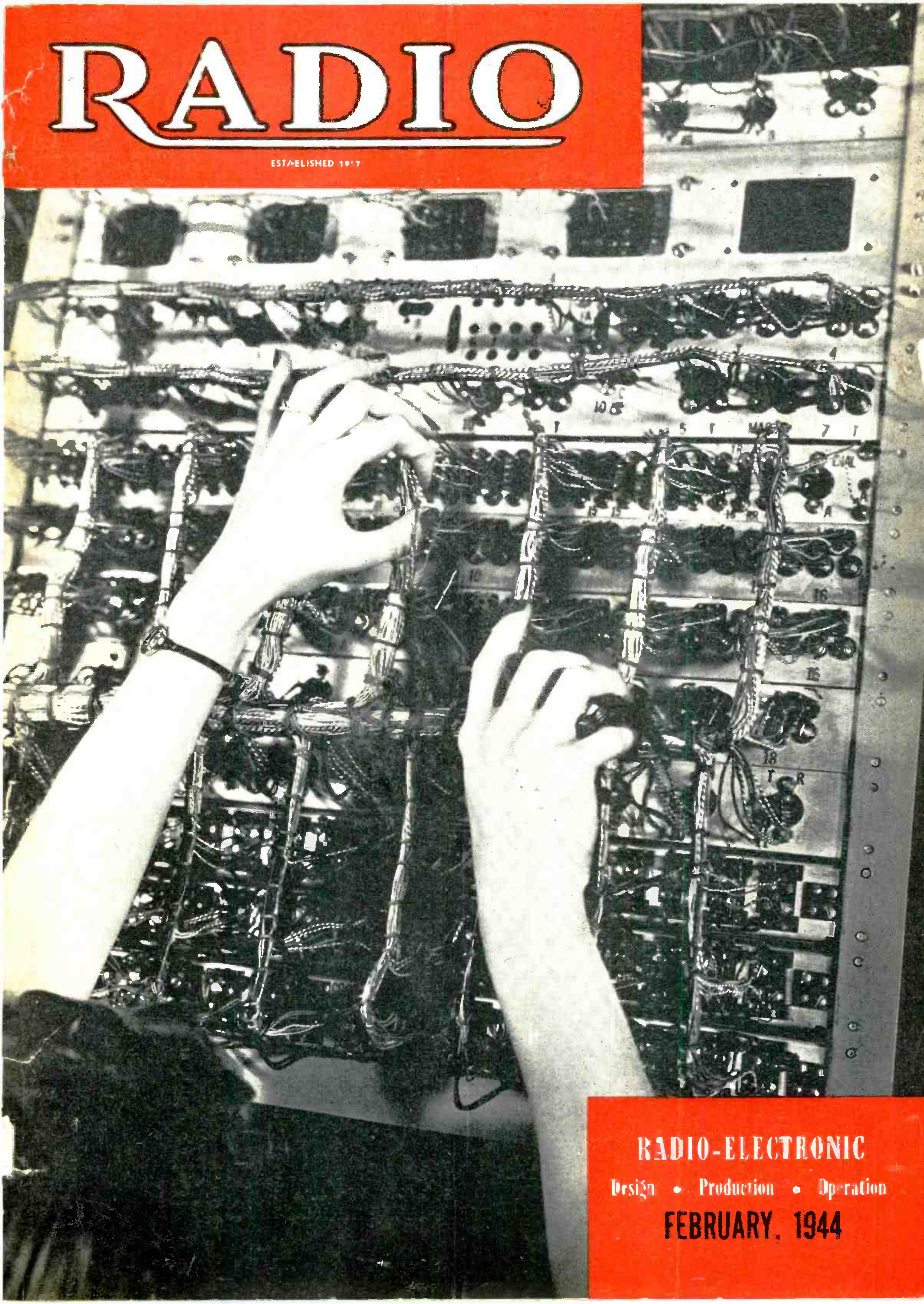
RADIO

ESTABLISHED 1917



RADIO-ELECTRONIC

Design • Production • Operation

FEBRUARY, 1944

the FUTURE is being made NOW!

