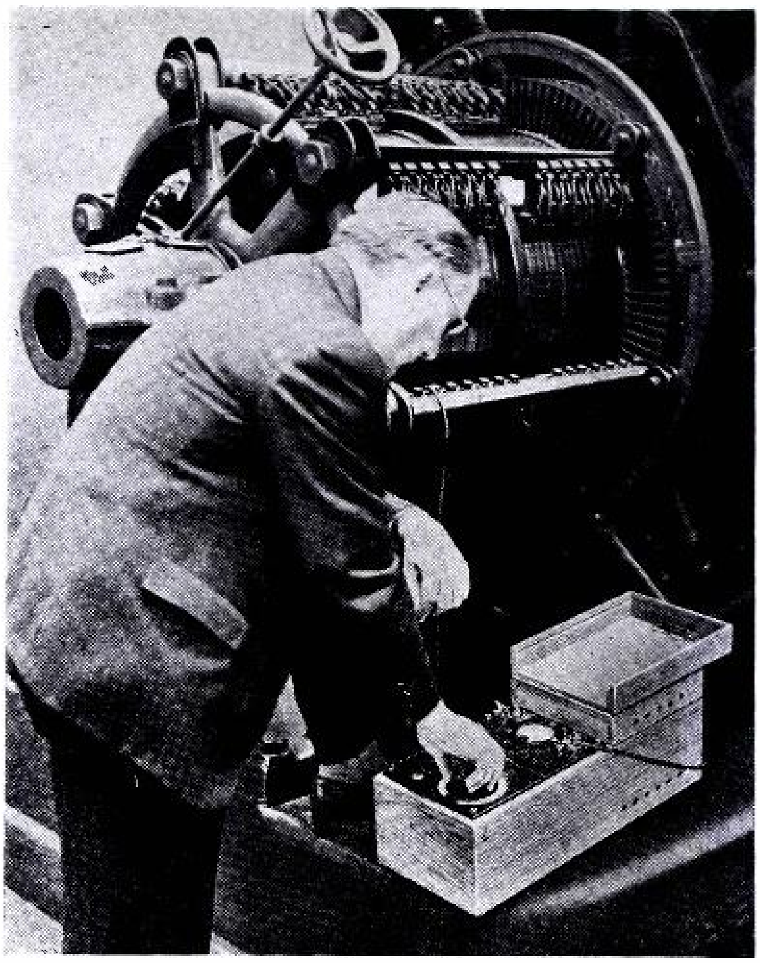

Figure 1

A megohm bridge, embodying the Wheatstone bridge principle, on field service.

(Courtesy General Radio)

THE present conflict has prompted increased interest in the construction of lines, loops and cables to facilitate broadcast, radio, telegraph and telephone communication throughout all of the theatres of war, as well as at home. One of the most important pieces of equipment used for the rapid location of faults in lines and cables and routine maintenance of all these important nerves of communication is the Wheatstone bridge. A volume could be written upon the subject, taking up all of the various commercial and industrial applications. However, only those applications which have a direct influence upon the problems mentioned will be taken up in this paper.

The Wheatstone bridge was actually invented by Samuel Hunter Christie in 1833, but no practical applications of its use were developed until ten years later. In 1843 Sir Charles Wheatstone developed the bridge by the judicious use of Ohm's Law to the network, in connection with problems arising in the field of telegraphy.

Lattice Network

In its unmodified form, the Wheatstone bridge is a special case of the generalized lattice network, where one of the branches of the lattice has a battery inserted in it and the conjugate of that branch has a moving coil type of galvanometer placed in it. The remainder of the branches of the lattice are composed of pure resistances except for the line or circuit being measured, which may have reactive components. These do not, however, enter into the direct current measurements.

Basic Theory

Irrespective of the applications of the bridge, the basic theory under the condition of balance is the same. The essential differences between various bridges are those of physical size and arrangement, purpose of operation and the accuracy of measurement desired. Some sets are small, compact and portable, using only one of a few dry cells for the source of potential, while others are relatively large, permanent, and utilize heavy-duty dry batteries or storage batteries for operation. The indicator in all direct current cases is a moving coil galvanometer of the D'Arsonval type, equipped with a pointer in the portable units or with either a pointer or a mirror in the permanent types of bridges. The pointer type is directly indicating, while the mirror type is indirectly indicating by means of a spot of light centered on a hair line and reflected by the mirror to a translucent scale upon which indicating marks or divisions are placed. Both indications are normally centered on a zero setting when the bridge is balanced, deflecting to the left when the balancing resistance is too low and to the right when the balancing re- sistance is too high.

Types

The types of Wheatstone brid may be classified roughly into th groups—plug and block, slidewire, dial types. In the plug and block t the plugs and blocks are machinec a taper fit and serve to reduce c tact resistance to a minimum. T type bridge is most frequently u in the laboratory as a standard and general use. The slidewire bridg useful for resistance measurem which are repeated often as in rou inspection of resistors in manufac ing plants. Such bridges are off by commercial concerns as ohmm and per cent limit bridges. Other u ful applications of the slidewire bri are in laboratories of schools and leges for instruction purposes. dial type of bridge is perhaps the n common and useful of the commer bridges, for location of faults in c munications circuits. This bridge ally has one dial for obtaining m plying values of .001, .01, .1, 10, and 1,000, and is known as the n dial. Frequently these dials have tings of M10, M100 and M1,000, use in Murray Loop tests. Fou more dials are used in series to n up the adjustable arm of the bri providing a range of from a frac of an ohm to about 11,111 ohms. exact arrangement and values vary slightly with the make and m facture of the bridge. Switches are provided to make the necessary tr formations for the connections t made as, for instance, the Loop, ley and Murray measurements.

Resistance Value Ranges

The range of resistance va which may be measured by the nary Wheatstone bridge is quite la covering from a small fraction o ohm to several megohms. The s tivity of the bridge is not sufficie

WHEATSTONE BRIDGE

ts Scope and Usefulness To The Communications Engineer Today

e high values to permit very great curancy, while contact resistance ters as the controlling factor in asurement of values less than an m. It is necessary to resort to a gohmmeter or an electronic device the high ranges and a Kelvin type uble bridge for the low ranges of istance.

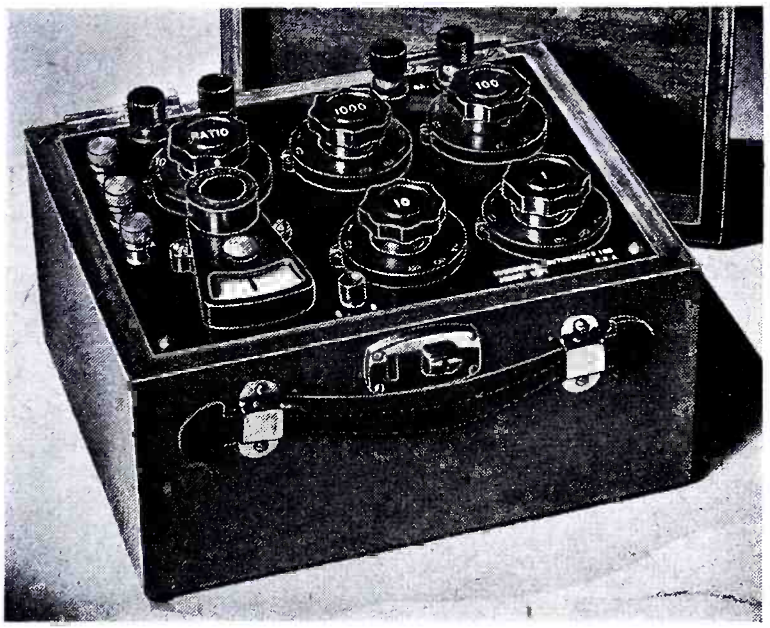

Figure 2

A portable Wheatstone bridge, with ratio dial settings of .001, .01, .1, 1, 10, 100, 1000, as well as built in resistance standards of 1, 10, 100, and 1000-ohm decades.

(Courtesy Industrial Instruments, Inc.)

sistance Standards Characteristics

Since the Wheatstone bridge is estially a resistance comparison unit, accuracy depends largely upon the racteristics of the resistance standds used and the tolerances which e set up in the manufacture of the dge. The important characteristics the resistance standards are[1]: (*1*) rmanence; (*2*) definiteness; (*3*) all temperature coefficient of retance; (*4*) small load coefficient, and) small thermoelectromotive force terminals when carrying maximum rrent.

tal Properties

Permanence requires that the retances have a constant value over g periods of time. Definiteness uires that the value remain the ne under all ordinary conditions of . The temperature coefficient of istance of a resistor depends largely the characteristics of the resistance terial but is slightly influenced by method of construction. Several istance alloys have zero temperae coefficients at some particular nperature, but no material is known ich has a temperature coefficient of o over any appreciable range of nperature. Some of these alloys [2] (*1*)—Copper-Nickel, known unvarious trade names as Advance, pron, Copel, and Constantan, with emperature coefficient of zero someere between 20° and 100° C and where in this range does it exceed parts per million; and (*2*)—Cop-Nickel-Manganese known to the trade as Magnanin with a temperature coefficient of zero somewhere between 15° and 75° C., and nowhere in this range will it exceed 250 parts per million. It is slightly less stable at high temperatures than Constantan. Other alloys such as Nickel-Chromium and Nickel-Chromium-Iron known as Tophet, and Chromel or Cromin, are sometimes used where it is desired to obtain a resistance of high value in a small space. The temperature coefficient of these alloys is five to six times as high as the first two mentioned and hence undesirable where precision work is required. The type of wire used for the resistance of practically all precision Wheatstone bridges is either Magnanin or Constantan, with the majority being of the former.

Tolerances

The tolerances allowable for the resistors of the bridge vary with the magnitude of the resistors involved and depend to a large extent upon economic factors and accuracy required. Greater tolerances are used for the low value resistances than for the higher values. The order of magnitude is approximately 0.1 per cent for .1 ohm resistors and .05 for all others in high precision bridges with ratio arm errors of 0.01 per cent. Portable bridges of good construction by reputable firms allow about two to five times the error permissible in the laboratory standards.

Sensitivity

The condition known as balancing occurs when the adjustment of the arms of the bridge is such that there is zero current through the galvanometer. The accuracy with which the Wheatstone bridge can be balanced is dependent upon the characteristics of the galvanometer used, the magnitudes of the resistances and the applied electromotive force or potential. Since the degree of precision of adjustment is greatest when the galvanometer is the largest for the smallest unit change in the variable arm of the bridge, the sensitivity is defined by the equation[3], sensitivity is defined by the equation[3],

$$S = C R_o \left(\frac{\partial i_g}{\partial R_o}\right)_{i_g = 0} \qquad (1)$$

the derivative being evaluated at the balance point, and where C is the galvanometer deflection per unit current.

R_o is the variable arm of the bridge, and i_g is the galvanometer current for any adjustment of the bridge with the internal resistance of the battery R_b considered negligible.

The current through the galvanometer is given by

$$i_g = \frac{(a R_o - bx) E}{a R_o (b + X) + b X (a + R_o) + R_g (a + X)(b + R_o)} \qquad (2)$$

From this equation, since i_g equals zero at balance, we may immediately obtain the condition.

$$a R_o = bx \qquad (3)$$

or

$$x = \frac{a}{b} R_o \qquad (4)$$

For a bridge unit with a given battery voltage and galvanometer, E and R_g are constant and subject to the condition given in *3*, a, b and R_o may be varied in any manner whatever to obtain a balance. Although this is mathematically correct, there are physical limitations which must also be met. These are caused largely by the current carrying capacity of the resistors which definitely limits the allowable range over which the parameters of the bridge may be changed. The current carrying capacity of resistors depends upon the construction of the resistances and this may in turn depend upon the space requirements of the unit as a whole. Most of the commercial bridges have accompanying charts or tabulations which show what value the ratio arms should have to obtain a maximum of sensitivity and accuracy for any given range of resistance values, at the same time keeping power dissipation within safe limits. Using equation *2* in *1*, the sensitivity relationships become,

$$S = \frac{CE}{\left[(a + b + R_o + X) + R_g\left(\frac{X}{a} + 2 + \frac{a}{X}\right)\right]} \qquad (5$$

which becomes a maximum as th denominator approaches zero, subje to the condition *3* and further th (6

$$b + R_o \geqq R$$

where R is the minimum safe val of the sum of b and R_o, irrespective whether or not the voltage, E, h been lowered to a value such as make any setting of resistance, a sa regardless of possible values of X Maximum of *5* requires that the equa sign in *6* be used and in addition, ther cannot be any variation of this valu from maximum with change in re sistance a. Hence

$$\frac{\partial}{\partial a}\left[(a + R + X) + R_g\left(\frac{X}{a} + 2 + \frac{a}{X}\right)\right] = 0 \qquad (7)$$

from which there is obtained.

$$1 - R_g \frac{X}{a^2} + R_g \frac{1}{a} = 0 \qquad (8$$

Solving *8* for a,

$$a = X \sqrt{\frac{R_g}{R_g + X}} \qquad (9$$

using *3* and *6* with $b + R_o = R$ in we get

$$R_o = \frac{RX}{a + X} \qquad (10$$

and

$$b = \frac{aR}{a + X} \qquad (11$$

Inspection of *9* shows that if the re sistance of the galvanometer is lar compared to the resistance bei measured, the best arrangement of t bridge is for $a = X$ and $b = R_o = R$, When external galvanometers a used so that a choice of R_g may made, the maximum sensitivity th may be obtained may be found by t use of equation *5*, taking into accou differences in the sensitivity of t galvanometer itself. The maxim deflection which is obtained from a galvanometer is dependent upon t maximum power which is supplied it, and since maximum power trans depends upon a matching of t

Figure 3
A typical impedance bridge, with Wheatstone bridge circuit.
(Courtesy General Rad

source and load impedances, we may deduce immediately that the resistance of the galvanometer should equal the parallel resistance of the bridge. This means, for example, if each of the arms of the bridge had equal resistances, the galvanometer should have the same value for greatest sensitivity. This is quite a general one and independent of other conditions or restrictions. Another way of looking at the problem is to consider that the deflection of a galvanometer is proportional to the product of a constant and the square root of its resistance, or $C = c\sqrt{R_g}$. If this is substituted into equation *5* and the partial derivative of the deflection sensitivity with respect to the variation of galvanometer resistance is equated to zero.

or $\frac{\partial S}{\partial R_g}$ we obtain

$$R_g = \frac{(R_o + X)(a + b)}{a + b + R_o + X} \qquad (12)$$

or

$$\frac{1}{R_g} = \frac{1}{a + b} + \frac{1}{R_o + X_o} \qquad (13)$$

which shows analytically that the galvanometer resistance should equal the equivalent parallel resistance of $(a + b)$ and $(R_o + X)$. Hence, if available equipment will permit, it is desirable to use a low resistance galvanometer for low resistance measurements and one having a high resistance for high resistance measurements. It should be noted that if the positions of battery and galvanometer are interchanged in the circuit, a balance will also be obtained. The sensitivity will be changed in accordance with the above considerations. A recognition of this may at times be helpful when a galvanometer which will give the best sensitivity for the measurement being made is not available. Further, for a given set of resistances, the galvanometer should be connected between the junction of the two larger resistances and the junction of the two smaller resistances. In most practical applications where the resistance to be measured is neither very low nor very high, but may assume any value in between these, the galvanometer is connected between the junctions of the high and low values of resistances. This effects a compromise with the requirements for the greatest sensitivity, but permits a fairly wide range of measurements with only moderate loss of sensitivity.

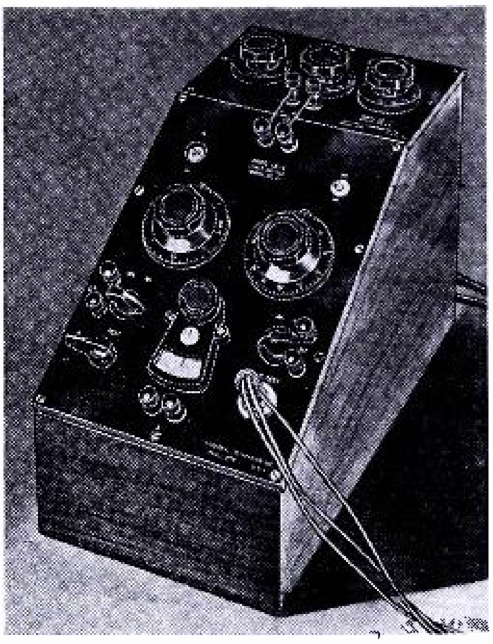

Figure 4
A resistance limit bridge, with a high speed Wheatstone bridge circuit.

(*Courtesy Industrial Instruments, Inc.*)

Protective Systems

Shunts are placed on most well designed bridges to protect the sensitive mechanism of the galvanometer which, especially in the case of the needle indicator, is easily damaged. The bridge is also normally equipped with battery and galvanometer keys for further protection. It is necessary to operate the battery key first when measuring lines and reactive equipment as the transient surge of current which takes place upon application of the battery will not be balanced by the variable resistance arm of the bridge. A deflection off scale will readily take place even though the bridge is balanced perfectly for the steady state measurement. The measuring procedure to follow after the necessary connections have been made is as follows: operate the keys controlling the shunts so that the smallest amount of current will flow through the galvanometer with the application of the battery key, which is then followed by operation of the galvanometer key. The sensitivity is then gradually increased by operating the shunt keys as the balance condition is more and more closely approached, until all shunts have been removed enabling a final and accurate balance to be made. In some cases where there are foreign potentials or swinging faults, it may be found impossible to remove the shunts to ever get a balance which is table. Figure 5 shows a simple shunt having a value equal to either a fraction or a multiple of the galvanometer resistance. Th current through the galvanometer f this type of shunt is

$$i_g = i\frac{R_g \alpha}{R_g + \alpha R_g} = i\frac{\alpha}{1 + \alpha} \qquad (1$$

where α is either an integer or fra tional number since the current d vides inversely proportional to t ratio of the two resistances. A go many of the older types of galva ometers had various shunts provid with the bridges which had res tances of 1/9, 1/99, and 1/999 of th of the galvanometer. These values f α give the proportionality factor *14* the values of 1/10, 1/100, a 1/1,000 so that the sensitivity of t galvanometer was reduced by the fa tor of 10, 100 and 1,000 by the use the shunts.

Universal Shunts

This type of shunt was very inco venient however since it required t use of special shunts for each ga vanometer. A different type of shu was developed. It is known as t Ayrton and Mather Universal shun and is shown in Figure —. The cu rent through the galvanometer is

$$i_g = \frac{i}{n}\frac{\alpha}{1 + \alpha} \qquad (1$$

which is one-nth of the current the former case. By making *n* equ to 1, 10, 100, 1000, etc. the sensitiv of the galvanometer may be conve iently reduced. Its sensitivity is duced in the ratio of 1:

$\alpha/(1 + \alpha)$ or by

$$100\left(1 - \frac{\alpha}{1 + \alpha}\right) = 100\frac{1}{1 + \alpha}$$

If $\alpha = n$, this is $100\frac{1}{1 + n}$ per ce

When $n = 10$, this is 9.1 per ce while for $n = 100$ and greater, reduction is negligible. In order t the current entering the combinat will remain unchanged, the total sistance shunting the galvanome must be equal to nR_g. This mea that if the shunt resistance across galvanometer is made at least times the galvanometer resistance, reduction in galvanometer sensitiv will be quite negligible.

Connecting Lines and Equipment

Communication systems utilize ma different sizes and types of wire connecting lines and equipme Among a few of the different met which are used for outside or o


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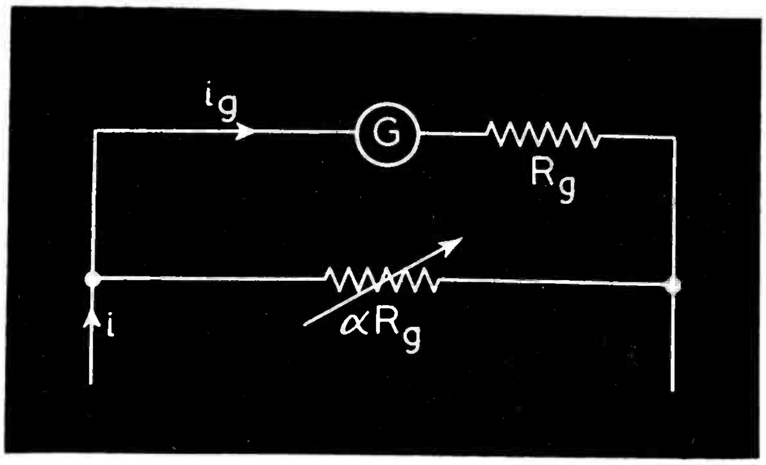

Figure 5
A simple type shunt which may be used in a meter for protection purposes.