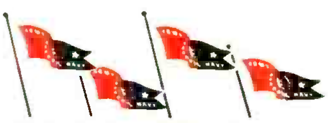
Long before America declared war, RAYTHEON electronic tubes were serving with distinction in our Army and Navy. Since Pearl Harbor, production has increased 1,000% or more—but the same "Plus-Extra" performance qualities are built into every tube made by RAYTHEON.

Taking over territory from the Axis does not end the need for communications equipment—and RAYTHEON will be on the job with the garrison forces as well as in the front lines, because wherever extra dependability is needed RAYTHEON usually gets the call.

Even before all our soldiers and sailors are home again, RAYTHEON—through the nationwide network of jobbers, dealers and servicemen—will be supplying civilian needs for quality electronic tubes for the many applications in the coming era of electronics.

Raytheon Production Corporation • **Newton, Massachusetts; Los Angeles, New York, Chicago, Atlanta**

DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES FOR THE NEW ERA OF ELECTRONICS

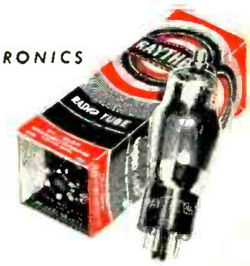


All Four Raytheon Divisions Have Been Awarded Army-Navy "E" Plus Stars

RAYTHEON

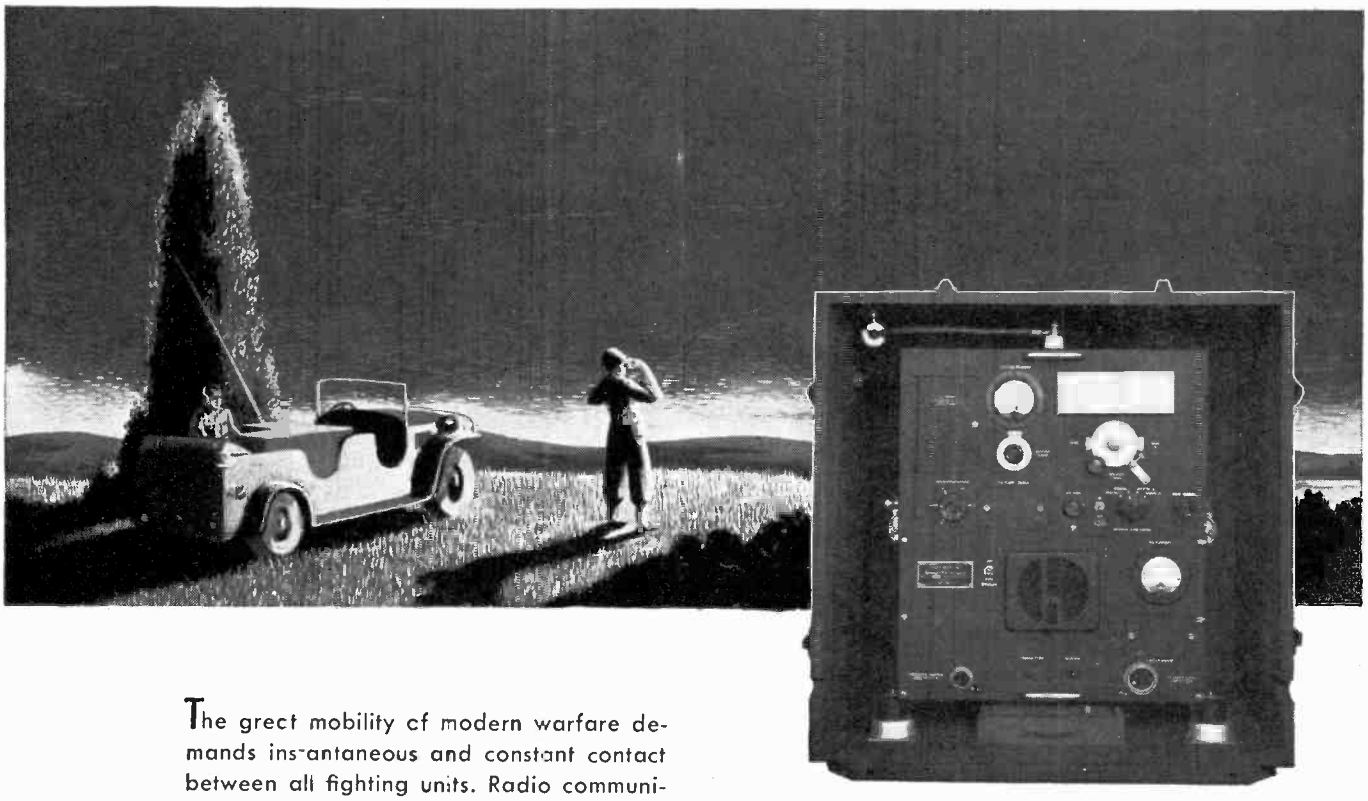
High Fidelity

RADIO & ELECTRONIC TUBES



Radiotelephones

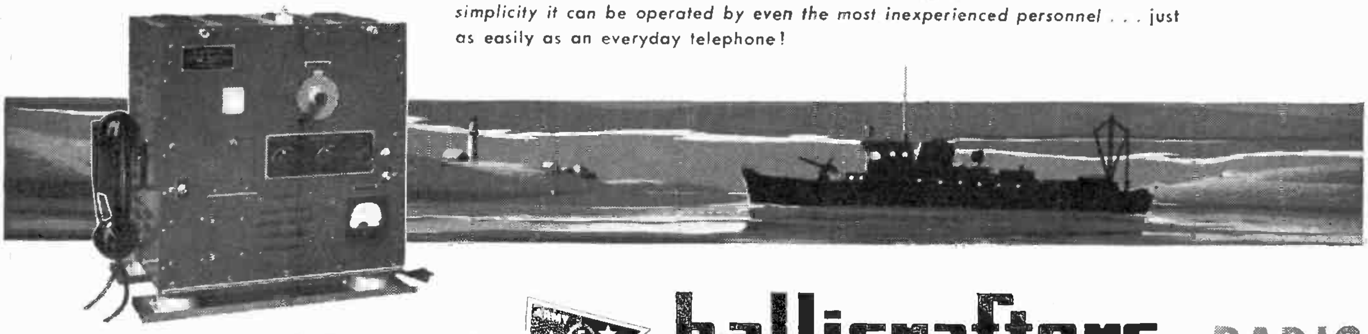
WEAPONS OF WAR...
INSTRUMENTS FOR PEACE!



The great mobility of modern warfare demands instantaneous and constant contact between all fighting units. Radio communications are indispensable weapons in any military operation. . . . Hallicrafters built SCR-543 (illustrated) is a low powered transmitting and receiving unit. When mounted in a scout car it dashes virtually into the jaws of the enemy to direct artillery fire and carry out similar communications duties. Designed and built to be operated by combat soldiers as easily as by highly trained radio personnel.

Peacetime will find the use of radiotelephones expanding to meet the needs of transportation—MARINE, AVIATION, RAILWAY and AUTOMOTIVE . . . assuring greater safety, efficiency and pleasure.