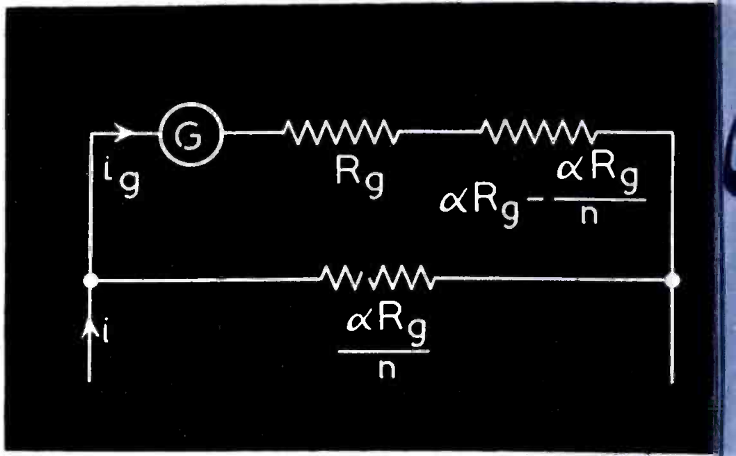

Figure 6
An Aryton and Mather universal shunt used on many precisio bridges.

wire lines are: (*1*)—hard drawn copper; (*2*)—copper clad steel; (*3*)—copper weld, which is a copper-steel wire; (*4*)—galvanized iron; (*5*)—galvanized steel; (*6*)—copper alloy; (*7*)—zinc-steel; (*8*)—bronze; and (*9*)—aluminum. The last named one is rarely used in the telephone plant, but is common in power circuits and therefore occasionally used in connection with carrier systems for maintenance of lines carrying high power. The copper-steel and copper weld conductors are becoming used more and more, and have about 30 to 40 per cent of the conductivity of pure annealed copper. Their use results in a considerable saving of copper. The iron and steel wires are particularly useful where some economies are to be effected and where it is necessary to bridge long spans over rough terrain.

Cables are made up of several different arrangements of copper wire. Some of these are (*1*)—pairs; (*2*)—quads, or grouped pairs; (*3*)—spiral-four disc insulated; (*4*)—single; and (*5*)—single disc-insulated with concentric copper sheath, or coaxial.

Temperature Changes

The resistance of all of these conductors varies with change in temperature, and further, each metal has a different variation at any given temperature. For pure metals such as those given above, the resistance increases for an increase in temperature and decreases with a lowering of the temperature. The amount that the resistance increases per degree rise of temperature per ohm of the resistance at some standard temperature is known as the temperature coefficient of resistance. The standard temperature basis for this purpose is zero degrees on the centigrade scale, and the coefficient of resistance is the change in resistance which takes place when changed one degree from zero degrees centigrade.

Cross Sectional Area Properties

The resistance of a wire changes in a manner directly proportional to its length and inversely proportional to its cross sectional area.[5] This is expressed by the equation:

$$R = \rho \frac{1}{d^2} \text{ Ohms} \qquad (16)$$

Where: 1 = length of wire in feet
d = diameter of wire in mils

and ρ is a constant known as the resistivity. It is expressed most commonly in ohms per mil foot in the practical system of units and in ohms per centimeter in the CGS system. It is the resistance of the material having a cross sectional area of one circular mil and a length of one foot. The resistivity is also defined as the reciprocal of the conductivity.

The resistance of a conductor at any temperature is given by the sum of the resistance at zero temperature the resistance change which t place in undergoing tempera variations, and may be expressed

$$R = R_o (1 + \alpha t) \qquad ($$

where:

R_o = the resistance at zero degree
α = the coefficient of resistivity ohm per degree change in t perature at the reference t perature.
t = the temperature at which resistance is to be found.

This equation gives us a means determining the resistance of a c ductor at any temperature if it known definitely at some given t perature. Letting the resistances temperatures t_1 and t_2 be R_1 and respectively and applying equation we may write

$$R_1 = R_o (1 + \alpha t_1) \qquad ($$

$$R_2 = R_o (1 + \alpha t_2) \qquad ($$

(*Continued on page* 95)

Figure 7
A capacitance bridge using Wheatstone br principle,
(*Courtesy General Radi*

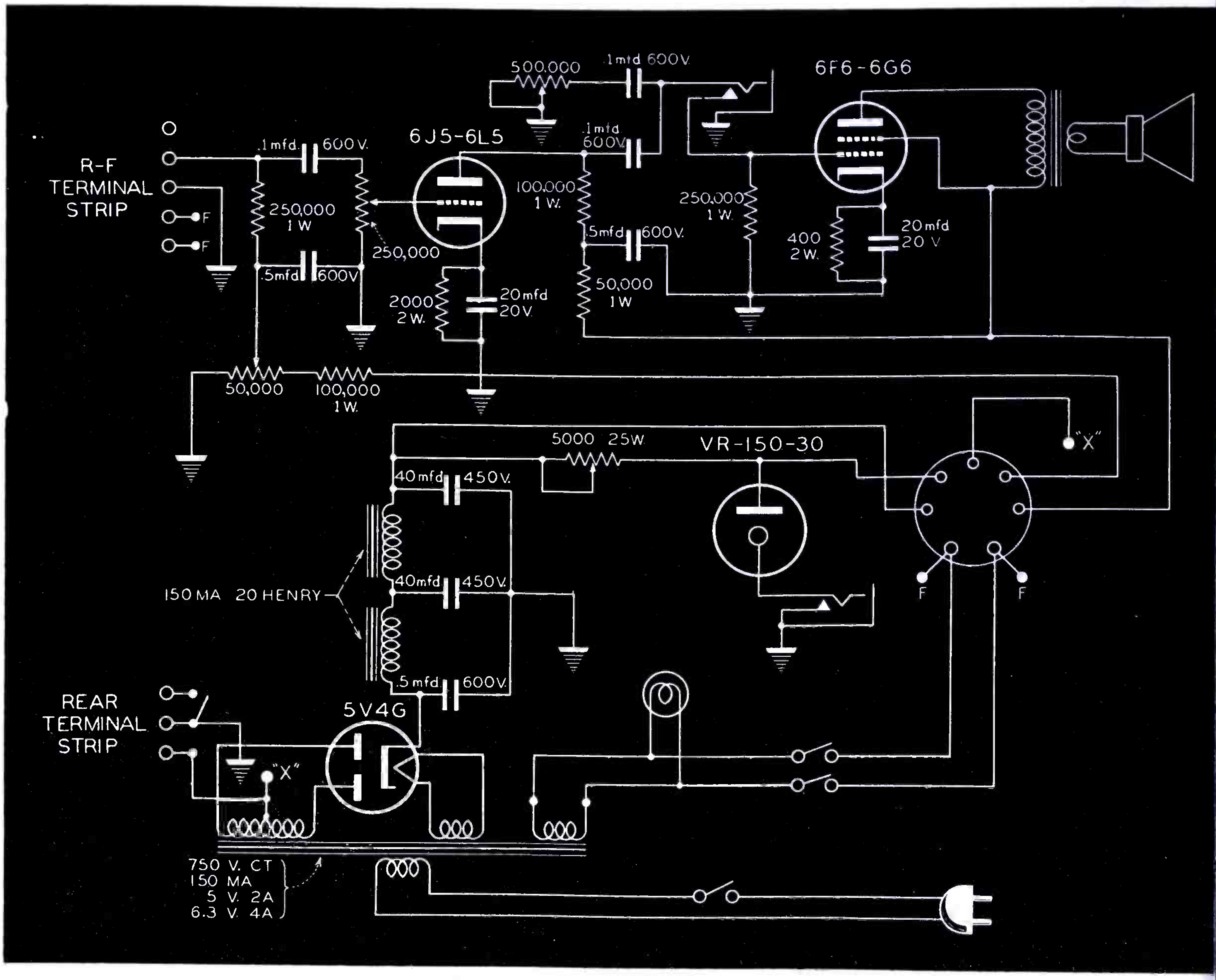

Figure 1
Basic circuit of the Stiles emergency receiver.

WERS RECEIVER CONSIDERATIONS

by WALTER J. STILES

Chief Engineer, WEEI

THE War Emergency Radio Service (WERS) was the outgrowth of a pressing need, by civilian defense organizers, for a means of reliable communications in times of civilian disaster. The very nature of the need dictated that the medium provided for its fulfillment be capable of operation after the complete failure of all forms of telephone and electric power facilities. Originally the plan had as its technical nucleus the licensed radio amateur and his extensive practical experience with u-h-f communications, gained over a period of several years' operations in the 56- and 112-megacycle amateur bands. While many communities were fortunate, or far-sighted enough, to take immediate advantage of this availability of trained technical personnel, many others simply allowed this initial advantage to dissipate itself through the gradual, but continual, departure of the radio amateur for active duty with the armed forces.

Therefore, we find today many, with but a meager knowledge of radio design, construction and/or operation, assuming major roles in local WERS organizations.

And the available average professional engineer is not too capable, from a practical standpoint, of efficiently assuming these responsibilities. For academic engineering concepts have proved and are proving grossly incapable of meeting the problem a[t] hand unless and until they are temp[er]ered with a practical knowledge o[f] the basic requirements and, particu[lar]larly, of the limitations of the opera[t]ing personnel available for such work.

We also find a total lack of priorit[y] assistance available for WERS opera[-]tions. Therefore, equipment desig[n] must be simple and a compromise be[-]tween what would be ideal and wha[t] is on hand, either from the availabl[e] pre-war amateur units, past WER[S] purchases and/or discarded broadcas[t] receivers. Generally speaking, onl[y] tubes on the preferred list and com[-]ponent parts of the so-called Victor[y] series can be considered for anythin[g] resembling new construction.

A receiver with these *essential* fea[-]tures is shown on these pages. Th[e]

EMERGENCY U-H-F RECEIVER DESIG[N]

IT, TOO, HAS WEIGHT

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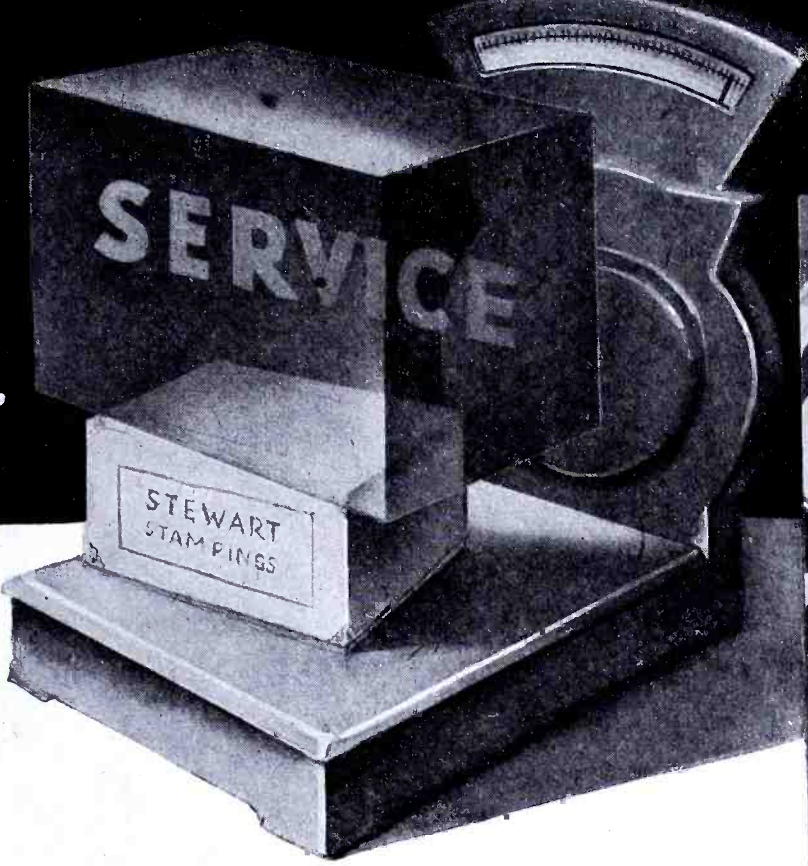

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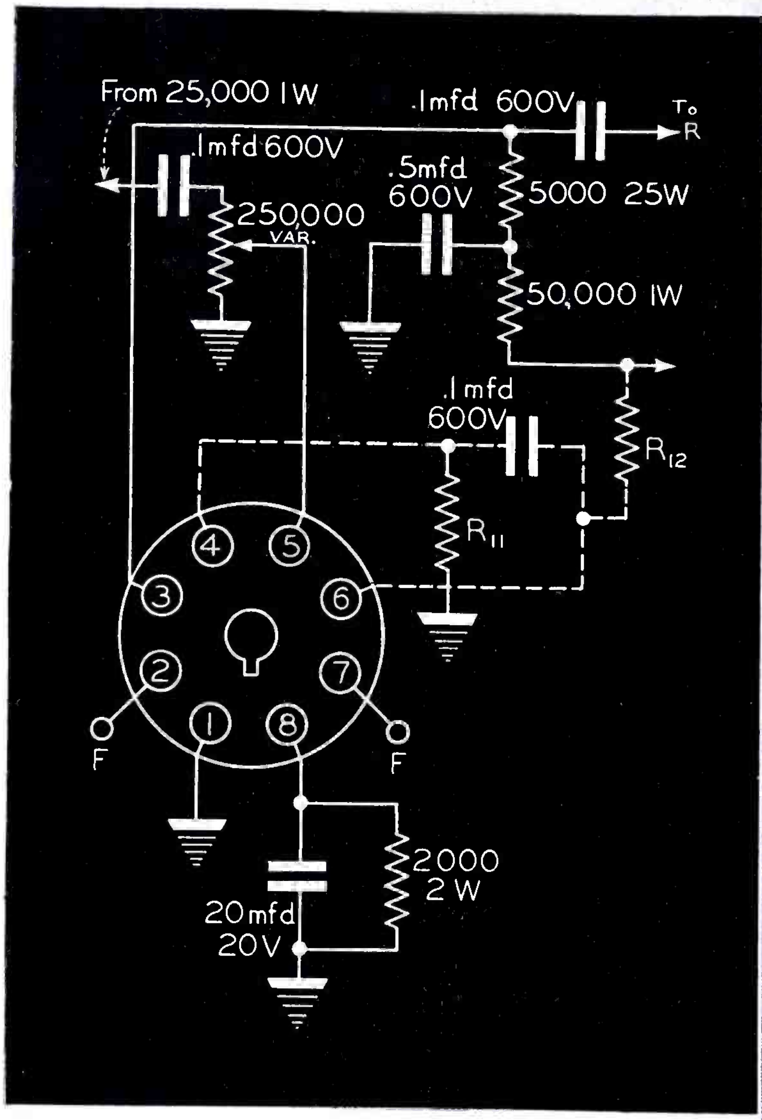
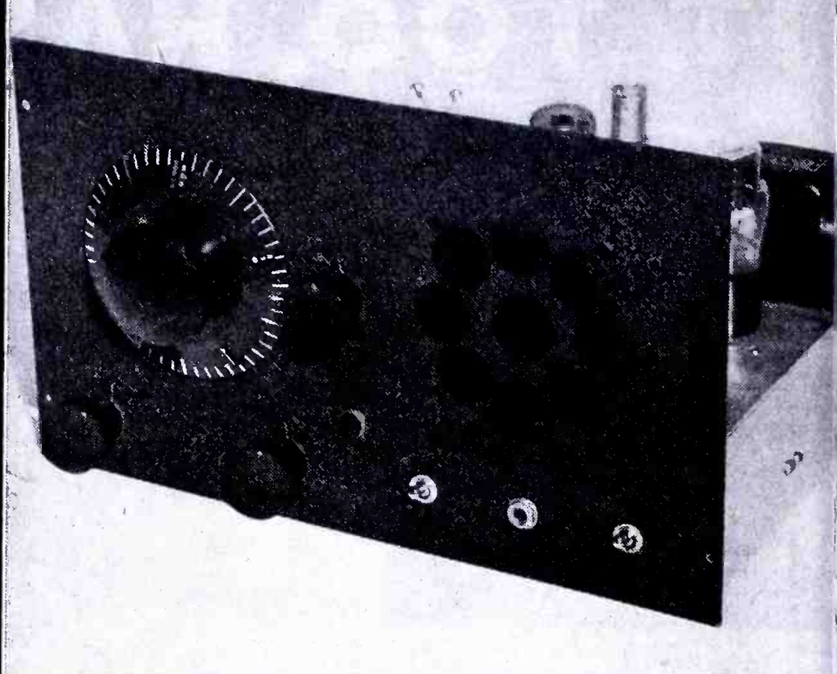
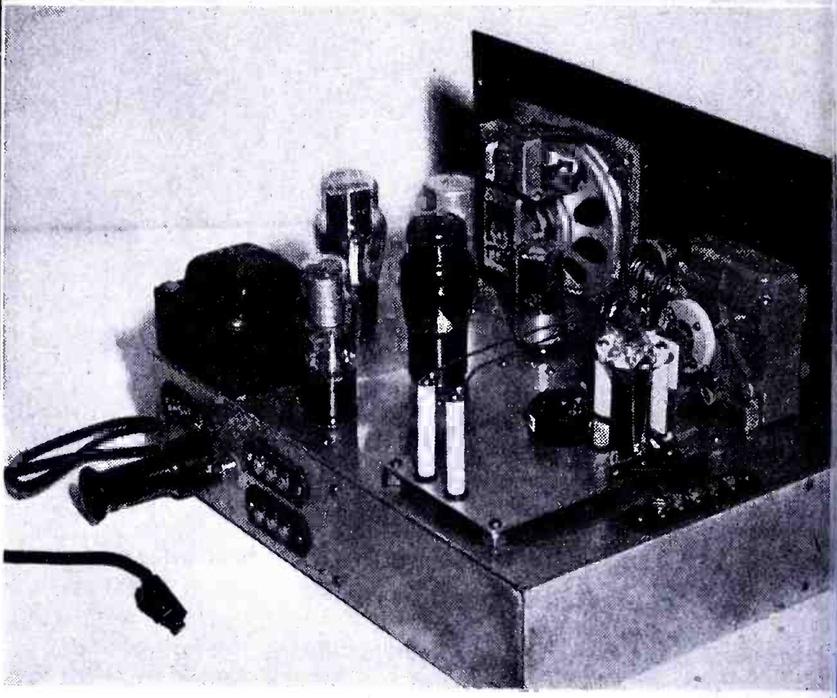






Figures 2 (above) and 3 and 4 (right)
In Figure 2 appears a method of increasing the gain of the audio amplifier. While the receiver normally uses a 6J5 as an input audio stage, by the addition of two 1-watt resistors and a bypass condenser, a 6N7 may be substituted and an additional stage of a-f realized. In Figures 3 and 4 appear the front and rear views of the completed u-h-f emergency receiver.

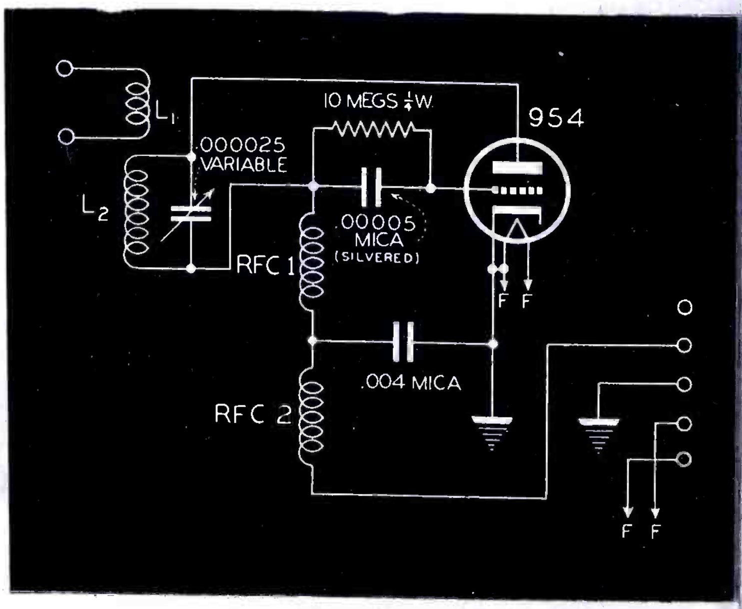
unit has been in service for quite a while and proved effective.

The Circuit

Figure 1 shows the circuit arrangement employed in the basic unit. This unit consists of a high gain, high quality audio amplifier, and a regulated power and filament supply sufficient to provide, in addition to the audio requirements, all power necessary for any reasonable form of r-f circuit. Nothing has been included in the design of this unit that does not contribute directly to the problem at hand. Resistance input coupling was found to have several advantages over the more conventional transformer coupling, particularly when the unit is used with its a-c power supply. Originally a high quality, well-shielded coupling transformer was employed, which contributed an objectionable amount of a-c ripple to the output regardless of its orientation. The use of .1-mfd interstage coupling condensers produces a frequency response that is essentially flat down to 30 cycles, which is a most advantageous feature, inasmuch as it may be necessary to use ICW during periods of difficult reception. Normally, few WERS transmitters are equipped for this type of work, except by applying raw 60 cy[cle] a-c to the audio input. Actually, it [is] possible to copy an ICW signal mod[ul]ated at 60 cycles long before the ca[r]rier signal strength reaches a po[int] where it starts to knock the sup[er]...