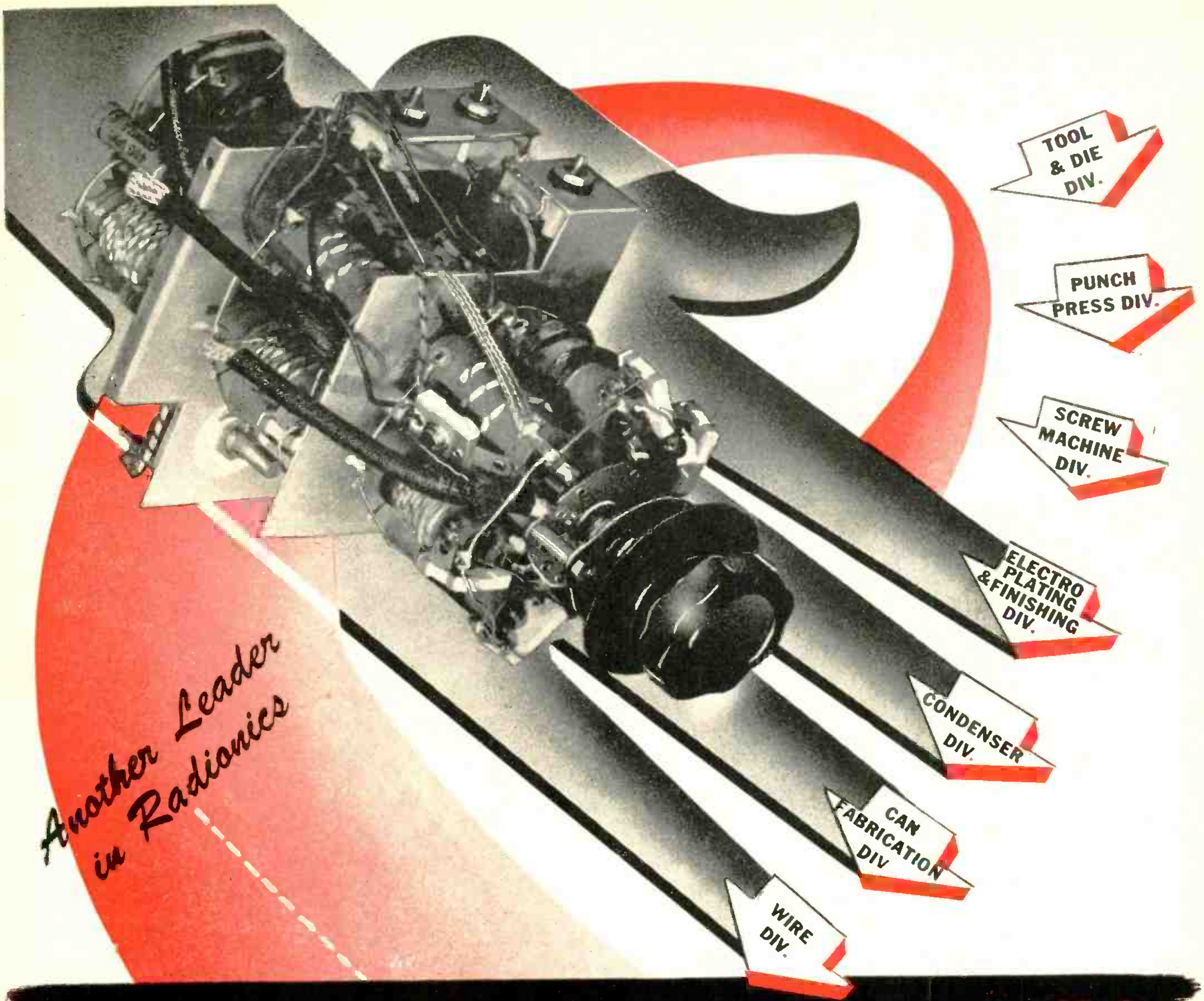
MARINE-TYPE RADIOTELEPHONE SCR-281 — another Hallicrafters built unit has gone to war! This radiotelephone installed in coastal and harbor vessels is performing vital ship-to-ship and ship-to-shore war duties. Because of its extreme simplicity it can be operated by even the most inexperienced personnel . . . just as easily as an everyday telephone!



BUY MORE BONDS!

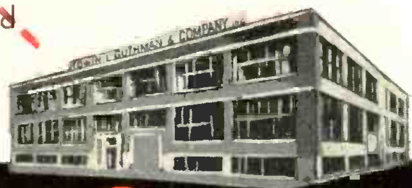
hallicrafters RADIO

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.