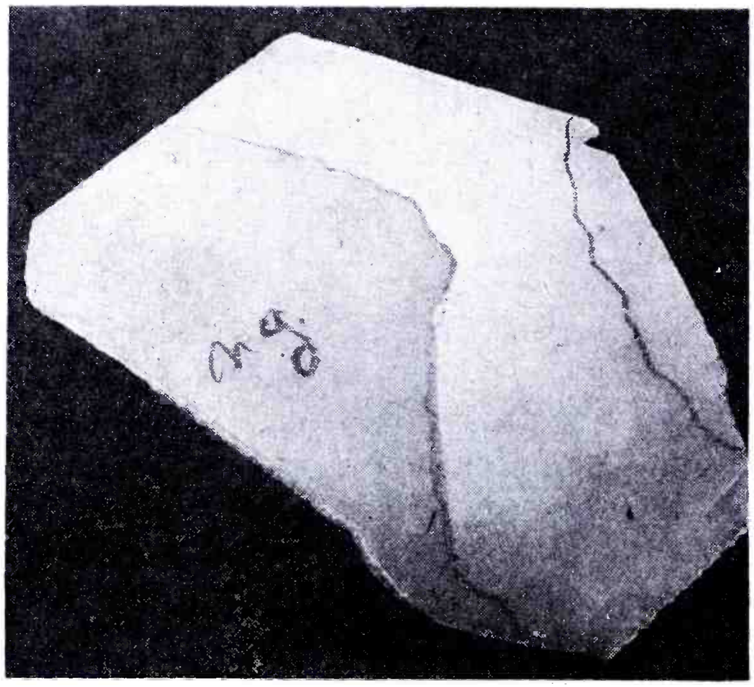
(*Continued on page 92*)

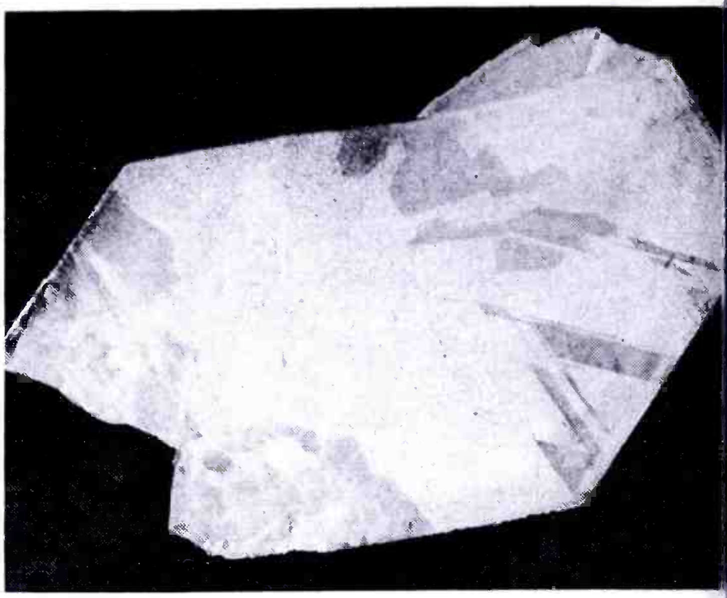
Figure 5
The r-f unit which super-regenerates with 15 volts on the plate at a current of .15 ma. L_1 has three turns of No. 14 wire on a 1/2" diameter, 3/4" long tube; L_2 has four turns of No. 14 on a 1/2" diameter, 1" long tube. RFC_1 can be a commercial unit or a 1/4" diameter form of No. 28 dsc, 1/4" winding length. RFC_2 is an 80-mh choke.



Figures 1 (below), 2, 3, and 4 (right; left to right)

Figure 1; etched wafer showing reflection of the light source from the etch pits on the surface of the good portion of the wafer. The shaded area bounded by the pencil line marked *NG* is electrically twinned. The portion at the right hand side of the wafer is marked off for cracks and other mechanical flaws. Figures 2, 3 and 4; infra-red views of twinned wafers. Note the random directions of the electrical twinning boundaries and the regular directions, and straight line boundaries, typical of the optical twinning.





QUARTZ

by SIDNEY X. SHORE

Senior Engineer, Crystal Division, North American Philips Company, Inc.

To properly examine quartz wafers for twinning, it is necessary to etch the wafer by immersing it in a solvent which will dissolve quartz. The solvent most generally used in the past has been hydroflouric acid. Recently a safer and generally more desirable etching fluid has been utilized, consisting of a solution of ammonium-bifluoride which may be heated slightly.

Quartz is not etched in the same manner as is glass. Glass is amorphous and the rate of solution of glass in ammonium-bifluoride is uniform in directions. The rate of solution quartz varies for various directio Etching a quartz wafer results in myriad of small facets which are cal etch pits. These facets conform to atomic structure of quartz and normal untwinned quartz lie in same general direction. If a qua wafer is electrically twinned the tilt the surfaces of the etch pits, with spect to the major surfaces of the w fer for the twinned portion, will quite different from the tilt for the twinned section. Therefore, a li beam striking the quartz wafer will reflected at different angles by etch pits of the different portions the twinned wafer. This fact is g erally utilized in determining wh

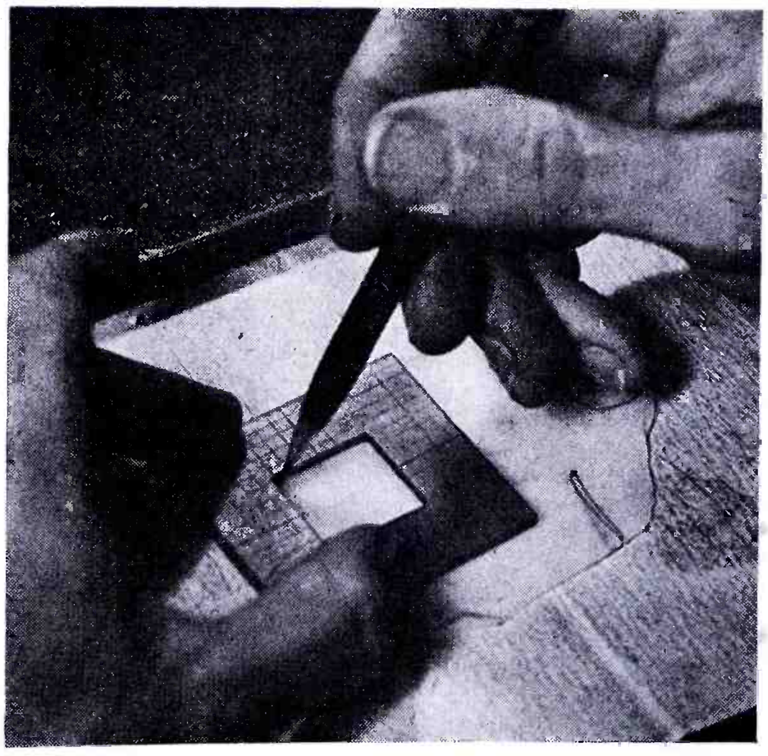
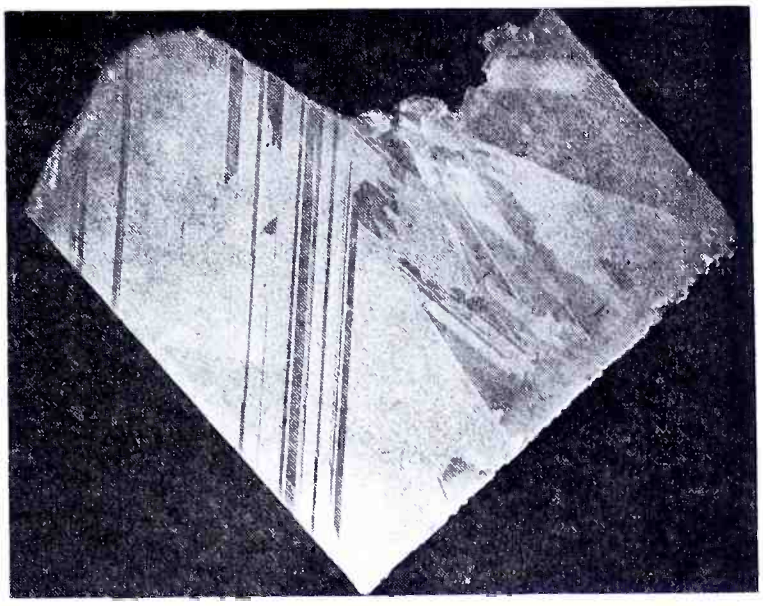


Figure 5
Layout jig used to draw the outlines for dicing or trim sawing. One edge of the blank is parallel to the X-axis. Note the marked spot on the lower right hand side which locates a crack to be avoided in layout.

This is the fourth of a series of artic covering a detailed analysis of crys manufacture. In a subsequent pap Mr. Shore will discuss finishing testing.



APPING AND FINISHING

Discussion of How Sawed Wafers Are Etched, aid Out, Diced, Angles are Double Checked, apped, Channel Checked and Hand Finished

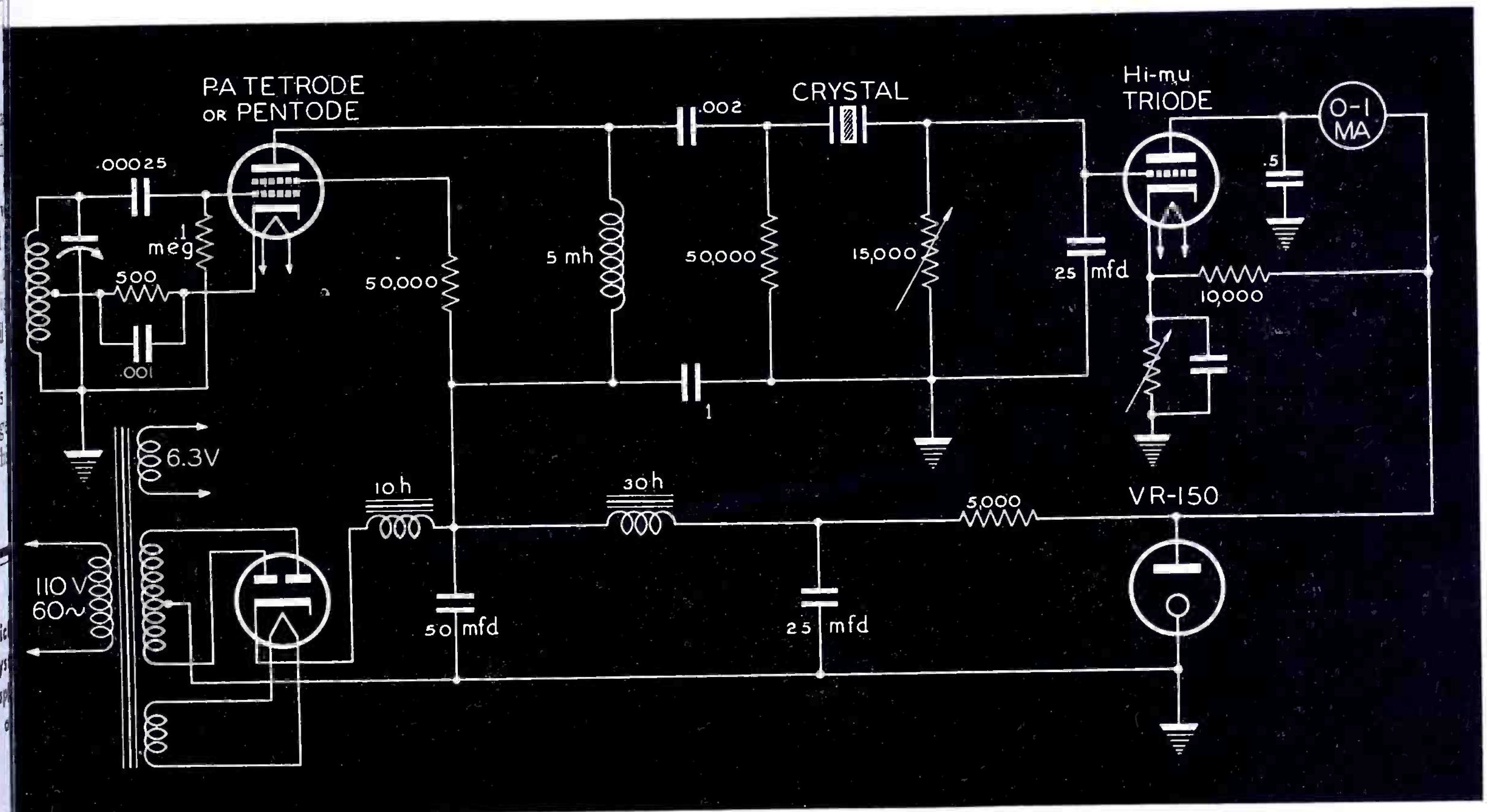
tion of the twinned wafer is the able portion.

An examination of Figure 7 which strates how twinning in a *mother* rtz crystal may result in the cut- g of so called miscuts, will show v the inversion of polarity of the X-axis affects the location of the major rhomb face.

The etch pits of the optically twinned portion of a wafer have the same general direction as the etch pits in the rest of the wafer, except that the pits are slightly rotated with ref-

Figure 6

A simple exciter-resonator circuit used to measure the thickness-frequency constant of a *rough-cut* blank. The frequency in kc multiplied by the thickness in inches of the *BT*-oscillator plate equals 99 to 100.



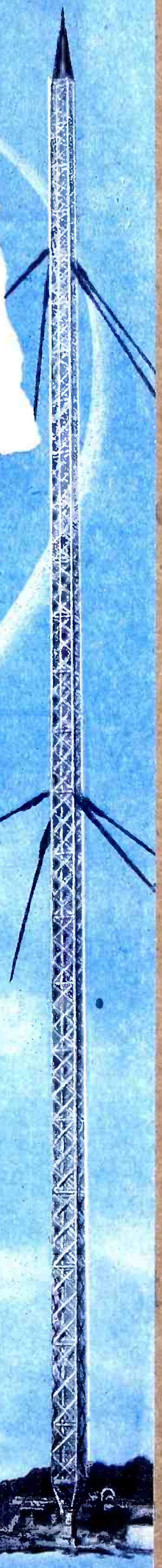

G-E Antennas . . .
G-E TELEVISION RELAY ANTENNA. This relay type of television antenna, developed exclusively by G.E., is in use at General Electric's television "workshop" station WRGB at Schenectady. It has had a remarkable record of reliable performance since its installation.
This antenna is completely enclosed and contains four horizontal bays. It is highly directional and is especially designed to permit the wide band operation which is so necessary to successful television transmitting. This G-E antenna is so efficient that no relay link should be built without it!
↑ G-E FM CIRCULAR ANTENNA. Measurements to date on this horizontally polarized circular antenna show such decisive electrical and mechanical advantages that it has clearly outmoded the conventional types.
Simple, rugged, compact, and pleasing in appearance, the design of this antenna makes it easy to mount on a pole of any diameter. It is grounded to the pole for lightning protection . . . easily adapted for sleet-melting . . . and easy to tune. Its wide frequency range and its lower coupling between bays are two of its strongest features. The latter permits optimum power gain per bay, compared to existing designs as evidenced by these figures:
One-bay Two-bay Four-bay
POWER GAIN 602 1.66 3.47
G-E FM circular antennas are being operated with surpassing success in six of the nation's important stations. Many others are planned, awaiting construction and installation at the war's end.

TO RULE THE WAVES

G-E VERTICAL RADIATOR FOR AM. The WGY antenna illustrated is a 625-foot, all-steel, uniform cross-section tower. It is of the most modern and rugged type. Its installation improved the coverage . . . reduced fading . . . and provided generally more reliable performance for station WGY.

G-E S-T FM RELAY ANTENNA. A multiple-dipole antenna easily mounted on a single pole. Its housings (appearing as dipole tubes in the photograph) are completely sealed and pressurized to keep out moisture. One bank of enclosed dipoles is the antenna while the other acts as a reflector, and permits extremely sharp-focus directional beaming in a powerful, narrow, horizontal pattern. This gives a power gain of 10 at studio transmitter and, if also used at the receiver, provides an additional and second power gain of 10.

of AM, FM, and TELEVISION



AMONG the important recent G-E contributions to broadcasting, broadcast and relay antennas are especially outstanding. Illustrated are four types of G-E antennas, for four distinct uses. All four are proving their high efficiency in present broadcast use . . . all four are unique in their performance . . . all four are rugged in construction and easy to install. G-E can supply all these types of antenna with the station equipment.

The operating characteristics of these antennas enable the broadcaster to put out *more radio frequency power,* and to radiate that increased power with more *effective coverage.* G-E antennas, properly co-ordinated with their transmitters, give greatly improved performance . . . profitably . . . by more efficient and economical distribution or radiation over broader areas.

G-E electronic engineers can provide the antenna best suited to your needs whether AM, FM or TELEVISION, or, indeed, can help you equip your station with any equipment you may need from microphone to antenna.

A PLAN THAT WILL SECURE YOUR PLACE IN RADIO BROADCASTING POST-WAR

General Electric offers you "The G-E Equipment Reservation Plan". . . a plan designed to enable you to complete *your* post-war plans *now.* It will enable you to establish a post-war priority on a broadcast transmitter and associated equipment. It will enable us to plan definitely for large-scale post-war production, thereby giving you the fastest possible post-war delivery and the savings of planned production. Investigate this plan today and assure your place in radio broadcasting post-war. *Electronics Department, General Electric, Schenectady, N. Y.*

• *Tune in General Electric's* "The World Today" *every evening except Sunday at 6:45 E.W.T. over CBS. Sunday evenings listen to G-E* "All Girl Orchestra" *at 10 E.W.T., NBC.*

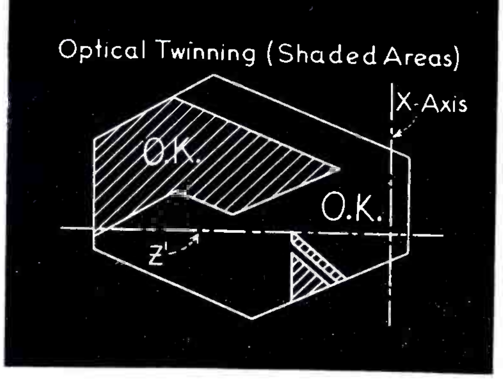
BACK THE ATTACK—BUY WAR BONDS!

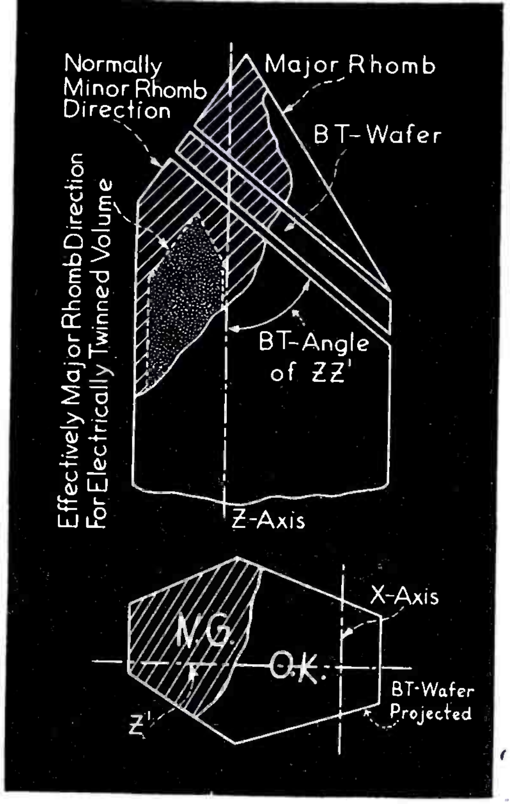
Complete Station Equipment • Studio Equipment • Transmitters • Antennas • Electronic Tubes • Receivers

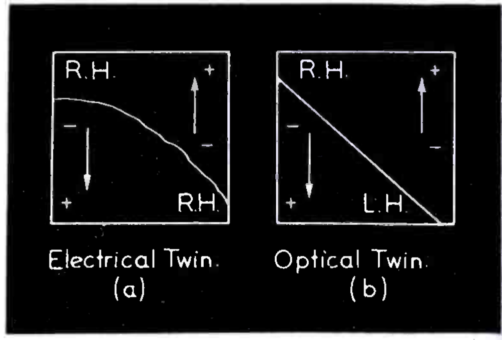
GENERAL ELECTRIC FM · TELEVISION · AM

160-C2

See G.E. for all three!







Figures 7 (center), 8 (left) and 9

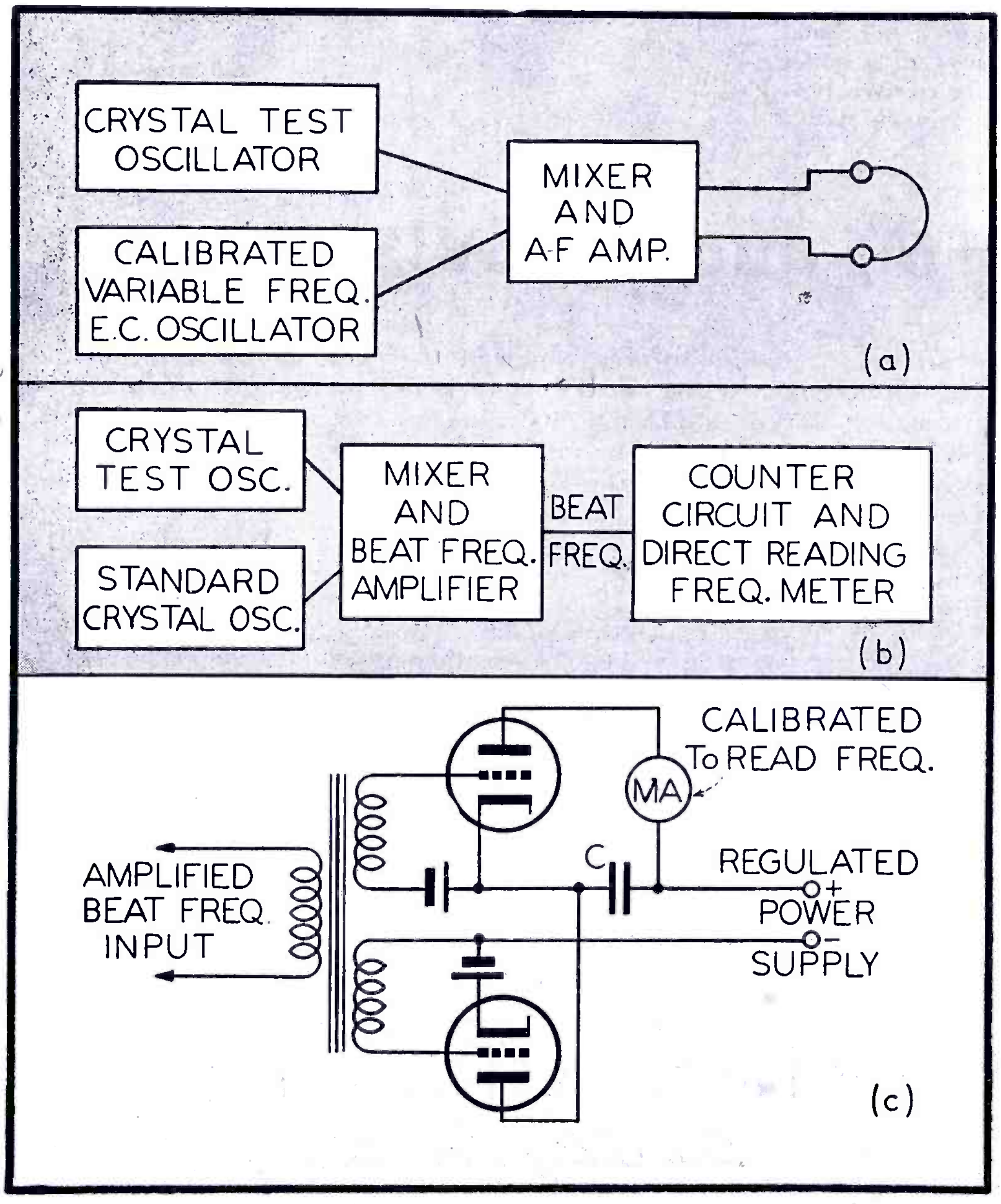
Figure 7; schematic diagram of electrically twinned quartz (lined areas) and a BT-wafer sawed from the *mother*. Note that the reversal of polarity of the X-axes results in the displacement of the major rhomb of the twinned portion, which is 180° rotated about the Z-axis. Figure 8; projection of a wafer of optically twinned quartz, cut at the BT-angle. Note that either portion of the wafer may be used for BT-oscillator plates. However, the oscillator plate must not contain the twinning boundary. Figure 9; representative oscillator plates with electrical and optical twinning boundaries contained within the plates. Note that in each case the polarity of the X-axis indicated (on compression) is reversed in each half containing twinning. However, both parts of the electrically twinned blank have the same handedness, whereas the handedness is different for each side of the optically twinned blank. Neither blank will make a satisfactory oscillator plate.

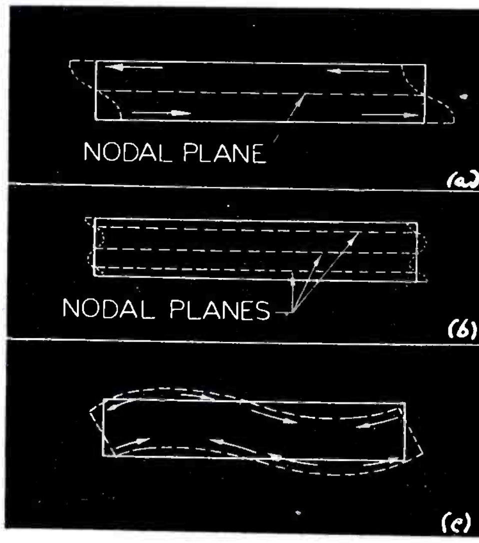
erence to an axis perpendicular to the surfaces of the wafer. This rotation exists because the optical twinned portion is reversed in handedness from the good portion of the wafer.

If a wafer shows patches of electrical twinning, these areas must be avoided in laying out the crystal blank. Laying out a blank in the electrically twinned portion will result in a *miscut* which will have a frequency-thickness constant of approximately 70-72. The frequency-thickness constant for normal *BT* blanks will be 99-100. Good *BT*-cut blanks may generally be laid out from the optically twinned portion of the wafer, but it must be remembered that a good blank should contain no twinning of either variety A twinned portion has reversed X-axis polarities and may result in markedly lower than normal activity of the finished oscillator blank.

When the twinning and the mechanical flaws are located in a wafer they are painted out with some opaque coloring to indicate that a blank should not be laid out to include any of these areas.

In order to insure uniformity of

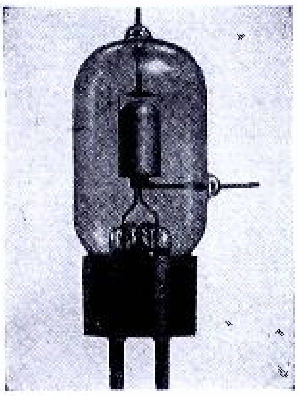




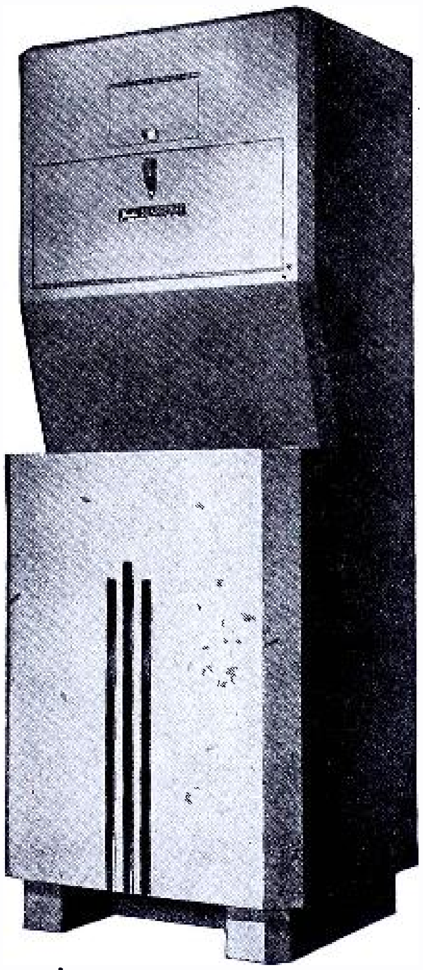
Figures 10 (left) and 11 (top)

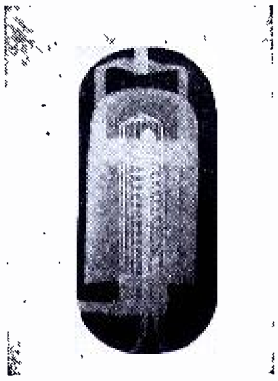
Figure 10; at (a) and (b), block diagrams of simple frequency measuring or channel checking devices. Schematic of a fundamental counter or frequency measuring circuit is shown at (c). This type of device in more elaborate form is typical in almost all frequency comparators and frequency recorders used in crystal manufacture. In Figure 11, we represent the forces acting within a quartz oscillator plate vibrating in a fundamental thickness-shear mode, a fundamental flexure mode and a second-harmonic flexure mode. Note that the even harmonic of the flexure mode is driven by similar forces as the fundamental thickness-shear mode, indicating the tendency for the vibration in these modes to be coupled.

Norelco Searchray Saves Manufacturing Trouble



Above is a photograph of a vacuum tube as the inspector's eye — and the camera — see it. A certain defect in manufacture is hidden to the eye. But Searchray, the new self-contained X-ray unit, shown in center, can spot it. See illustration at right.





Same tube as seen radiographically by Searchray. Note defect. The filament is too close to the grid, which will cause the tube to heat up. Searchray saves time, money and labor by checking products *before* assembly.

If you manufacture lamps, tubes, electrical parts, rubber, ceramics, light alloys or plastics—NORELCO Searchray can pay for itself many times over by acting as an X-ray inspection tool at every step of manufacture or assembly.

Shockproof, rayproof, foolproof and readily mobile, Searchray, the self-contained X-ray unit, is so simply devised that anyone can operate it safely. It examines objects both fluoroscopically and radiographically; it is as useful in the laboratory as on the assembly or production line.

The Searchray Model 80, illustrated above, is an 80 KvP, 5MA unit which operates on 110 volt A.C. simply by plugging into an outlet. Another Searchray — Model 150, likewise a self-contained, rayproof, shockproof, X-ray unit for fluoroscopic and radiographic examination, permits use of any kilovoltage up to 150 KvP, 10MA. It operates on 220 volts A.C.

Searchray may be of help in *your* product inspection problems. Write today to North American Philips. Let us tell you more about Searchray—and other NORELCO products.

For our Armed Forces we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes for land, sea and air-borne communications equipment.

For our war industries we make Searchray (X-ray) apparatus for industrial and research applications; X-ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies; High Frequency Heating Equipment.

And for Victory we say: Buy More War Bonds.

Norelco ELECTRONIC PRODUCTS

NORTH AMERICAN PHILIPS COMPANY, INC., 100 EAST 42ND STREET • NEW YORK 17, N. Y.

Factories in Dobbs Ferry, N.Y.; Mount Vernon, New York (Philips Metalix Corporation); Lewiston, Maine (Elmet Division)
Represented in Canada by Electrical Trading Company, Ltd., Sun Life Building, Montreal, Canada

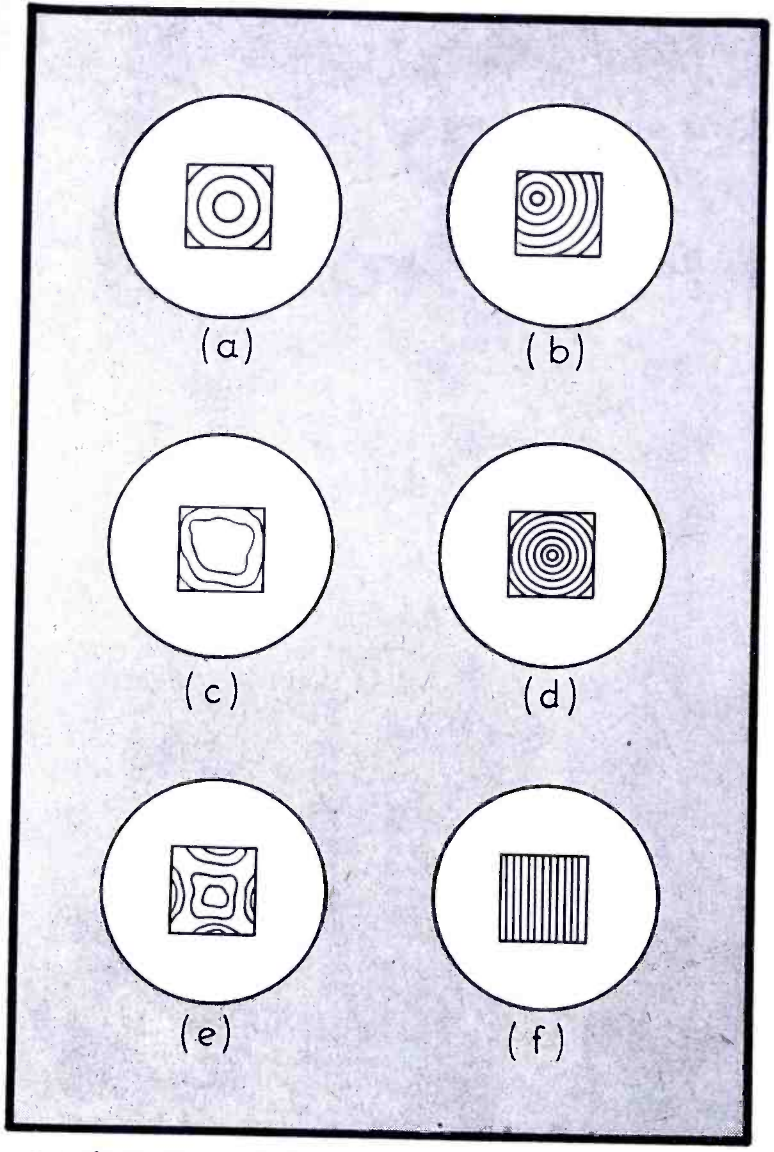


Figure 12

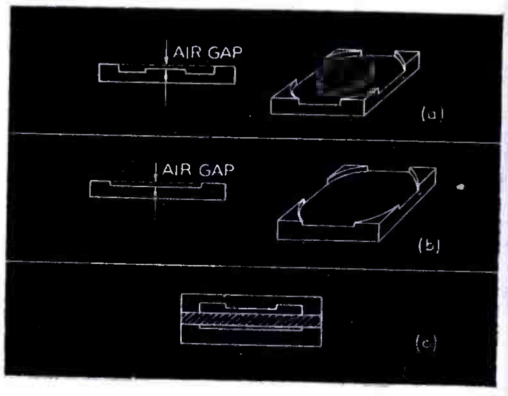
Typical contour patterns of the surface of crystal oscillator plates finished by hand lapping. Optical flats are the large circles. Crystal is the square within the large circle. Visible patterns are put in, in ink. A representative pattern for slightly convex crystal oscillator plate, a desirable shape, is shown at (a). In (b) pattern shows a high corner indicated by the displaced center of contour lines. Pressure at that spot causes rings to diverge, hence a convexity. In (c) we see how localized finger pressure at center caused an irregular concavity to be ground. Pressure at center causes rings to converge towards point of pressure, hence a concavity. In (d) a highly convex crystal indicated by large number of concentric contour lines diverging when pressure is applied at center. At (e), crystal showing a convex center with four concavities at the edges where the index and middle fingers exerted too much pressure while grinding. Pressure at center causes rings to diverge, and pressure at the middle of each edge causes the contour lines to move towards the pressure point. In (f), parallel-line contour pattern often means that a speck of dust or lint has been dropped under one of the edges. The small dihedral angle formed by crystal and flat results in the parallel line pattern.

manufacturing technique and results, crystal blanks are laid out from the wafer so that one edge of the blank is always parallel to the X-axis lying in the plane of the wafer. A simple stauroscope is used to determine and mark the X-axis direction on each wafer. The blanks are then laid out accordingly. The laid out blanks are *diced* or *trim sawed* utilizing a small diamond wheel similar to the type used in cutting wafers. There are many techniques of dicing and a fairly rapid procedure is illustrated by the photograph of a simple trim saw.

Every trim sawed blank, commonly referred to as a *rough cut* must be checked on the x-ray machine for the conformance of its *ZZ'*– and *XX'*–angles with specifications. Experimental results of the effect of variations in these angles will be further illustrated in the discussion on the temperature cycle test.

Miscuts should not be laid out from the wafer, but errors may be detected rapidly and simply by the use of an exciter-resonator circuit. As a *miscut* checker, the oscillator may be calibrated in terms of thickness of the *BT* blank, rather than frequency. *Miscuts* may then be detected by an incorrect oscillator tuning position for the thickness of the blank. *Rough cuts* are generally trimmed from .025" to .075" over size. This enables us to accurately square and dimension the

(*Continued on page* 79)



Figures 13 (top) and 14 (left)

Figure 13; typical flat- and button-type air gap electrodes utilizing corner clamping of oscillator plate. It is desirable to have the four corners lying in the same plane within several fringes of light, this plane to be parallel to the plane of the flat surfaces within .0001". At (a), button-type electrode; (b), flat-type electrode; c, assembled BT-oscillator plate, showing air gaps between crystal and electrodes. Figure 14; trim saw machine, using a high-speed ball-bearing motor with a 3" diamond saw. The table on which the wafer rests is fastened to a lever with a pivot below the motor. The table is simply pushed forward, tilting the wafer against the cutting edge of the diamond wheel.

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Cumulative Index, Alphabetically Arranged for Authors and Subjects

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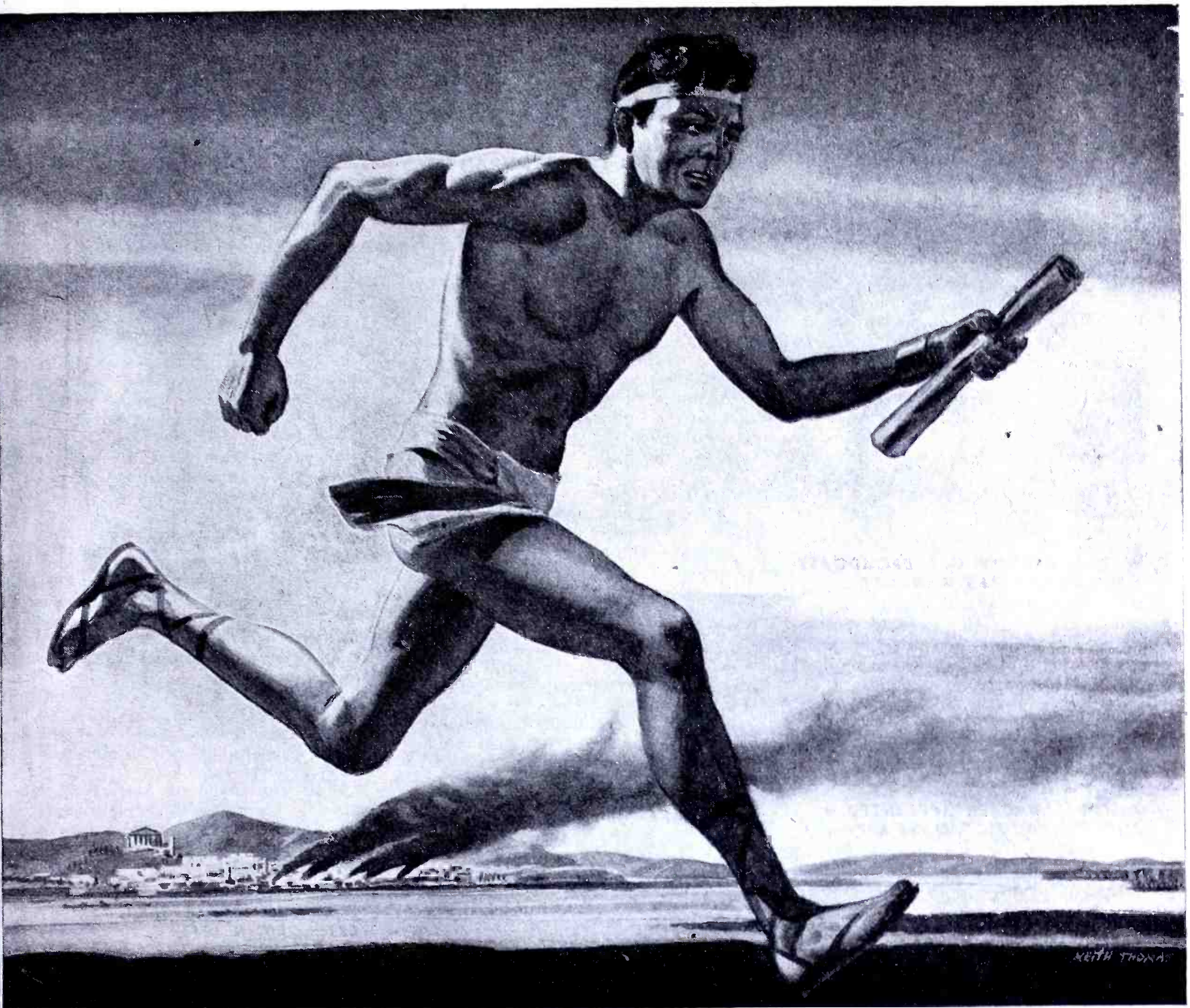
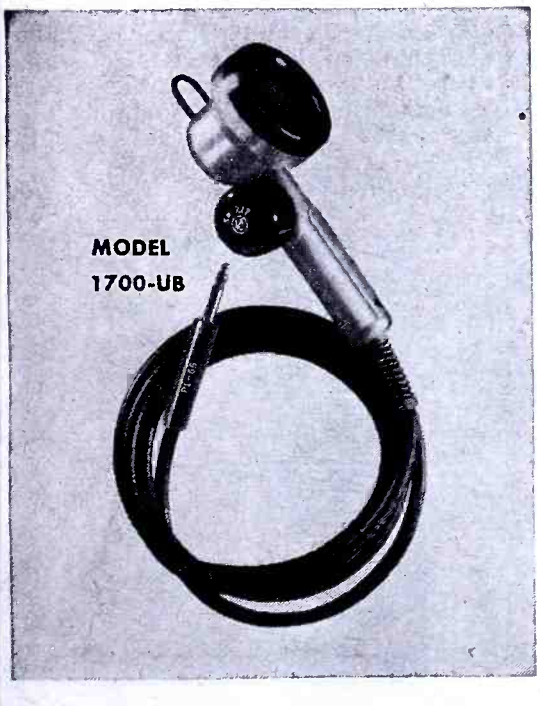


History of Communications Number One of a Series

A FORERUNNER OF MODERN COMMUNICATIONS



One of the first known channels of message carrying was by runner, and annals of Grecian and Phoenician history describe the nimble lads who firmly grasped rolls of parchment and sped hither and yon. Clad in typical running gear of the period, they covered amazing distances with almost incredible speed. That was the forerunner of today's modern communications where scientific electronic devices are "getting the message through" on every war front. Universal Microphone Co. is proud of the part it plays in manufacturing microphones and voice communication components for all arms of the United States Armed Forces, and for the United Nations as well. Other drawings in the series will portray the development of communications down through civilization and the ages to the modern era of applied electronics.

< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

UNIVERSAL MICROPHONE CO., LTD.