GUTHMAN *Super-Improved* COILS

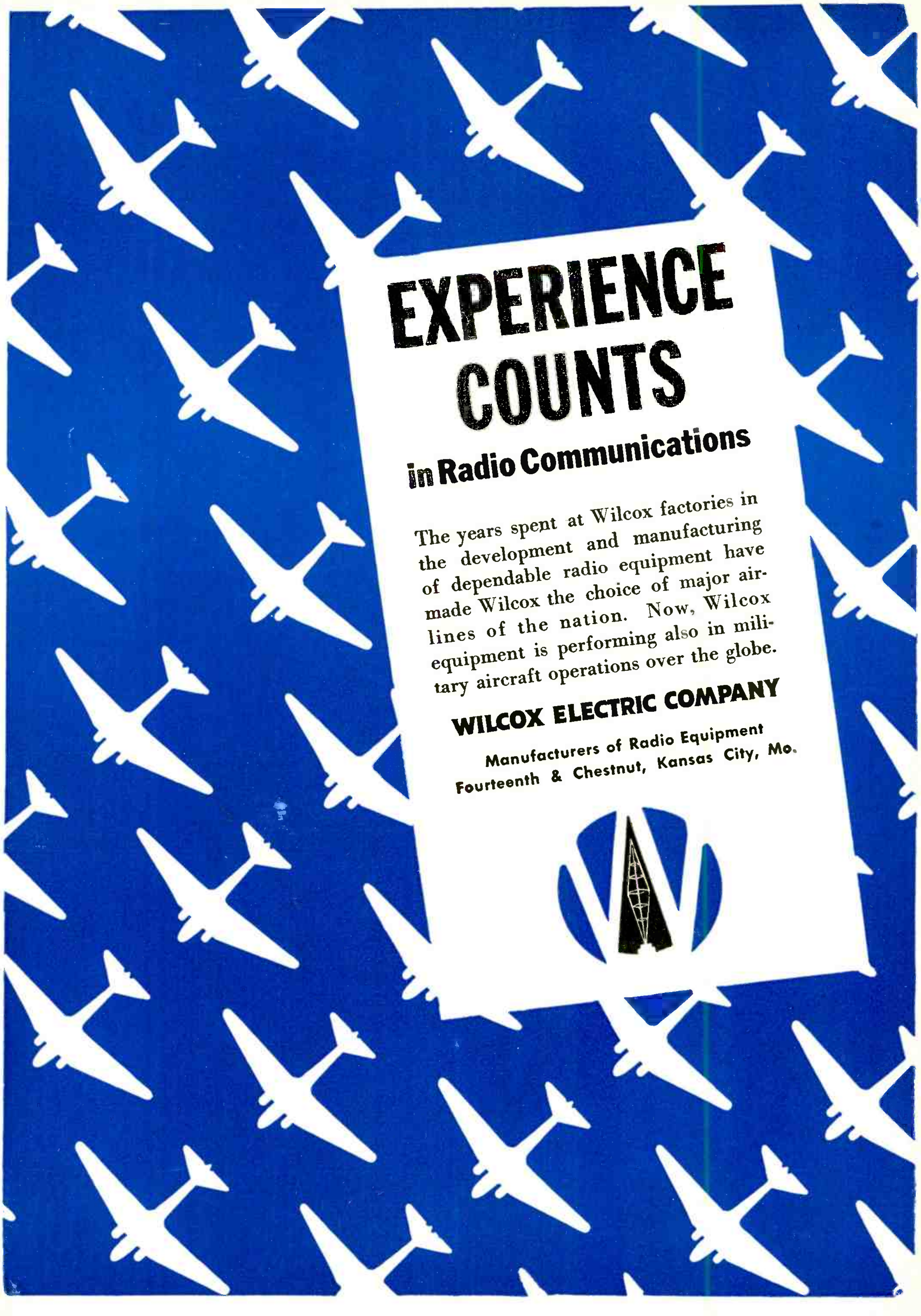
For many years before the war, Edwin I. Guthman & Co. was especially known for manufacturing better coils. With war came greater demands upon our facilities . . . U. S. Army and Navy orders for many diversified radio parts . . . expansion of our plant . . . the addition of many new manufacturing departments. All manufacturing and assembling of these many units was done in our own completely equipped plant. Thus, our engineers and skilled personnel gained a broader experience in modern radionics. Now, we are concentrating all this technical experience in the engineering and production of Guthman Super-Improved Coils . . . promised leaders in peacetime radionics.