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

NEWS BRIEFS OF THE MONTH . . .

MICA ALLOCATIONS REVISED

Allocations of good stained and better quality mica for capacitor manufacture for the year 1944 have been revised downward to 85% of the average consumption during the first nine months of 1943. Mica requirements over the 85% allowance must be obtained from lower qualities, WPB officials have pointed out.

The supply situation has become progressively worse in the past few months, according to WPB. They pointed out that the situation may deteriorate still further and in that event, allocations may be out to even less than 85% of the base period set. Government stockpile receipts during the last quarter of 1943 showed a decided decrease as compared with the first three quarters.

* * *

W. R. DAVID NOW G. E. BROADCAST EQUIPMENT SALES MANAGER

W. R. David has been named sales manager of broadcast equipment for the G. E. transmitter division, according to Paul L. Chamberlain, manager of sales for the division.

In this capacity, Mr. David will be responsible for the sales of both a-m and f-m broadcast equipment, with headquarters at Schenectady.

* * *

JAMES J. BACKER APPOINTED ANDREW PACIFIC COAST REP.

James J. Backer has been appointed Seattle representative for the Andrew Company, Chicago.

* * *

PERMOFLUX HOLDS WAR PRODUCTION MERIT BANQUET

The fourth annual banquet of Permoflux Corporation, 4916-22 West Grand Avenue, Chicago 39, Illinois, was held recently.

The invitations were issued in the form of an *Award of Merit* for distinguished co-operation with the Permoflux war production campaign.

* * *

DUNLAP AND HEATH IN NEW RCA AND NBC POSTS

Orrin E. Dunlap, Jr., manager of the RCA department of information, has been appointed director of advertising and publicity for RCA.

Mr. Dunlap succeeds Horton H. Heath, who has accepted a position with the National Broadcasting Company as assistant to Frank E. Mullen, vice president and general manager.

Orrin Dunlap, Jr.

Horton Heath

LAMINATORS TEST PROGRAM UNDER WAY AT JOHNS HOPKINS

A test program, organized and financed by members of the laminated plastics industry, to record properties of laminated materials, standardize specifications and determine *best use* applications, has been given further impetus in a research-test center at Johns Hopkins University, Baltimore, as a wartime development which is conceivably projected for possible permanent establishment.

Members of the industry who have organized and financed the program, officially known as the Johns Hopkins Laminators Testing Program, include Continental-Diamond Fibre Company, Formica Insulation Company, General Electric Company, Mica Insulator Company, National Vulcanized Fibre Company, Panelyte Corporation, Richardson Company, Spaulding Fibre Company, Synthane Corporation, Taylor Fibre Company and Westinghouse Electric & Manufacturing Company.

George H. Clark, vice-president and chief engineer of the Formica Insulation Company, Cincinnati, a member of the Plastics Industry Committee on Laminates and of NEMA's Laminated Section, who had been entrusted with the responsibility to keep the industry informed on developments served as a "one-man clearing house" for the industry for digesting the early information obtained.

Dr. Ralph K. Witt of Johns Hopkins is in charge of the test program.

* * *

AMERICAN NETWORK APPOINTS LEWIS EXECUTIVE V-P

William B. Lewis has been appointed executive vice president and general manager of The American Network, Inc. The appointment will take effect on or about April 1, 1944, after completion of the nation-wide program study he is making for William S. Paley and the Columbia Broadcasting System.

John Shepard 3rd was reelected president; Walter J. Damm, vice president, and Robert Ide, secretary-treasurer.

* * *

DR. SALINGER RETURNS TO FARNSWORTH

Dr. H. Salinger, mathematical physicist, has returned to active duty in the Farnsworth Research Laboratories after a year's leave of absence, during which time he conducted specialized instructional work in physics and mathematics at various institutions in Indiana.

Dr. Francois C. Henroteau, who was chief of astro-physics division at the Dominion Observatory in Ottawa, Canada, over a period of 14 years, will join Dr. Salinger on the research staff.

* * *

CLARK COMPANY COMPLETES NEW PLANT

The Robert H. Clark Company has announced the completion of a new plant at 9330 Santa Monica Boulevard, Beverly Hills, California.

VANNEVAR BUSH WINS EDISON MEDAL

Vannevar Bush, president of the Carnegie Institution of Washington, and Director of the Office of Scientific Research and Development, of the Office of Emergency Management, Washington, D. C., has been awarded the 1943 Edison Medal of the American Institute of Electrical Engineers.

The award goes to Doctor Bush "for his contribution to the advancement of electrical engineering, particularly through the development of new applications of mathematics to engineering problems, and for his eminent service to the Nation in guiding the war research program."

* * *

ASA LIST OF STANDARDS

A new list of standards with more than 600 standards listed, has been released by the American Standards Association. The standards cover specifications for materials, methods of tests, dimensions, definitions of technical terms, procedures, etc.

One important phase of the work built up during the 25 years that the ASA has been in existence, is in the field of safety engineering. The new list includes 95 safety standards.

American Standards are constantly revised to keep up with the advances in industrial methods. This list represents the cumulative work of the past 25 years in practically every field.

* * *

PLATINUM METAL USE EXTENDED IN 1943

Platinum metals, including palladium and ruthenium received extensive use in 1943, according to Charles Engelhard, president of Baker & Co., Inc.

* * *

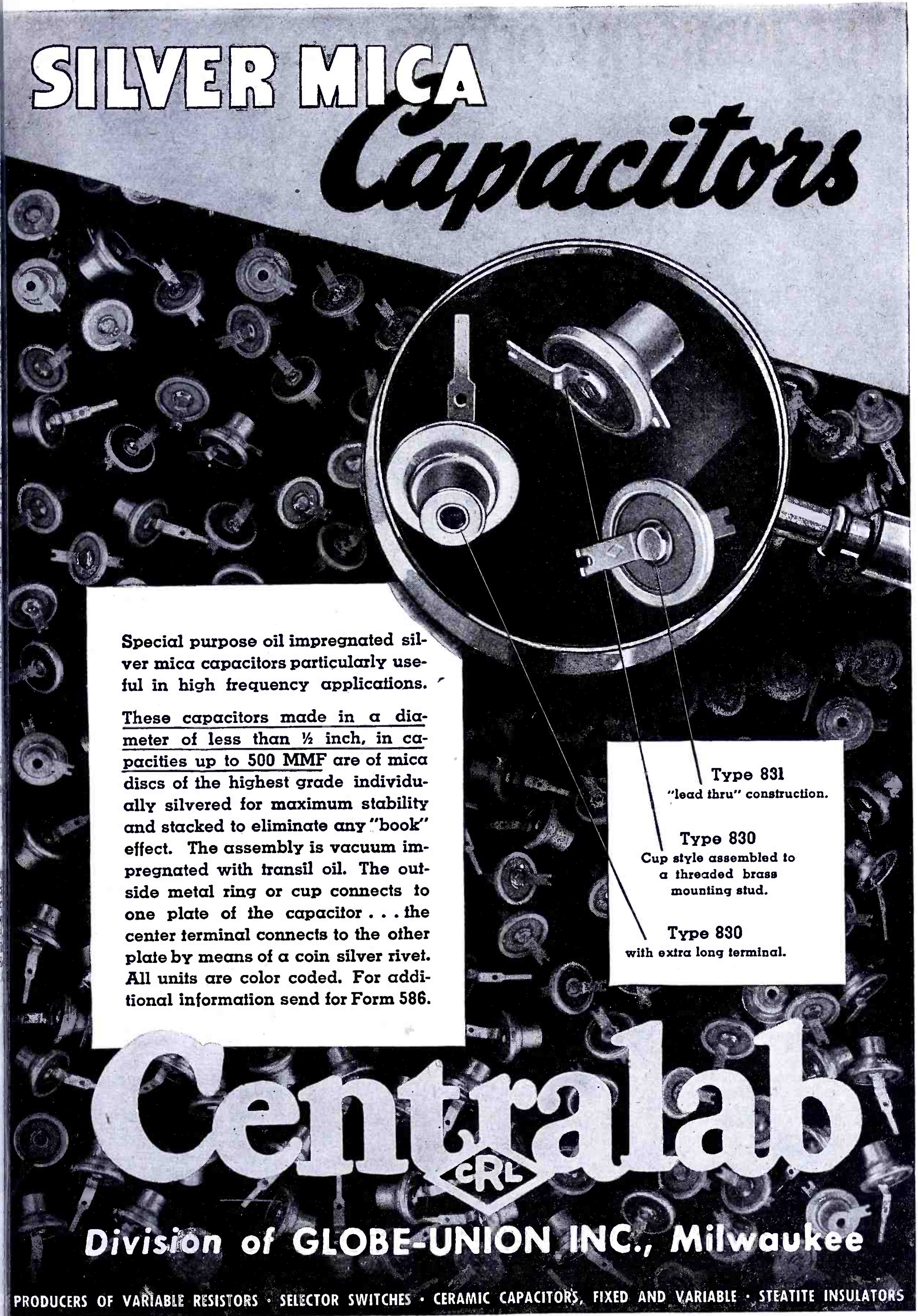
W. P. SAUNDERS NOW SIGNAL CORPS MAJOR

It's now Major W. P. Saunders, on duty in the Office of the Chief Signal Officer.

In October of 1941, Major Saunders assumed duties with the Radio Unit of the Durable Goods Section of OPA, where he assisted Maurice Despres in the administration of radio prices. He was active in the formulation of the OPA

(*Continued on page* 64)

W. P. Saunders

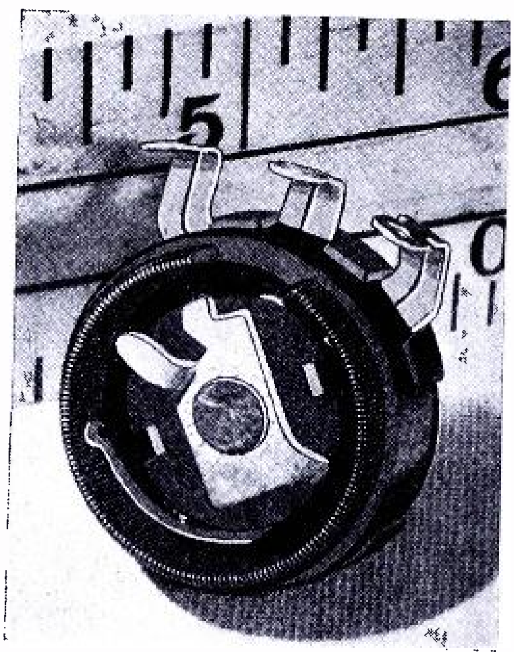

SILVER MICA
Capacitors
Special purpose oil impregnated silver mica capacitors particularly useful in high frequency applications.
These capacitors made in a diameter of less than ½ inch, in capacities up to 500 MMF are of mica discs of the highest grade individually silvered for maximum stability and stacked to eliminate any "book" effect. The assembly is vacuum impregnated with transil oil. The outside metal ring or cup connects to one plate of the capacitor . . . the center terminal connects to the other plate by means of a coin silver rivet. All units are color coded. For additional information send for Form 586.
Type 831
"lead thru" construction.
Type 830
Cup style assembled to a threaded brass mounting stud.
Type 830
with extra long terminal.
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee
PRODUCERS OF VARIABLE RESISTORS · SELECTOR SWITCHES · CERAMIC CAPACITORS, FIXED AND VARIABLE · STEATITE INSULATORS

THE INDUSTRY OFFERS . . .

CLAROSTAT MIDGET WIRE-WOUND CONTROLS

A small wire-wound control, 1⅛" in diameter by 9/16", type 43, has been announced by Clarostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y.

A bakelite body is completely enclosed by a dust-tight metal cap, or by an attached switch. The control virtually matches in both size and general appearance type 37 or midget composition-element control. The wire winding is curved and held in a concentric slot in a molded bakelite body. The alloy contact arm presses against the inside surface of the winding. The control is supplied with or without switch; in resistance values up to 10,000 ohms; linear tapers only; rated at 1½ watts.



* * *

TINY FLUORESCENT LAMP

A miniature fluorescent lamp that is said to give off more light than a quarter-watt neon glow lamp, and consumes but 1/10 watt, has been developed by Westinghouse engineers.

Energy can be supplied by dry batteries. If available after the war for household use, the lamp could burn constantly for six months (to mark a stair-step or keyhole) for about a penny's worth of electricity.

The lamp contains two spiral electrodes in a gaseous atmosphere. A discharge takes place when about 100 volts a-c or 140 volts d-c is applied across the electrodes. This creates an ultraviolet radiation that is retransformed (at high efficiency) into a green light—accomplished by the phosphor coating on the interior of the bulb. Other colors are possible but green phosphors convert *black light* to visible light most efficiently. A tiny resistor in the lamp base stabilizes current flow after discharge begins.

* * *

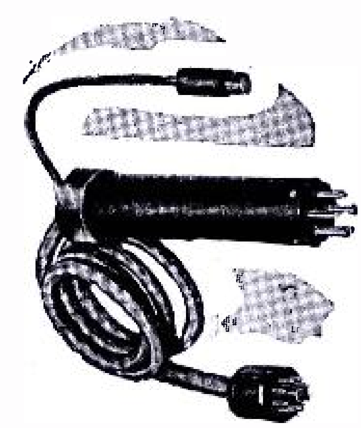
WESTINGHOUSE GLASS JEWELS

Glass jewels, substitutes for sapphires, are now being turned out by automatic machines at the rate of 3,500 per day at Westinghouse. One girl can tend two machines that is said to produce almost no poor jewels.

CML PRODUCTION PLUGS

Production plugs developed for use with the Rotobridge in testing electronic equipment, are now available for general use by manufacturers. CML production plugs made by Communication Measurements Laboratory, 116 Greenwich Street, New York, are 5" long and 1¼" in diameter, so that the handle will project above the average i-f transformer, condenser, making it readily accessible. Plugs are made with a heavy steel barrel and are filled with a wooden handle to permit ready removal from socket. All pins are case hardened steel.

In both the octal and loktal plugs, center key extends through in form of a threaded rod to permit cable to be fastened firmly in position without strain on pin connections. A flat head machine screw serves same purpose in the other plugs. In addition to the octal and loktal types, these plugs are available in 4, 5, 6 and 7 pin models, small and medium.



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RCA MULTIPLIER PHOTOTUBE, 1P21

A 9-stage multiplier phototube, 1P21, has been announced by RCA.

The 1P21 is similar to the recent 931-A, but features a sensitivity almost three times as great. Because of this sensitivity, the 1P21 is intended only for those special applications in which extremely low light levels are involved, such as may be encountered in astronomical measurements or in various kinds of scientific research. For the more usual applications which do not require so much amplification, the 931-A is recommended.

The 1P21 is small in size, is said to have low noise level, extremely low dark current, and freedom from distortion.

* * *

HIP TOOL KIT

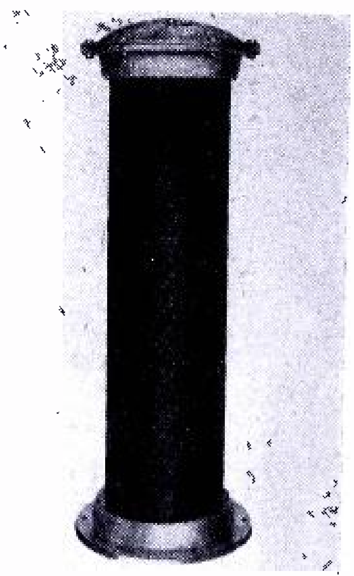
A hip tool kit, replacing apron tool holders, has been announced by E. F. Hillegas Company, 516 Allen Avenue, Box 289, Glendale, California.

The kit case is made from soft chrome elk tanned cowhide. The kit case features one large pocket for drives, cutters, pliers, chisels; two medium pockets for knives, markers, rules; one long pocket for the large screw driver; one small pocket for punches, sets, drills, scribes; and one loop holder for hammer or large cutter.

INDUSTRIAL SPECIALTY HI-VOLTAGE CAPACITOR

A .02-mfd, 250,000-volt capacitor has been developed by Industrial Specialty Company, 1725 West North Avenue, Chicago 22, Illinois. It consists of liquid impregnated capacitors housed in a wet process porcelain tube and filled with a liquid dielectric. The end caps are of the Westinghouse solder seal type which act both as a mounting arrangement and terminals.

This unit is said to have been built for total salt water submersion. Voltage ratings range from 7,500 volts to 250,000 volts in single units, and can be connected in series for operation up to several million volts.



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D-C RECORDING VACUUM VOLTMETER

A d-c recording vacuum tube voltmeter has been produced by Sound Apparatus Company, 150 West 46th Street, New York 19, N. Y.

Its sensitivity is said to be 1-volt full scale, ±½-volt center scale. Input impedance is said to be very high, that of a negatively based grid. Recording chart is 2" width, wax coated. Recording speed is approximately 1 volt in .3 second. Paper speed is 1 mm per second. Size, 8" × 10" × 12"; weight, 16 pounds; for 115 volts 60 cycles, 60 watts.

The d-c recorder is physically similar to the PS recorder. The device can be supplied for operation off a 6-volt battery and with different width charts, papers speeds, etc.

* * *

WESTINGHOUSE FOUR-IN-ONE DYNAMOTOR

A dynamotor providing four voltages has been produced by Westinghouse. The machine requires four separate commutators. Ordinarily, output voltage of a dynamotor bears a fixed relation to the supply voltages. In this case, however, all output voltages are held constant for all normal input-voltage variations. This is accomplished by means of a regulator field which weakens when the input voltage rises and strengthens when the voltage drops; the regulator utilizes a separate core.

The complete armature has four com-

(*Continued on page 72*)

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

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

OUR VICTORY DINNER-CRUISE

THE nineteenth anniversary meeting this year, February 12, will be known as the United Nations Radio Victory Dinner-Cruise. It will be held in the North Ballroom of the Hotel Astor, Times Square, New York City. The East Ballroom has been engaged as a reception room.

Invited to be guests of honor at this gala occasion are: General Henry H. Arnold, Commanding General Army Air Forces, pioneer in the use of aircraft radio, who this past year received the Collier trophy for his contributions to aviation; General Thomas Holcomb, former Commandant of the United States Marine Corps, the first officer in Marine Corps history to attain the rank of full General; representatives and Consular personnel of each of the United Nations; radio officers of each United Nations' vessel in port on February 12; William J. Halligan, president of Hallicrafters, who will receive the Marconi Memorial Medal of Achievement; E. A. Nicholas, president of Farnsworth Television and Radio Corporation; Ted McElroy, president of the McElroy Manufacturing Corporation; and Maurice Pierce, chief engineer of WGAR in Cleveland and chief engineer of the Psychological Branch of the Office of War Information, the man responsible in large measure for the successful surrender of the Italian Fleet. . . . Nicholas, McElroy and Pierce will receive Marconi Memorial Medals of Achievement. . . . FCC chairman James Lawrence Fly has also been asked to attend. . . . Honorary membership in the VWOA will be presented to Bryan S. Davis, publisher of COMMUNICATIONS, in recognition of his cordial cooperation and unfailing support during the past ten years. . . . Honorary membership will also be accorded Rear Admiral Joseph Redman, Director of Naval Communications and Major General Harry C. Ingles, Chief Signal Officer of the Army. . . . Life membership will be conferred upon our very industrious treasurer "Bill" Simon and Arthur H. Lynch, one of radio's pioneers.

The outstanding deeds of radiomen of the United Nations will be recognized by suitable awards.

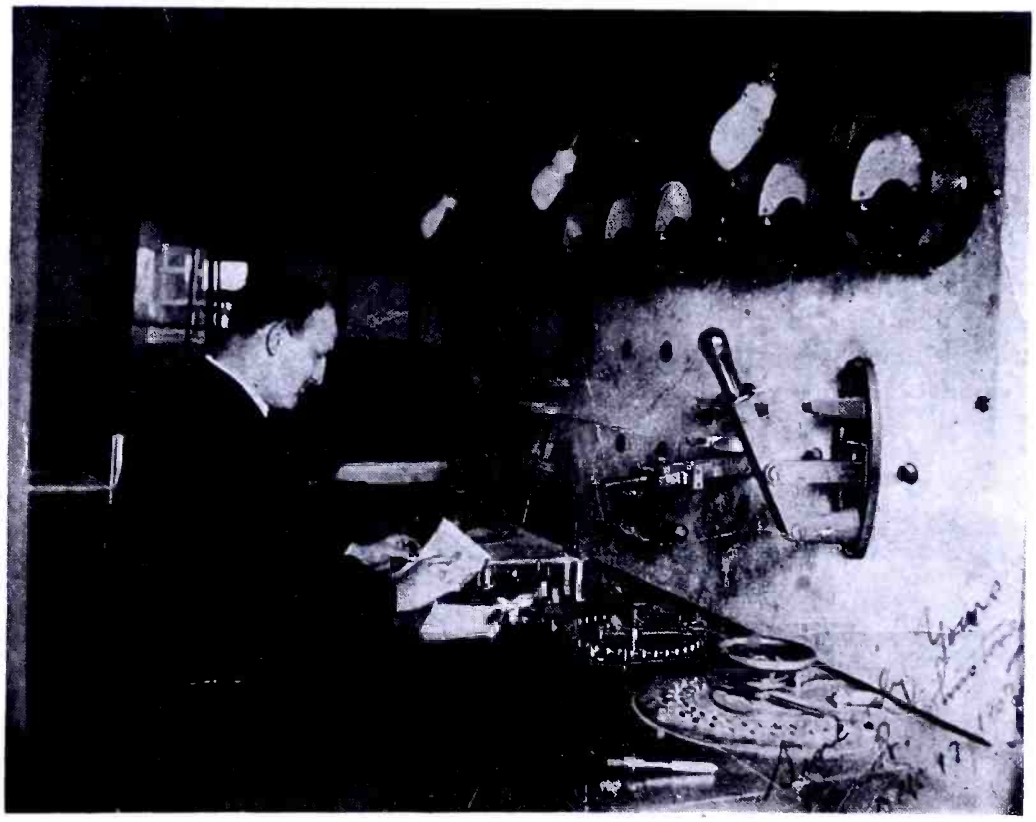
IN MEMORIAM

JOHN B. DUFFY, a former VWOA president, died recently. He was a pioneer wirelessman, and an intimate friend of practically all wirelessmen who went to sea during the first three decades of this century. Our sincere condolences to his family. . . . Guy Entwistle, formerly chairman of the Boston chapter, reports the death of Sam Curtis of the Boston chapter. We extend our deepest sympathy to his family.

PERSONALS

GEORGE P. SHANDY, VWOA member and RCA's expert on direction finders, has been made chief inspector of the Radiomarine Corporation of America. Keep on the bearing, George! . . . Funds totalling about one thousand dollars on hand to guard the upkeep of the Operator's Monument at Battery Park, N. Y. City, has been almost entirely transferred into War Bonds, thanks to the advice of Jack Duffy, of the Monument board. . . . The Monument is today rather ingloriously hidden behind the fence necessitated by the Battery-to-Brooklyn tunnel project. After the War it is planned to move the structure to a prominent position in the center of the Park, and at the same time greatly enlarge its scope. It is probable that this will be a joint enterprise of the Monument trustees and the VWOA. . . . Steffan Nielsen, now at RCA Victor, Camden, was once an operator just like Bill Fitzpatrick, with the exception that Bill didn't clip his dashes. One night years ago Steffan was operating a ship bound for Porto Rico, and called that station — NAW — with a message. However, he was a little too snappy with his sending, and it sounded too much like NAS-Pensacola, so that station answered and received the message. The Navy carefully forwarded the dispatch to Porto Rico by cable, at a cost of $60.00 or so, and there was much interchange of accusations and denials when the wireless com-

(*Continued on page* 90)



Transmission of first transatlantic press messages from radio station in Glace Bay Towers to Clifden, Ireland, on October 17, 1907. L. R. Johnstone is at key.

NEWS BRIEFS

(*Continued from page* 58)

radio receiver and parts maximum price regulations.

* * *

CREATIVE PLASTICS EXECUTIVE OFFICES NOW IN N. Y. C.

Creative Plastics Corporation, 963 Kent Ave., Brooklyn, N. Y., manufacturers of insulating grommets and other fabricated plastic parts for industrial uses, has opened a sales and executive office at 393 Seventh Avenue, N. Y. City.

Todd Harris, sales manager, will be in attendance at the New York offices Tuesdays and Thursdays, while Paul E. Monath, purchasing agent, will be present Mondays and Fridays. On Wednesdays, both will be at the Brooklyn plant.

Telephone number of the New York office is CHickering 4—0828.

* * *

PHILIP MURRAY JOINS MIDLAND

Philip Jesse Murray, formerly with the Air Conditioning Training Corporation, Youngstown, Ohio, has been appointed sales director of Midland Radio and Television Schools, Kansas City, Missouri.

* * *

WARE NOW MANAGING KWFC

William E. (Bill) Ware, has become general manager of KWFC, Hot Springs, Arkansas, MBS affiliate.

* * *

AMPEREX EXPANDS

Amperex Electronic Products, 79 Washington Street, Brooklyn, N. Y., has opened another plant in Brooklyn.

* * *

MASSEY NOW WESTINGHOUSE GENERAL LAMP SALES MANAGER

William J. Massey has been appointed general lamp sales manager of the Westinghouse lamp division, with headquarters at Bloomfield, N. J.

* * *

POSTWAR PLANS WIN HUDSON AMERICAN AWARDS

At the recent International Municipal Signal Association War Conference held in Cleveland, the Hudson American Corporation, 25 West 43rd Street, N. Y. City, offered War Bond prizes for the best sug-

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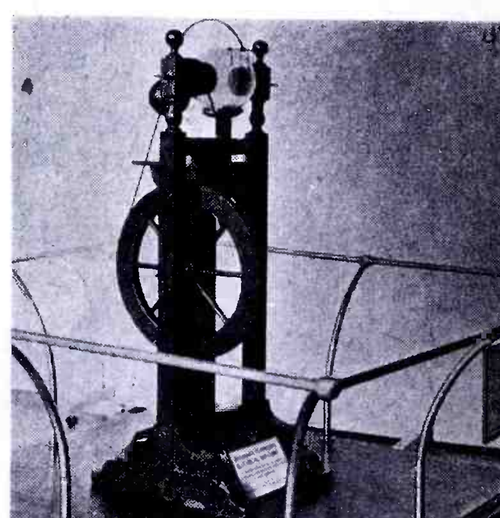
BENJ. FRANKLIN ANNIVERSARY



The 238th birthday of Benjamin Franklin was celebrated on January 17. Above, his famous static electricity device, at the Franklin Institute, Philadelphia (now in storage for the duration).

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estions on the development of municipal ignaling for postwar application.

The prize winners have just been announced. First prize of a $100 War Bond was won by Clement Wetmore, uperintendent of fire alarms, 675 Shepard venue, Hamden, Conn. His suggestion overed a walkie-talkie unit for firemen, attery-powered, and fitted with earhones and a throat microphone.

The second prize, a $50 War Bond, as worn by Herbert A. Friede, superinendent and chief of emergency communiations, Fire Headquarters 4th, Douglas treet, N. W., Washington, D. C. He uggested a chain of mutual aid radio tations to be established on a national asis; one station to be installed in elected fire control centers, the State fire arshal, or other authority, to designate e installation.

L. C. Van Inwegen, Jersey Central Power & Light Company, 501 Grand Aveue, Asbury Park, N. J., won the third rize, a $25 War Bond. He suggested a ireless fire-alarm box, primarily for mall districts lacking fire apparatus of heir own.

A $100 War Bond, special award, was on by Alfred Theurich, fire alarm suerintendent (present ISMA), 145 East Holly Street, Pasadena, Calif. His postar development plan covered a walkiealkie unit for firemen, designed with a hroat microphone and a single ear plug r a receiver hinged to the helmet; the ntenna to be built into the helmet or ewn into the turn-out coat.

* * *

STANCOR CATALOG

A 36-page catalog, 140-F, covering varius types and sizes of stock transformers nd converters has been released by Standard Transformer Corporation, 1500 North Halsted Street, Chicago, Ill. Charts are provided to expedite identifiation of parts.

* * *

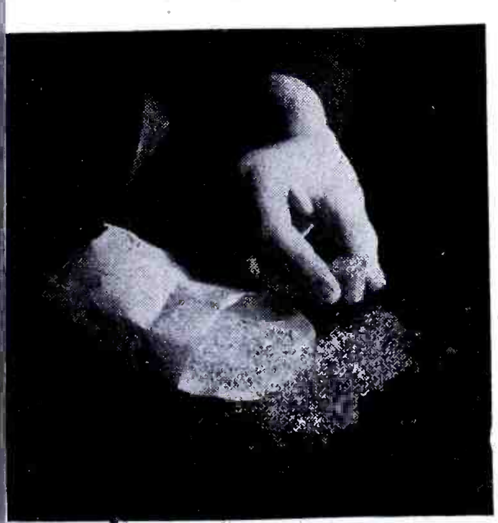
I. W. BRYANT JOINS G. E. IN CHICAGO

. W. Bryant, formerly with the radio division of the Missouri State Highway Patrol, has joined the Chicago office of G. E. He will assist users of emergency communication equipment in the selecion and installation of equipment for heir needs in the central region of the United States.

Mr. Bryant joined the Missouri State Highway Patrol as a member of the

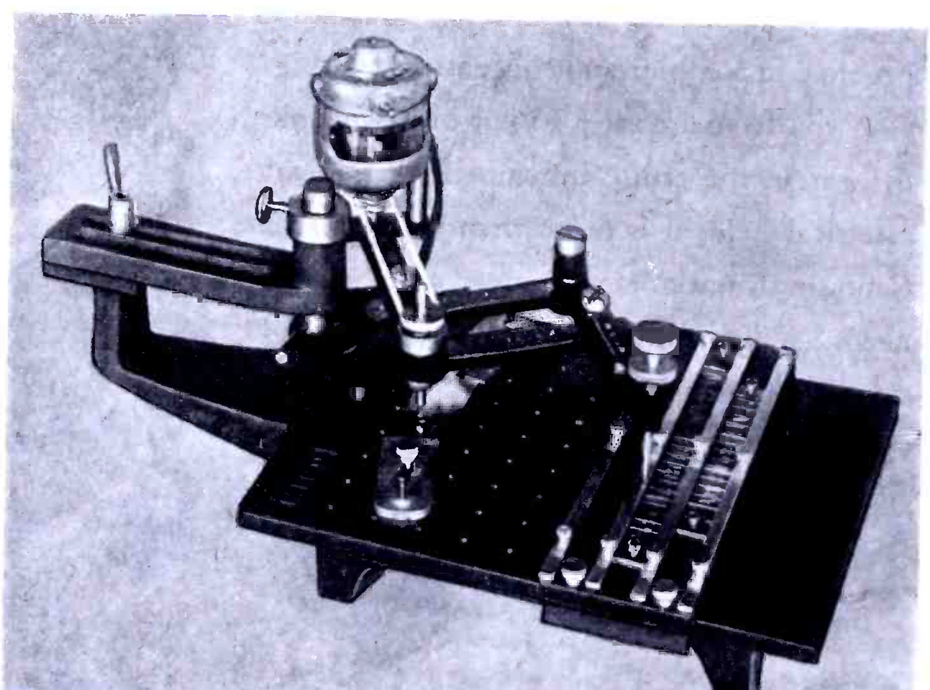
(*Continued on page* 66)

GLASS VEE JEWELS



(*Courtesy Westinghouse*)

Glass vee jewels now available for instruments. Diameters are 0.051 and 0.076 inch.



NEWS BRIEFS

(*Continued from page 65*)

Radio Division in 1936. At that time the patrol operated station WOS, whose regular programs were interrupted to transmit calls and information to patrol cars *on the road.* He was one of the three members of that division who built and operated the patrol's first short-wave station, KIUK. He designed and prepared the operating procedure for the patrol's complete 6-station system installed in 1938, and was appointed Sergeant in charge of personnel and operations for this new system under Captain J. M. Wherritt, patrol communications officer.

Mr. Bryant has been an active member of the Associated Police Communication Officers since 1936, serving as chairman and member of several APCO committees.

* * *

CAPTAIN ROBERT ADAMS JOINS TEMPLETONE

Captain Robert Adams, recently retired from the Signal Corps, has joined Templetone Radio Company, Mystic, Connecticut, as production manager of the radio division.

Prior to entering the Armed Services, Captain Adams was works manager of Sonora Radio and Television Company. Previous associations were as superintendent, radio division, Stewart Warner Corporation, and with General Electric Company, RCA Victor Company, and Raytheon Manufacturing Company.

* * *

SOLDIERS WIN HALLICRAFTERS AWARD

First Lieutenant Robert Phillips, Jr., of the Signal Corps, and Technical Sergeant Ervin A. Hurley, with an Air Base Squadron in the Aleutians, tied for first prize in the Hallicrafters Company cash prize contest for radio men in the Service. Each of the soldiers received a check for $100. The prizes were awarded for letters telling of their personal experiences with Hallicrafters military and naval communications equipment.

The contest is open to Servicemen, either in the United States or overseas, with V-mail letters acceptable from the latter.

Lt. Phillips was invited to come to Chicago and attend Hallicrafters annual Christmas dance to receive his award.

At the battle of Kasserine Pass, while driving an SCR-299 mobile radio station, Lt. Phillips was hit by dive bombers. He wears an empty sleeve as a result, also the Order of the Purple Heart. With

Lt. Robert Phillips, Jr., receiving his $100.00 award from Kenneth McClelland, Hallicrafter personnel director.

is arm nearly blown off, he drove six ounded men to a first-aid station and ent back an ambulance for more. In is prize-winning letter he told how the Iallicrafters SCR-299 was used to establish communications between an African ase and London, England, a distance of ,300 miles.

T/Sgt. Ervin A. Hurley told in his tter how the SCR-299 overcomes severe idio disturbances caused by adverse eather conditions in the Aleutians.

* * *

ALCOM, OF SYLVANIA, JOINS 5-YEAR CLUB

I. F. Balcom, vice president of Sylvania lectric Products, Inc., and a member of s board of directors, has just been made member of the firm's Quarter-Century lub.

Mr. Balcom is also a vice president of ie Radio Manufacturers Association.

* * *

SAM CUFF IN NEW DUMONT POST

Samuel H. Cuff has been appointed genral sales promotion manager for DuMont television. Mr. Cuff will direct ales promotion on television receiving nd transmitter equipment. He will also iave charge of sales on the DuMont teleision station.

* * *

HYTRON'S FACILITIES EXPANDED

Hytron Corporation, Salem, Massachuetts, have now quadrupled their producive facilities, according to Hytron offiials.

* * *

ARMY-NAVY "E" TO BELL

The Army-Navy "E" has been awarded o the Bell Sound Systems, Inc., 1183 Essex Avenue, Columbus, Ohio. Lieuenant Governor Paul M. Herbert of Ohio, served as master of ceremonies and lelivered the main address. Colonel H. R. Yeager, commanding officer of the Signal Corps, Aircraft Signal Agency, Wright Field, Dayton, Ohio, presented

(*Continued on page* 68)

Floyd W. Bell and Earl Hosler with the Bell Sound "E" flag.

NEWS BRIEFS

(*Continued from page* 67)

the flag to Floyd W. Bell, Bell Soun System president.

* * *

DEAN CELL GOES TO UNIVERSAL MICROPHONE

Dean Cell, formerly assistant engineer charge of production testing at the Lo Angeles plant of the Robert Hadley Co transformer manufacturers, has joined th Universal Microphone Co., Inglewoo Cal., in a supervisory capacity.

* * *

G. E. APPOINTS STANDARDS POLICY COMMITTEE

A standard policy committee has been se up at G. E. L. F. Adams has been ap pointed committee manager by W. R Burrows, vice-president in charge of gen eral manufacturing matters, and R. C Muir, vice-president in charge of genera engineering matters. The committe will be responsible for the developmen and maintenance of sound design engi neering and manufacturing standards an practices for use throughout the com pany.

Others on the committee are H. W Robb, secretary; P. L. Alger; T. D. Foy the engineering assistants to the work managers; the general superintendent o each works, and a representative of eac of the appliance and merchandise, elec tronics, and lamp departments.

* * *

ERIE RESISTOR WINS "E"

The Erie Resistor Corporation, Erie, Pa has been awarded the Army-Navy "E. Lieutenant Colonel William H. Edwards U. S. Signal Corps, presented the "E flag to G. Richard Fryling, Erie Resisto president.

* * *

W. C. SPEED IN NEW REEVES POST

William C. Speed has been appointe vice-president in charge of manufacturin of Reeves Sound Laboratories, Inc., 6 West 47th Street, N. Y. City. Mr. Spee is also vice-president of Audio Manu facturing Corp., Stamford, Conn.

* * *

JEWELL NOW WESTINGHOUSE INDUSTRY DEPT. ASST. MANAGER

James H. Jewell has been appointed as sistant manager of the industry depart ments of Westinghouse Electric an Manufacturing Company. Mr. Jewel manager of the agency and specialties de

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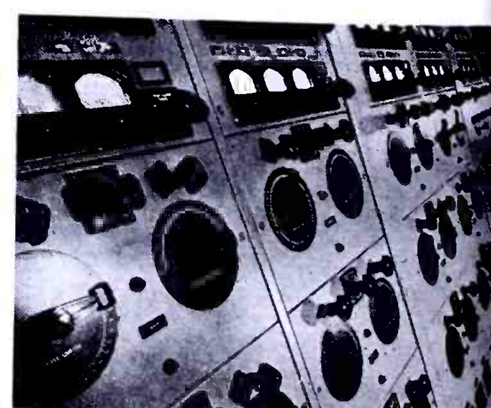
A-C CALCULATING BOARD



The new a-c calculating board recently in stalled by Westinghouse at East Pittsburg that makes it possible to solve complicate power-system problems. It simulates a tota of 18 power sources.

artment since 1940, will continue to head hat division.

In his new post Mr. Jewell will supervise all activities of the industry department except application data and training nd general contract.

* * *

)AVID GROSS NOW DUMONT :YCLOGRAPH SALES DIRECTOR

David Gross has been appointed sales director of the materials test division of Allen B. DuMont Laboratories, Inc., Passaic, N. J. This division handles the DuMont cyclograph, which non-destructively tests the metallurgical properties f ferrous and non-ferrous metals.

* * *

IEW PLANT FOR BELMONT

Construction has begun on an addition o the plant of the Belmont Radio Corporation, 5921 W. Dickens Avenue, Chicago, Ill. The addition will provide space r the firm's augmented laboratory staff.

* * *

. W. HUBBEL CHAIRMAN, 4TH WAR OAN COMMUNICATIONS DIVISION

ames W. Hubbell, president of the New York Telephone Company, has accepted he chairmanship of the Communications Division for the Fourth War Loan.

* * *

RAYMOND LOEWY TO DESIGN FOR EMERSON

Raymond Loewy, industrial designer, will design cabinets for Emerson Radio and Phonograph Corporation for the postwar ra.

* * *

CARRINGTON AND BESSEY WIN ALTEC SERVICE PROMOTIONS

G. L. Carrington has been elected president and H. M. Bessey vice president of Altec Service Corporation, 250 West 57th Street, N. Y. City.

Mr. Carrington, one of the founders of Altec, has served as vice president and general manager since its formation in 1937. With his new duties as president, he also retains the post of general manager of Altec Service Corporation, as well as the presidency of Altec Lansing Corporation, west coast manufacturing subsidiary.

* * *

WILLIAMSPORT SYLVANIA PLANT WINS "E"

The Williamsport, Pa., plant of Sylvania Electric Products, Inc., received the Army-Navy "E" award.

Major General Roger B. Colton, chief of the Engineering and Technical Ser-

(*Continued on page* 70)

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COMMANDO-TOUGH RADIO

(*Courtesy Westinghouse*)
Giving the commando-tough radio a water test.

NEWS BRIEFS

(*Continued from page* 69)

vice of the Signal Corps, awarded th "E" to Walter E. Poor, president.

* * *

CHEMICAL PUBLISHING CATALOG

A new catalog of technical books ha just been issued by The Chemical Pub lishing Co., Inc., 26 Court Street, Brook lyn 2, N. Y. This catalog includes th latest books on chemistry, technology physics, general science, mathematics engineering, radio, aviation, foods, for mularies, cosmetics, gardening, medicin metals, technical dictionaries, etc.

This catalog gives the date of publica tion of each book as well as a concis description and full table of contents.

* * *

IRC BOOKLET REVEALS WARTIME PRODUCTION PROGRESS

A booklet entitled *Reporting on Planco No.* 1666, telling how additional faciliti were secured under wartime condition has been released by the Internationa Resistance Company, 401 N. Broa Street, Philadelphia, Pennsylvania.

The report reveals how difficult equip ment was finally secured or built, man power trained and a new plant construct ed. All this, says the report, involve some 23,000 telephone calls and telegram and 7,000 hours in purchasing and ex pediting.

* * *

WNBT ON AIR TWICE WEEKLY

The National Broadcasting Company ar now presenting television programs twic a week for at least two hours each night over WNBT.

Normally, the station will transmi short subjects and feature films on Mon day and Saturday evenings from 8 to 1 o'clock, but if a public event providing acceptance television material is avail able at Madison Square Garden on some other night, the Saturday program for that week may be replaced by the specia telecast.

This new schedule was announced by C. L. Menser, NBC vice president in charge of programs.

* * *

E. O. WOODWARD AWARDED REACTOR PATENT

E. O. Woodward, owner and chief engineer of Hollywood Transformer Company, 645 North Martel Avenue, Los Angeles 36, California, has been awarded a patent for an improvement on inductive reactors, and a new and useful core arrangement for these reactors.

* * *

MINUTE FLAG TO JAMES KNIGHTS

The Treasury Minute Man flag was recently awarded to the James Knights Company, Sandwich, Illinois.

* * *

UTC EMPLOYEES FORM VICTORY CORPS; DONATE BLOOD

Members of the United Transformer Company, 150 Varick Street, New York City, have formed a Victory Corps to participate in home front war activities. Thus far, members of this group have donated over 350 pints of blood to the Red Cross.

* * *

COMMUNICATION PRODUCTS' R-F LACQUER

A radio frequency lacquer that is said to have a low loss factor over a wide frequency range has been announced by

Communication Products Company, 744 Broad Street, Newark, N. J.

A 24-page booklet describes the uses of the lacquer, known as Q-Max A-27. Illustrated graphically, for a wide frequency range, are the dielectric constant, power factor and loss factor while data are included for dielectric strength, density, drying time, adhesion and other characteristics.

* * *

RADIOMARINE WINS SECOND STAR FOR "E" FLAG

A second white star has been awarded the Radiomarine Corporation of America for its Army-Navy "E" flag.