EDWIN I. GUTHMAN & CO. INC.

15 SOUTH THROOP STREET · CHICAGO

PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT


EXPERIENCE COUNTS
in Radio Communications
The years spent at Wilcox factories in the development and manufacturing of dependable radio equipment have made Wilcox the choice of major airlines of the nation. Now, Wilcox equipment is performing also in military aircraft operations over the globe.
WILCOX ELECTRIC COMPANY
Manufacturers of Radio Equipment
Fourteenth & Chestnut, Kansas City, Mo.

RADIO

Published by RADIO MAGAZINES, INC.

FEBRUARY 1944 — Vol. 28, No. 2

CONTENTS

COVER

Deft fingers are required to make the neatly cabled wires and connections necessary in all radio and electronic apparatus. Shown here are leads being connected to terminals on a Western Electric PBX 2600 switchboard at the Kearny plant.

ARTICLES

MISCELLANEOUS

RADIO (title registered U. S. Pat. Off.) is published monthly at 34 N. Crystal Street, East Stroudsburg, Pa., by Radio Magazines, Inc., Executive and Editorial Offices at 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States and Possessions, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U.S.A. All rights reserved, entire contents Copyright 1944 by Radio Magazines, Inc. Entered as Second Class Matter October 31, 1942, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

Transients

FREQUENCY MODULATION

★ There is no longer any question as to what the status of frequency modulation will be directly after the war. Recent straws in the wind are: 1) an extension of FM program services by NBC and CBS, 2) the announcement by RCA that the company will enter the field with both feet, 3) the more-than-fatherly interest in FM shown by Fly of the FCC, 4) the large number of applications on file for station permits and, 5) the irrefutable fact, now apparent to most engineers, that frequency modulation is playing a major role in the war and has, to a large extent, replaced amplitude-modulation systems; and that frequency-modulation practice, by the mere pressure of its role in the war, is bound to play an equally important role in peacetime.

It is also apparent that frequency modulation can readily enter the post-war period without upsetting radio's economic structure; first, because a great deal of communications equipment has become technically obsolescent and must be replaced in any event; and, second, because most household receivers will have become unserviceable due to wear and will also require replacement. A large part of the slate will therefore be wiped clean for any new progressive move the industry may care to make on V-day, and frequency modulation seems the most acceptable venture. If it is included at the outset as an additional service in the majority of household receivers, then the transition from amplitude - modulation to frequency - modulation broadcast services can be accomplished without any disruption of present systems and without inconvenience to the public.

At the same time, frequency modulation provides a definite sales appeal that the public will be quick to recognize, if the service is properly expanded. It is sufficiently "new" to capture public interest at a time when the average person will be looking for the fulfillment of the many promises made for a glittering post-war world.

LET 'EM EAT CAKE

★ Design engineers are often amazed at and blinded by their own accomplishments. That they should be amazed is proper, for it's good for the soul; to be blinded by an attainment of perfection or near perfection in engineering design is neither proper nor good for the sales department.

There was a time when engineers and experimenters, blundering through the woods of idealism, sought the technical perfection of a flat frequency response from something like 20 to 20,000 cycles. Having found the means of accomplishing this by fairly simple procedures in design, a reasonable facsimile of the response was incorporated in audio amplifiers, with the emphasis placed on the flatness of the curve. Henceforth, many engineers became flat-conscious and proceeded to lose sight of the fact that a flat response—to say nothing of a wide response—might not be at all desirable in a receiver or a phonograph from the listener's standpoint. It was like telling the listening public to eat cake when what the public wanted was bread.