Radiomarine's original "E" pennant was presented in December, 1942. In April, 1943, the first star was added to the flag for continued production efficiency. In addition, the Radiomarine Corporation, in March, 1943, won the Maritime "M" Pennant and Victory Fleet Flag.

* * *

G. R. NOISE PRIMER

An interesting analysis of noise appears in the recently issued 44-page manual published by General Radio Company, Cambridge, Massachusetts. The manual entitled *The Noise Primer* is divided up into 13 chapters and covers such subjects as sound level meters, vibration meters, sound analyzers, the decibel, noise and noise measurements. Decibel conversion charts are also included in this interesting presentation.

The manual is well illustrated with operating graphs and photos of equipment.

* * *

L-183 DISCUSSED IN JFD BULLETIN

A 4-page bulletin in which a review of L-183 appears, has been released by the JFD Manufacturing Co., 4111 Fort Hamilton Parkway, Brooklyn, New York. The bulletin also contains priority data on JFD products.

* * *

INSULINE CATALOGUE

A 48-page catalogue describing a variety of parts has been issued by the Insuline Corp. of America, 3602-35 Avenue, Long Island City, New York.

Data in the manual covers jacks, plugs, terminal strips, fuse mounting, test leads, alignment tools, switches, dials, cabinets, antennas and general hardware.

* * *

RADIO'S FUTURE TOLD IN RCA BOOKLET

The future of radio and electronics in industry receives an interesting analysis in a 32-page booklet just released by the Radio Corporation of America, RCA Building, New York City.

The booklet, which contains an introduction by David Sarnoff, RCA president, tells of the variety of applications that are in store for radio and electronics in the postwar era. The application of these facilities to the home, farming, food, highways, aviation, railroads and ships are discussed.

* * *

AMP SOLDERLESS TERMINAL BULLETIN

Pre-insulated solderless terminals are described in a 6-page bulletin released by Aircraft-Marine Products, Inc., 1523 North 4th Street, Harrisburg, Pennsylvania.

The bulletin provides dimensional data on two types of supports known as red 22-18 and blue 16-14.

THE INDUSTRY OFFERS . . .

(*Continued from page 60*)

mutators, two cores and four winding The total diameter is 2.8" and the lengt is 11". Maximum voltage is 450.

* * *

G. E. IGNITION CABLE

A high-tension sheath-type ignition cab for use on aircraft engine ignition sys tems, has been announced by the G. E wire and cable division.

Synthetic neoprene is used. It is sai to have high heat, moisture and oil re sistance and can withstand the effects of an electrical discharge at low atmospher pressures.

The conductor of this new cable i flexible. It consists of monel wire twisted together and covered with an in sulation of low-capacitance rubber com pound reinforced by a braid of glass yar for added tensile strength and rugged ness.

* * *

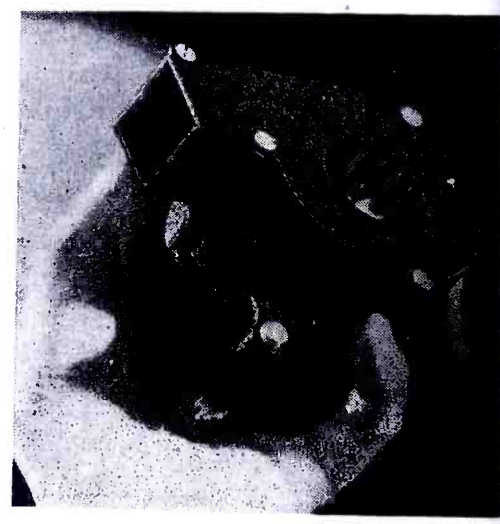
CENTRALAB CENTRADITE CERAMIC

A new development in ceramic material Centradite, has been announced by Centralab, division of Globe Union, Inc., 900 East Keefe Avenue, Milwaukee, Wisconsin. Its characteristics are described in a one-page bulletin 720-A.

* * *

WESTINGHOUSE AIRCRAFT RADIO BLOWER UNIT

A blower for use on aircraft radio equipment that operates on 60 cycles, and at a speed of 7,000 rpm, has been developed at Westinghouse. A new type blower fan made by Torrington with extra blades is also used to increase cooling properties.



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HAINES U-H-F SIGNAL GENERATORS

Calibrated u-h-f signal generators, type HF73, are now being produced by the Haines Manufacturing Company, 248-274 McKibbin Street, Brooklyn, New York. It is continuously variable from 200 to 800 megacycles. Frequency in both megacycles and centimeters appear directly on scale. Housed in steel cabinet, 15" x 7" x 7½".

* * *

SURPRENANT PLASTIC TUBING

Plastic for tubings and wires, that are said to have an average dielectric strength of 1,500 volts per mil thickness is being produced by Surprenant Electrical Insulation Company, Boston. The material is said to retain its dielectric and mechanical strength in temperatures as high as 295° F. and as low as minus 80° F.

The plastic insulation, produced under

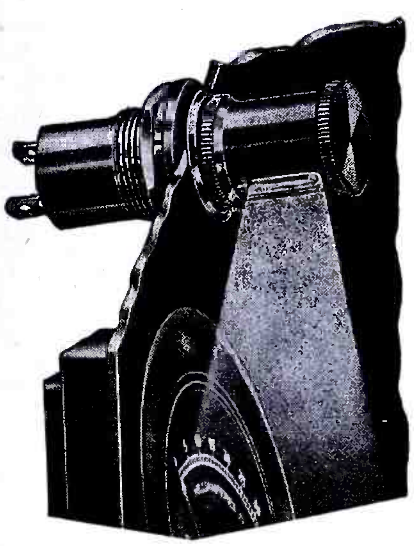
name, *Surco-American*, are available 26 formulations, in thicknesses of " to 2" inside diameter, and are sup- d in all lengths and colors. In- ated wires are supplied in continuous gths, also in all colors, in sizes No. 12 No. 48; AWG tubings are said to non-aging, non-inflammable, resist isture, acids, alkalis, and hot oil, and ffected by weather.

* * *

INEL LIGHT

panel light assembly is being made by Dial Light Co. of America, Inc., 90 est Street, New York. A feature is a urled head which is rotatable 360°, thus sting the light at any desired angle.

The lamp housing is made of Navy ecification bakelite varnish, while the ad is made of brass and may be finished th any desired plating. Lamp socket commodates miniature bayonet base mp which is easily removable from ont of panel. The unit requires an 11/16" nel hole for mounting.



* * *

OWER RECTIFIERS

line of power rectifiers has been an- ounced by Selenium Corporation of merica, 1800-04 West Pico Boulevard, os Angeles 6, California. Included are even disc sizes ranging from ¾" to 4½" n diameter.

All the units are stated to be moisture roof and to have permanent character- stics. Assemblies with output up to 1000 mperes can be supplied.

The rectifiers known as Selco type are vailable for bolt or stub mounting direct o equipment or with mounting brackets s per specs.

BOOK TALK . . .

HYPER AND ULTRAHIGH FREQUENCY ENGINEERING

By *Robert I. Sarbacher*, Sc.D., Associate Professor of Electrical Engineering, Illinois Institute of Technology, and *William A. Edson*, Sc.D., Assistant Professor of Electrical Engineering, Illinois Institute of Technology . . . 644 pp. . . New York: John Wiley and Sons, Inc. . . . $5.50.

This volume is a commendable contribution to the communications world. Analyzed are a host of u-h-f problems which long have puzzled many engineers.

The book has been prepared in a very unique way to facilitate interpretation of the subjects discussed. For instance, a very complete table of symbols with page references are presented. In addition, at the conclusion of each chapter, are problems for study. In the appendix are presented fundamental constants, a conversion table for the units affected and unaffected by rationalization, and a 20-page bibliography, covering text books and manuscripts.

There are 17 chapters in the book. These chapters cover: electrostatics and magnetostatics; the electromagnetic equations; Maxwell's equations; reflection and refraction of plane waves; parallel plane wave guides; rectangular wave guides; cylindrical wave guides; wave guide experimental apparatus; transmission line theory; cavity resonators; radiation from horns and reflectors; the behavior of vacuum tubes at high frequencies; amplifiers; the negative grid oscillator; the positive-grid or retarding-field oscillator; the magnetron; and tubes employing velocity modulation.

In discussing the terms hyper-frequency and ultrahigh frequency as presented in this volume, the authors say: "Although no definitely established frequency limits are associated with the terms hyper frequency and ultrahigh frequency as applied to radio communications systems, frequencies above about 30 megacycles per second are generally referred to as ultrahigh frequencies. Originally no upper limit was associated with this term. The term microwaves is sometimes used to identify the band of frequencies beyond those known as ultrahigh. These wavelengths covered the range from approximately three centimeters to 30 centimeters. We may, therefore, consider the ultrahigh-frequency band to cover frequencies lying between 30 to 1,000 megacycles per second, and the hyper-frequency band to embrace those of 1,000 to 10,000 megacycles per second."

This book should be read by every-
ıe interested in, or engaged in, hyper
ıd ultrahigh-frequency work.—*O. R.*

•

RAPHICAL CONSTRUCTIONS OR VACUUM TUBE CIRCUITS

***Albert Preisman*, A.B.E.E., Director Engineering Texts and Consulting ıgineer, Capitol Radio Engineering stitute . . . 237 pp. . . . New York: cGraw-Hill Book Co., Inc. . . . $2.75.**

The use of geometric manipulations secure solutions to nonlinear circuit oblems, involving particularly vacım tubes, affords an interesting mea of study. In this volume, Mr. reisman analyzes this procedure most fectively. Since analytical methods e sometimes used with the graphical ocedure, Mr. Preisman has there- re included this concept where esntial.

There are seven chapters in the ɔok covering the following subjects: ıe nonlinear-circuit problem; thermiıic vacuum tubes; elementary graphal constructions; reactive loads; balnced amplifiers, detection; and misellaneous graphical constructions.

In the discussion on thermionic vacum tubes, Mr. Preisman analyzes hild's Law, revealing departures om the theory. The chapter on eleıentary graphical constructions conıins data on parabolic characteristics nd graphical constructions for tetɔdes and pentodes.

The discussion of reactive loads is a ıost interesting one covering inducınce, capacity and nonlinear resisınce with a number of very effective xamples. Discussed in this chapter, ɔo, are parallel inductive, capacitive, nd resonant circuits.

In his analysis of balanced ampliers, Mr. Preisman presents a physial analysis of the push-pull system nd then a graphical application. Iodes of operation of class *A*, *AB*, nd *B* systems are developed. Data n correction for mid-branch impednce and winding resistance are also rovided in this chapter. The intersting properties of the square-law ıbe are discussed in a rather complete ıanner. Other data in this chapter overs driver tube constructions, deermination of grid current and driver esistance, plate circuit distortion roducts with a geometric interpretaion.

The concluding chapter covering niscellaneous graphical constructions discusses voltage and current feedack, plate isolation and effect of low grid coupling resistance.

Engineers will find this presentation a most useful one in solving many vacuum tube problems.—*O. R.*

TUBE INDEX

(*Continued from page 21*)

12B7/14A7	F43-12L
12B8-GT	TF13-12K
12C8	DDF12-12M
12H6	DD22-12M
12J5	T25-12M
12J5-GT	T25-12K
12K8	KTH11-12M
12L8-GT	PP13-12K
12SA7	KS25-12MS
12SF7	DF11-12MS
12SG7	F16-12MS
12SH7	F41-12MS
12SJ7	F26-12MS
12SK7	F33-12MS
12SQ7	DDT12-12MS
12SR7	DDT15-12MS
12Z3	R13-12U
15	F25-2U
19	AA14-1fU
22	Q22-3fU
24A	Q24-2U
25A6	P49-25M
25A7-GT/G	DP13-25K
25AC5-GT/G	A18-25K
25B5	tA13-25U
25B6-G	P51-25G
25B8-GT	TF15-25K
25C6-G	B21-25G
25L6	B25-25M
25L6-GT/G	B25-25K
25N6-G	tA13-25U
25Z5	RR22-25U
25Z6	RR22-25M
27	T15-2U
28D7	BB11-28L
28Z5	R44-28L
30	T13-1fU
31	A19-1fU
32	Q26-1fU
32L7-GT	RB11-32K
33	P29-1fU
34	F15-1fU
35	Q13-2U
35A5	B23-35L
35L6-GT	B25-35K
35Z3-LT	R17-35L
35Z5-GT/G	R19-35HK
36	Q28-6U
37	T17-6U
38	P43-6U
39/44	F53-6U
40	T19-5fU
41	P37-6U
42	P31-6U
43	P49-25U
45	A17-2fU
45Z3	R31-45P
45Z5-GT	R19-45HG
46	A12-2fU
47	P33-2fU
49	A14-2fU
50	A13-7fU
50L6-GT	B25-50K
50Y6-GT/G	RR22-50K
50Z7-G	RR24-50G
53	AA16-2U
56	T21-2U
57	F22-2U
58	F19-2U
59	P33-2U
70L7-GT	RB13-70K
71A	A11-5U
75	DDT12-6U
76	T21-6U
77	F22-6U
78	F31-6U
79	AA20-6U
80	R22-5fU
81	R15-7fU
82	mR22-2fU
83	mR24-5fU
84/6Z4	R64-6U
85	DDT13-6U
89	P45-6U
117L7/M7-GT	RB15-117K
117N7-GT	RB17-117K
117P7-GT	RB15-117K1
117Z6-GT/G	RR26-117K
954	uF63-6A
955	uT35-6A
956	uF55-6A
1201	uT35-6L
1203	uD19-6L
1204	vF63-6L
1231	vF27-6L
1232	vF-29-6L
1284	vP14-12L
1291	vTT11-3fL
1293	vT37-1fL
1294	uD19-1L
1299	vB13-3FL
1612	kS11-6M
1620	yF22-6M

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NOMOGRAM DESIGN

(*Continued from page* 30)

, and E scales of the N diagram are sed; A, C, and E are to be used gether and likewise for B, D, and . A and B are squared scales.

Suppose we wish to find $1.5\ (7.6^2 + 5^2)$: We first locate 7.6 on the R xis and 6.5 on the X axis of the Z agram. The coordinate of these two umbers lies on the quadrant of one a family of circles whose common enter is at the origin. The intersection f this circle with the X axis is the nswer, which is 10.0 in this case. hould the coordinate lie on the quadant of a circle not shown on the iagram, the answer could easily be ound by interpolation. Now let us ansfer 10.0 to the A scale and locate .5 on the E scale of the N diagram. he intersection of the line connecting ese two points with the C scale is e solution (see broken lines on the iagrams).

Having, in the preceding paragraph, hown the working principle of the iagrams, we are now in position to alculate the equivalent impedance of network. Let us therefore consider igure 2, and determine the equivalent mpedance of branches (a) and (b) irst, using equation *5* as reference.

$$Z_{ab} = \frac{R_b(R_a^2 + X_a^2) + R_a(R_b^2 + X_b^2)}{(R_a + R_b)^2 + (X_a + X_b)^2} + j\frac{X_b(R_a^2+X_a^2) + X_a(R_b^2 + X_b^2)}{(R_a + R_b)^2 + (X_a + X_b)^2}$$

Substituting

$$Z_{ab} = \frac{4.6(6.4^2+4.8^2)+6.4(4.6^2+3.0^2)}{(4.6+6.4)^2+(4.8+3.0)^2} + j\frac{3.0(6.4^2+4.8^2)+4.8(4.6^2+3.0^2)}{(4.6+6.4)^2+(4.8+3.0)^2}$$

(*Continued on page* 78)

NEW TUBE INDEX

(*Continued from page* 76)

1629	IT22-12G
1631	B17-12M
1632	B25-12M
1635	AA15-6K
1642	TT21-6MU
1644	PP15-12K
9001	uF63-6P
9002	uT35-6P
9003	uF53-6P
9004	uD13-6A
9005	uD15-6A
9006	uD17-6P

(*Continued on page* 78)

NOMOGRAM DESIGN

(Continued on page 77)

Using the Z diagram we get

$$\frac{4.6(8.0)^2 + 6.4(5.5)^2}{(13.5)^2} + j\,\frac{3.0(8.0)^2 + 4.8(5.5}{(13.5)^2}$$

Transferring to the N diagram we g

$$\frac{297 + 194}{(13.5)^2} + j\,\frac{192 + 144}{(13.5)^2}$$

$$\text{or}\quad \frac{491}{(13.5)^2} + j\,\frac{336}{(13.5)}$$

This step is accomplished by laying off the square on the A scale and the multiplier on the E scale. The resultant is found on the C scale.

$$\frac{491}{(13.5)^2} = 2.65 \qquad \frac{336}{(13.5)^2} = 1.8$$

$$\text{or}\quad Z_{a,b} = 2.65 + j\,1.8$$

This step is accomplished by laying off the square on the A scale and the whole number on the C scale. The resultant is found on the A scale.

Completing the Solution

To complete the solution of this example, it is merely necessary to combine this resultant with the third part of the problem, using equation *6*. The detailed solution of this part is not shown, but the final result is.

$$Z_{a,b,c} = 3.0 + j\,0.96$$

The Z diagram also permits graphical solution of the magnitude of impedances whose equations are in the form of $Z = (R^2 + X^2)^{1/2}$ for any value of R and X, provided a suitable factor such as 0.1, 0.5, 10.0 or 100 is chosen to multiply the constants so that the problem can be applied to the range for which the diagram is intended. The result, of course, will have to be multiplied by the reciprocal of this original factor. This procedure likewise applies to parallel circuits, if the given constants are greater than the R or X scale.

To illustrate, let us take the following problem. To determine $Z = (55^2 + 104^2)^{1/2}$, use a factor, say 0.1 and locate 5.5 and 10.4 on the R and X axes respectively. The coordinate of 5.5 and 10.4 falls on the quadrant of a circle cutting the X axis at 11.77. The final solution is 10 × 11.77 or 117.7.

•

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•

QUARTZ

(*Continued from page* 52)

·ystal in addition to allowing suffi-ent quartz to be removed for the imination of edge chips and cracks.

The crystal may be squared as a ›ugh *cut* or later on in the process, :rhaps within the lapping procedure.

Rough cuts are generally .040″ to 50″ thick. The final thickness of the ›mpleted oscillator plate may be any-here from .008″ to .020″ thick. The :moval of quartz from the surface of e *rough cut* is accomplished by a lap-ng process. The most desirable type : lapping machine is a planetary type p. In the planetary lap device, each of ie crystals are placed within the pen-ıgonal holes of gear-toothed discs ·ing on the serrated lapping plate. 'he outer ring gear rotates at approx-nately ⅓ the speed of the inner gear. 'his causes the crystal carrier to exe-ıte a rotary motion about its own enter in addition to rotating about ıe axis of the two driving gears. Jsing the proper gear ratios the lap ıay be so designed that each portion f the lap plate will be covered equally y crystals moving over its surface. 'his keeps the lap plates flat.

Lapping is accomplished by load-ıg each of the geared crystal carriers vith 6 crystals. They are then placed n a cast iron serrated plate, similar o the bottom plate, on top of the rystals. The top plate is held fixed s is the bottom plate and the crystals ıre dragged between the two plates vhile an abrasive and lubricant mix-ure is applied through feed holes in he top plate.

Lapping is generally done by using ;everal grades of abrasive, starting vith the coarsest and going to the inest. The grades of abrasive in com-non use are 320 and 600 silicon car-

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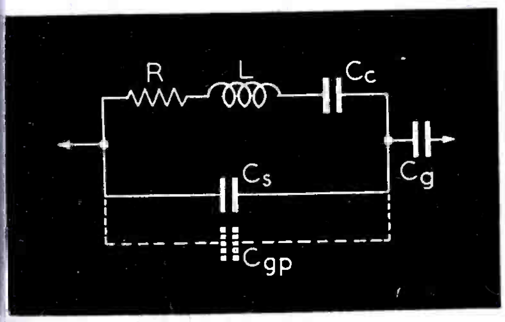

Figure 15

Equivalent circuit of a crystal oscillator plate between two air-gap type electrodes. *R*, *L* and C_c are the inherent tank circuit constants of the oscillator plate. C_s represents the equivalent shunt capacity of the crystal itself. C_g represents the series capacity introduced by the presence of the electrodes on each side of the crystal. C_{gp} represents the shunt capacity formed by the metal electrodes.

QUARTZ

(*Continued from page* 79)

bide and 303 or 303½ aluminum oxide in the order named. Lapping in the finer stages must remove enough thickness of quartz so that the abrasive scratches caused by the coarser abrasive will be completely removed.

Another lapping procedure which has been found to work successfully utilized the *Q-Lap*, a diamond wheel type of lap, which abrades one side of the crystal at a time. Crystals coming from the *Q-lap* are then lapped in the 600 grit abrasive and then in 303 or 303½ as formerly described.

Meeting a schedule of crystal frequencies require that the end product of the lapping procedure results in flat crystals with parallel faces and close enough to the final frequency so that they may be individually finished by hand. The hand finisher may receive crystals from the lapping department at frequencies from 5 to 50 kilocycles below the desired frequency, depending upon the technique and the apparatus used to finish the crystal. This requires that fairly accurate measuring equipment be available so that this tolerance of frequencies may be maintained and checked. Several types of frequency measuring apparatus have been used. A calibrated receiver with a bandspread dial is perhaps the simplest. Spot frequencies are located with pre-calibrated standard frequency crystals. A direct reading frequency meter may be constructed with a stable electron-coupled oscillator calibrated directly in frequency, providing a signal beating against the test crystal in a test oscillator. Frequency is measured by tuning the eco to zero beat with the test crystal signal. Another type of frequency measuring device utilizes two crystal oscillators; one a standard and the other the test oscillator. The beat between the two is measured with a direct reading frequency meter counter circuit. Perhaps the most elegant device is a cathode-ray oscillograph with proper sweep frequency circuits which will spread the desired spectrum of frequencies over the screen.

The tolerance for crystal oscillator plates delivered to the hand finishing room is generally of the order of —5 to —50 kilocycles from final frequency. It is the hand finishers' job to remove additional matter from the surface of the oscillator plate so that its frequency is raised the proper amount. The removal of quartz from the surface of the oscillator plate is normally done by abrasion.

Tools used by the finisher include a

flat glass plate about 8" in diameter, very loose abrasive mix of 303½ emery or finer, mild soap solution or *soapless soap* solution substitute, tooth brush, cup of ammonium biflouride, pair of plastic print developing tongs commonly used in the photographic dark room and a frequency and activity measuring device.

In finishing, the following procedure is used: The crystal which has arrived from the channel checkers is first scrubbed with soap and water and dried with compressed air after which its frequency is checked. The finisher then proceeds to lap the crystal on the glass plate using a light abrasive mixture, applying pressure to the crystal very lightly making a spiral or *figure eight* motion. If large pressures are applied locally, hollows may be ground on the surface of the crystal next to the lapping plate. This is undesirable and may be eliminated by the use of a small square or round flat glass backing for the crystal. Then if pressure is applied to the glass backing, that pressure is more likely to be evenly distributed over the surface of the crystal so that uniform lapping will occur. From experience, finishers judge their lapping times. Periodic frequency checks are made during the hand finishing process until sufficient quartz has been removed from the surface so that the crystal oscillates at the proper frequency.

A good cleansing agent for the crystal surfaces is ammonium bifluoride. Since ammonium biflouride dissolves quartz, the frequency of the quartz oscillator plate is kept several kilocycles lower than final frequency before being dipped into the ammonium biflouride.

Often the activity of the quartz crystal oscillator plate will decrease as the hand finishing operation proceeds. This decrease may be caused by various factors. If the oscillator plate is thrown out of flat or if the major surfaces become non-parallel, the activity of the oscillator plates is likely to decrease. If interfering modes of vibrations occur at the final frequency, the energy of vibration may be divided amongst them or the net vibration may drop to zero. The *BT*-oscillator plate has few interfering coupled modes of vibration. The effect of coupled flexure modes of vibration may be minimized by the adjustment of the length of the X-axis. The effect of coupled face shear modes may be minimized by altering the ratio of edge dimensions.

The edges are ground or lapped on a glass plate using a similar wet abrasive mixture as for final hand lapping,

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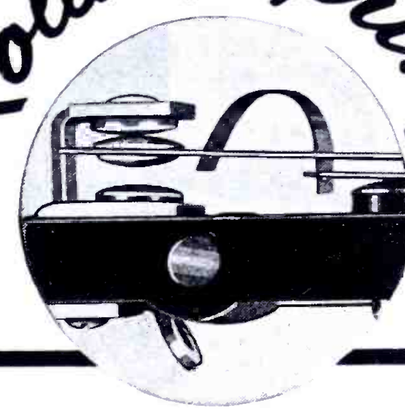

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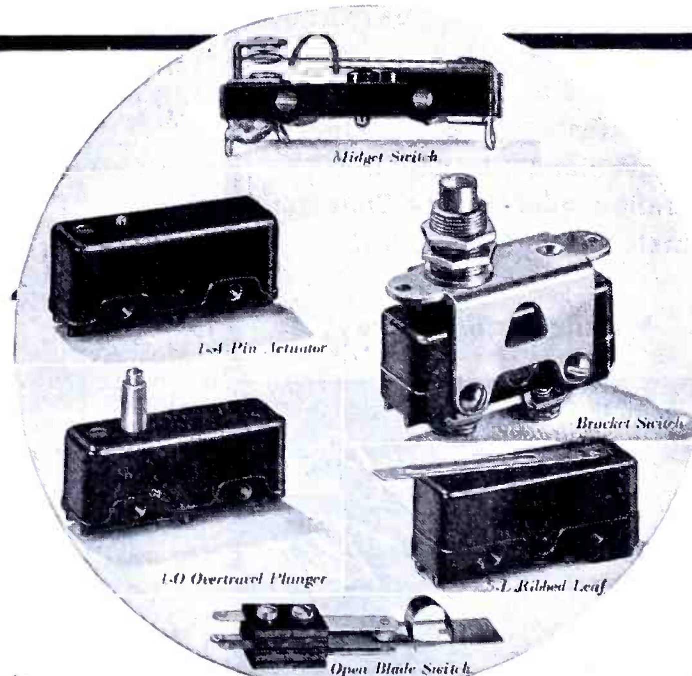

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VWOA NEWS

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pany got the bill. No one is quite sure who won, but after this little incident Steff looked up *W* in McElroy's code chart and sent it correctly thereafter. . . . Bill Fitzpatrick in his later years ran a radio gift service, and many are the curious items forwarded by radio request. He once sent a dog by radio. He got the order from a ship, per George Ahrens, operator. The dog was bought, sent to the express people with a container for food and another for water, and the necessary legal papers. All in a day's work!

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QUARTZ

(*Continued from page* 81)

or on a fine dry abrasive paper. Some manufacturers require that all crystals be beveled on all edges. Perhaps the greatest difficulties encountered by finishers are in this problem of variation of activity during the hand finishing process.

It is possible to calculate and to determine empirically, optimum dimensions for the finished quartz oscillator plates at specified frequencies. The considerations are manifold owing to the fact that activity of oscillation must be maintained above certain acceptable minima throughout a wide temperature variation. If the crystal is properly dimensioned, it may have little activity during the finishing process but its activity at final frequency will be acceptable.

The optical flat permits checking of the contour of surface of the oscillator plate. Differences in level between various points on a crystal surface may be measured within millionths of an inch with ease. In Figure 12 we see various conditions encountered in production as observed on the optical flat.

When a Johannsen block is lapped to final dimensions, these dimensions will remain, within the specified tolerance, for many, many years, as long as the dimensions are measured at the same temperature. Steel has a uniform temperature coefficient of expansion in various directions, is mechanically stable, and is strictly speaking, amorphous. Quartz, a crystalline substance, has different temperature coefficients of expansion in different directions. Thus, temperature changes of crystalline quartz are likely to set up strains of various magnitudes within the crystal. If the abraded surface of a crystal oscillator plate were greatly magnified, the scratches would appear as cliffs and valleys of irregu-

EMERGENCY RECEIVER DESIGN

(*Continued from page* 44)

regeneration hiss down. The heavy tone control, which works on both the speaker and the 'phones, also contributes considerably to such operation.

Figure 2 illustrates a method of increasing the gain of the audio amplifier by approximately 20 db, should this be desired. It will be noted that while the receiver normally uses a 6J5 as an input audio stage by the addition of two 1-watt resistors and a bypass condenser, a 6N7 may be substituted and an additional stage is thus realized. This in no way affects the operation of the unit when a 6J5 tube is being used. In actual practice, this additional stage has been found necessary only when operation is undertaken in close quarters with other forms of noisy communications equipment, thus necessitating a high receiver output. Any tendency toward self-oscillation by the use of the three-stage amplifier may be stopped by the use of a 250,000-ohm resistor between the first and second plates of the 6N7.

The feedback thus realized stabilizes the high gain circuit without in any way altering the results realized when operation is desired using a 6J5.

Figure 6 illustrates the plug connections employed when it is desired to operate the unit from a battery power supply. Under such conditions, a 6L5 is substituted for the 6J5/6N7 and a 6G6G is used in place of the 6F6G. This lowers the filament current from 1,000 ma to 300 ma. The filament switch disconnects the power transformer winding during periods of battery operation, and the locating of the pilot-light bulb on the transformer side of the switch eliminates that extra filament drain. The use of the plug type power changeover also provides a means for supplying both filament and plate potential for a low power transmitter, while the standby switch with its contacts brought out to terminals at the rear of the chassis, provides a means for controlling the same (see *C*). The power supply is conventional, using choke input with high capacity electrolytics for filter and a .5-mfd input capacity to eliminate any tendency toward tuneable hum. The VR-150-30 stabilizes only the voltage used by the r-f unit employed. The actual power changeover assembly consists of a 7-prong tube socket with Amphenol plugs.

Up to this point no mention has been made of the r-f assembly, inasmuch as the only r-f component actually designed into this basic unit is the National dial. This dial provides

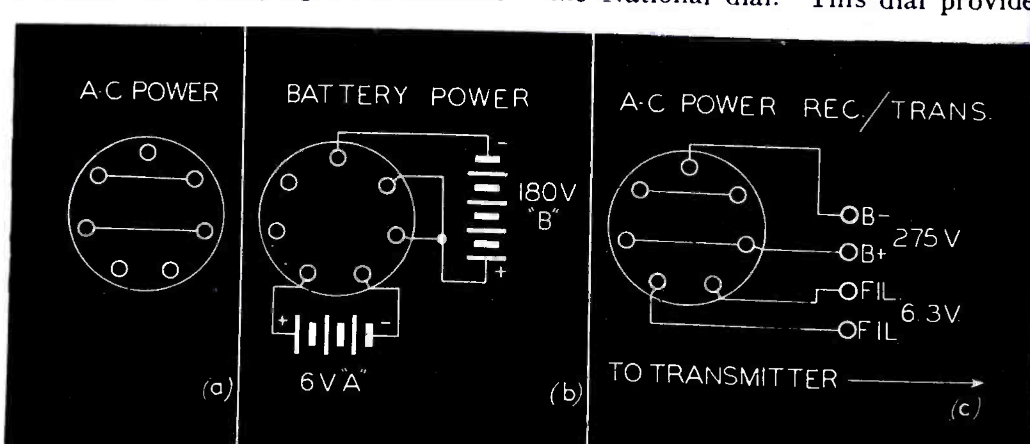

Figure 6
Plug connections for battery or a-c operation.

high ratio bandspread tuning meium, and its general design contribtes much to the elimination of hand apacity and other r-f circuit diffiulties encountered at these frequenies. Available at the r-f input and ower terminal strip are: (1) 6.3-volt, -amp filament supply; (2) 150 volts f *B* for r-f amplifier or superhet scillator use; and (3) 0-50 volts used or super-regenerative detectors and ontrolled through the regeneration ontrol potentiometer.

The selection of the r-f circuit is a roblem that can best be solved to uit the particular case under study. The basic principles that must be contantly kept in mind can be summarzed as follows:

(1) The acceptance bandwidth must be at least 30-kc wide, since 90% of all WERS transmission is accomplished with modulated oscillators, which produce considerable frequency modulation in addition to the desired amplitude modulation.

(2) It is practically impossible to realize any r-f amplification at the u-h-f frequencies available for WERS use with the tubes now provided. Even the 954 acorn must be given special care to produce a gain or 2 or 3.

(3) Receiver radiation represents one of the greatest problems encountered in WERS operations. With the extremely low power used for transmission (25 watts being the legal limit) and with two or more receivers running simultaneously at control centers, the radiation problem must be given important design consideration.

With these facts in mind, it becomes immediately apparent that the super-regenerative detector offers a satisfactory solution to the problem, provided only that care be taken to minimize, as far as practical, the objectionable feature of detector radiation. Despite many claims to the contrary, it is the opinion of the author that the only method of accomplishing this, short of the use of a stage of r-f amplification, is to operate the detector at the lowest plate potential practical and reduce antenna coupling to the absolute minimum consistent with acceptable receiver sensitivity.

The selection of the super-regenerative detector tube usually is a case of what is available rather than what would be ideal. Generally speaking, the 954 acorn is far superior to anything else now on the civilian market. This is followed in turn by the 9002, HY-615, 7A4, 6J5GT and the 6G5GT. The decline in the operating potential for the tubes listed is reasonably linear with the 6C5GT representing the minimum acceptable limit. The r-f unit shown in Figure 5 super-regenerates with 15 volts on the plate at a current on .15 ma, while the 6C5GT requires approximately 48 volts at 2 ma, which represents a considerable stepup in input power and consequently detector radiation. From a practical standpoint, it is possible to copy a modulated signal accurately with the 954 acorn detector that cannot be detected with the 7A4 detector. This same qualification holds true when comparing the HY-615 and the 6C5GT.

The use of a broad tuning superhetrodyne r-f unit has much to offer from the standpoint of operating stability and low radiation, but the lack of suitable tubes to provide any reasonable degree of r-f amplification is still the main limiting factor. Actually, the author has been unable to produce an r-f amplifier using any of the so-called commercial receiving tubes, such as the 1852, 7H7, 7G7, 6SK7, etc., that was capable of contributing anything but a loss at these frequencies.

QUARTZ

(*Continued from page* 91)

lar shape and contour, some of the cliffs perhaps being undercut. Strains set up in these microscopic cliffs of quartz are likely to result in chipping and progressive fracturing of these cliffs. This would result in an apparent deposition of quartz dust on the surface of the crystal. This generally causes an increase in frequency due to the decrease in mass of the basic crystal oscillator plate. The average thickness also appears lowered. Activity may be lowered due to increased surface friction and physical loading.

The phenomenon of *ageing* is perhaps the most disturbing one of the crystal industry and much work is being done at present in an effort to solve this particular problem. This seems to be an inherent sequel because of the very nature of the abrasion process.

Causes of ageing, other than the one just described, may be improper cleaning of the surface of the oscillator plate, poorly tempered and normalized electrodes, poor spring material, foreign matter sealed with the crystal unit within the holder, spreading of chips and progressive fractures of microscopic cracks.

A finishing procedure which eliminates the hand lapping with wet abrasive and substitutes an etching solution, seems to have excellent possibilities in connection with the inhibition of ageing.

Experiments have shown that crystals which have been etched from 10 kc to 100 kc have remarkable frequency stability after being submitted to rapid heat cycling runs. Apparently the irregular scratches caused by the abrasive particles in the final hand lapping operation and machine lapping operation have been modified so that the tendency for chipping of the microscopic cliffs is practically non-existent. The electron microscope could be applied towards the study and solution of the problem of crystal ageing. Further investigation and development of this technique seems warranted.

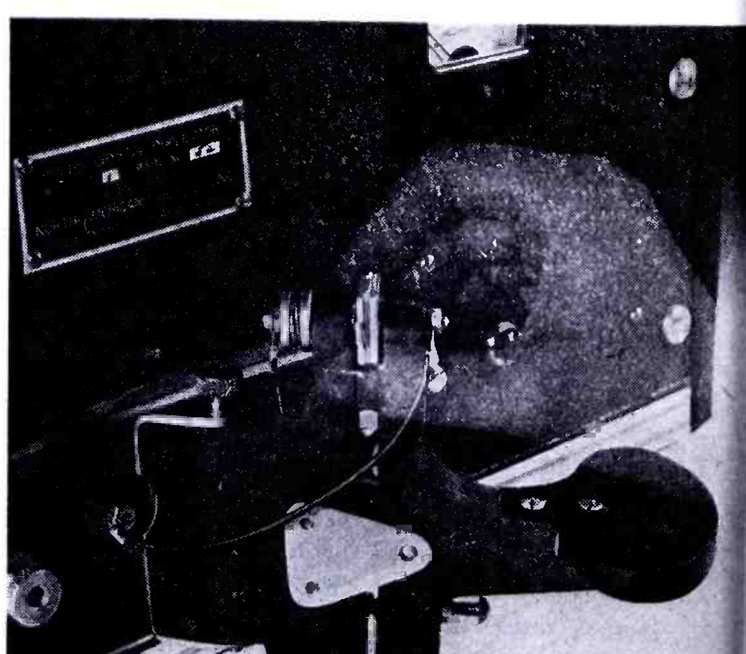

Figure 16
Phantom view of a crystal duplicator or channel checker illustrating the manner in which the crystal oscillator plate is placed between the test electrodes. The meter shown indicates the difference in frequency between a standard frequency crystal and the test crystal just inserted in the jig.

THE WHEATSTONE BRIDGE

(*Continued from page* 40)

lviding equation *18* by *19* a very ıeful form is obtained which relates e resistances and temperature ianges, or

$$= \frac{1 + \alpha t_1}{1 + \alpha t_2} \qquad (20)$$

For reference purposes, the trans-rmation between degrees F. and grees C. is:

$$C = \frac{5}{9}(F - 32)$$

ıd

$$F = \frac{9}{5}C + 32$$

A useful alternative form of equa-ɔn *20* is found by dividing numerator ıd denominator by α, getting

$$= \frac{\sigma + t_1}{\sigma + t_2} \qquad (21)$$

here σ is the reciprocal of the coefficient of resistance. For pure copper, α and σ have the values of 0.00427 and 234.5 respectively. Practically all text books on electricity and radio as well as most of the radio and electrical handbooks have tables of the resistance, resistivity, and the temperature coefficients.

Use of Equations 16 to 21 in Fault Location

Equations *16* to *21* inclusive, are particularly useful in fault location work when the amount of information about a given pair of wires is not available. Note that equation *16* may be rewritten as

$$R = rl \qquad (22)$$

where $r = \rho/d^2$ and is the resistance per unit length for the given conductor: hence, if the resistance per unit length is known, the total is found by *22*. Again, if the factor α is not known it may readily be determined by making two loop measurements upon a pair at different times of the day when the temperatures are several degrees apart and substitute values in equation *20*, thus obtaining the coefficient of resistivity. From equation *22* the resistance per loop mile may be found by making a loop measurement and dividing by its length. Ordinarily, for those engaged in everyday operation and maintenance where records are adequate, the main concern is accuracy and technique of methods.

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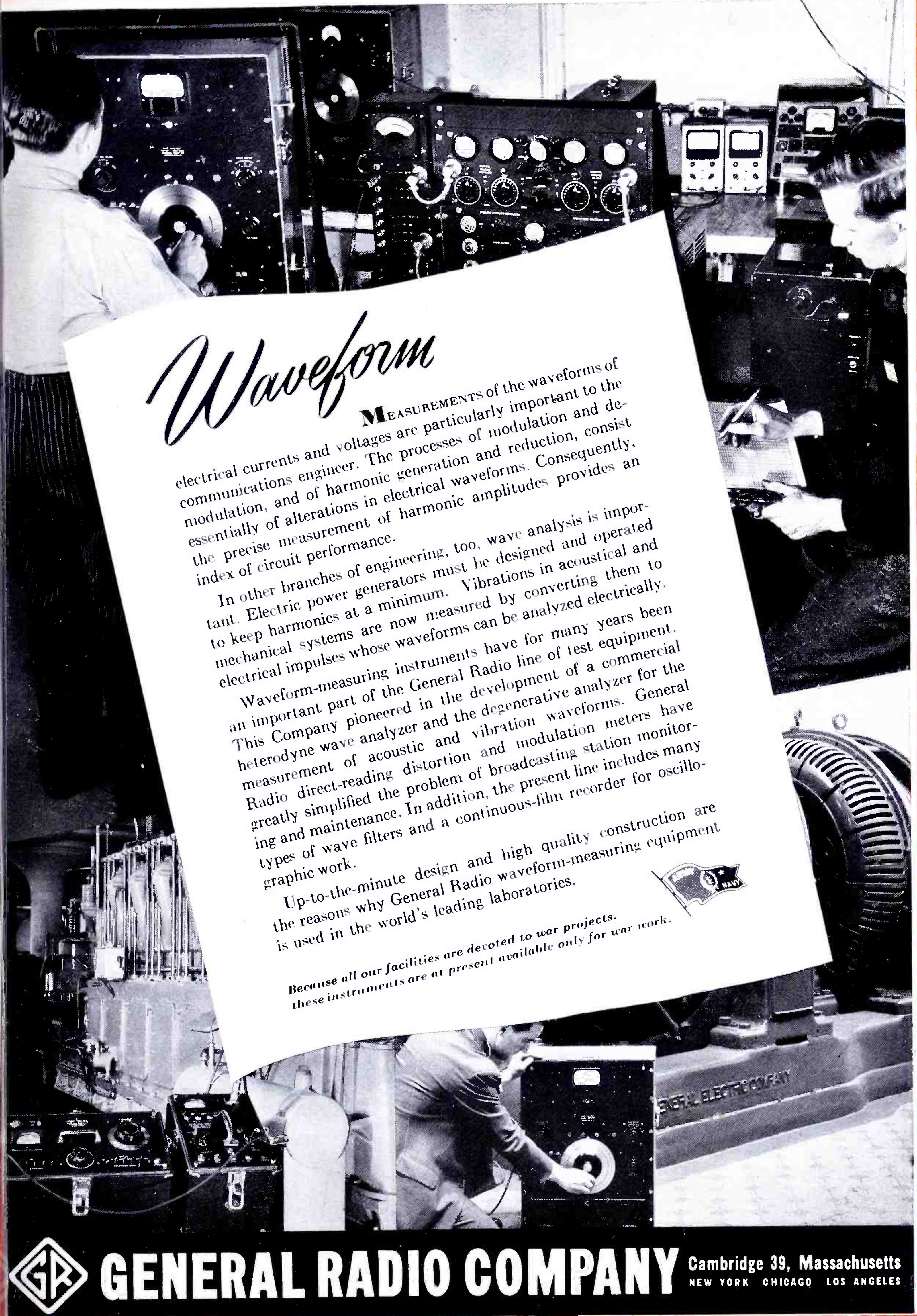
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