This type of blindness is common to both design and research engineers, though the enthusiasm for perfection shown by the design engineer is usually tempered by the commercial department. Nevertheless, it is peculiar that both groups, dedicated as they are to seeking the truth, often lose sight of the end use of the product upon which they are working. A radio receiver, for instance, is definitely designed to be listened to, yet many engineers seem to place more faith in what we might term "technical response curves" than in "listener response reactions," when the former mean little, if anything, if they fail to please the ear.

The matter has considerable importance with regard to the design of frequency - modulation receivers because, on the whole, pre-war designs were not well accepted. A great many listeners found the response unpleasant, if not downright annoying; and we feel that this mistake should not be made again. If the full advantages of frequency-modulation broadcast reception are to be obtained, it is necessary that the response be adjustable to the listener's ear, irrespective of what murder may be committed in the audio band.

The engineer basks in the sound of frequencies from 10,000 to 15,000 cycles (whether he can hear them or not), but the average listener yells, "Let me out of here!" It's up to the engineer to find out why the listener reacts in such an unfavorable (and unfair) way, and do something about it, so that the listener may eat cake and actually love it.

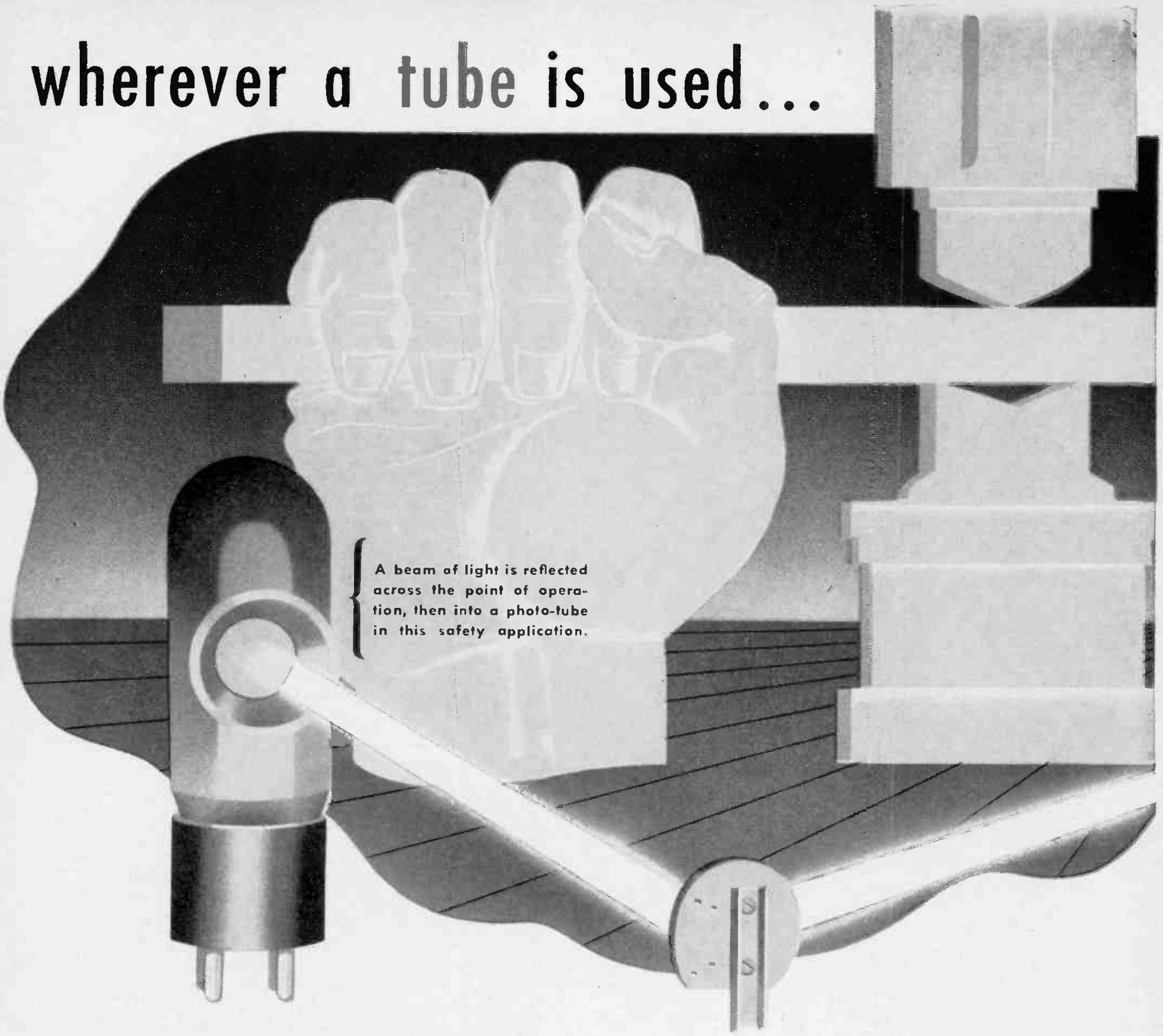
ELECTRONICS A SCIENCE

★ Under "Quotes" in this issue appears a very pertinent remark made by Dr. W. R. G. Baker of the General Electric Co. The essence of this remark is that electronics is not a product but a science, such as chemistry. As such, it is a highly flexible instrument of knowledge applicable to all approaches to industry, society and science itself.

Mr. Baker's statement is one of those self-evident truths that are often lost sight of. It seems almost too self-evident to be given second thought; but the research engineer who will retain this truth in mind will have broadened his view and extended his own horizons of productiveness.

M. L. Muhleman

wherever a tube is used...



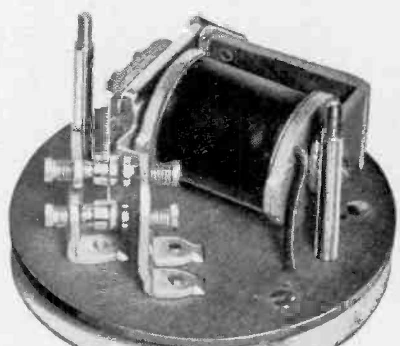
THERE'S A JOB FOR

Relays BY GUARDIAN*

Where makeshift mechanical devices rudely thrust your workers' hands and fingers away from punching and forming dies, the electron tube in combination with a relay offers definite advantages for safer power press operations.

Instantly responsive, dependable and simple—a beam of light, if broken or modulated, actuates the electron tube; the relay breaks the circuit and locks the controls in the "off" position until the full light beam is restored. Typical of relays which may be used in conjunction with such a photo-tube safety application, is the Series 5 D.C. Relay by Guardian. In hundreds of other ways—especially in your postwar developments—*wherever a tube is used there's usually a job for Relays by Guardian.*

* Not limited to tube applications but used wherever automatic control is desired for making, breaking, or changing the characteristics of electric circuits.



Series 5 D.C. Relay. Maximum switch capacity two normally open—two normally closed—or DPDT Contacts. Resistance range .01 up to 15,000 ohms. Send for bulletin 14.

GUARDIAN ELECTRIC

1605-R W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

TECHNICANA

WWV TRANSMISSIONS

★ Two changes (beginning Feb. 1, 1944) are announced in the standard frequency broadcast service of the National Bureau of Standards. One is the addition of a new radio frequency, 2500 kilocycles per second, at night. The other is omission of the pulse on the 59th second of every minute. The service is described here. It comprises the broadcasting of standard frequencies and standard time intervals from the Bureau's radio station WWV near Washington, D. C. The service is continuous at all times day and night, from 10-kilowatt radio transmitters. The services include: (1) standard radio frequencies, (2) standard time intervals accurately synchronized with basic time signals, (3) standard audio frequencies, (4) standard musical pitch, 440 cycles per second, corresponding to A above middle C.

The standard frequency broadcast service makes widely available the national standard of frequency, which is of value in scientific and other measurements requiring an accurate frequency. Any desired frequency may be measured in terms of any one of the standard frequencies, either audio or radio. This may be done by the aid of harmonics and beats, with one or more auxiliary oscillators.

At least three radio carrier frequencies are on the air at all times, to insure reliable coverage of the United States and other parts of the world. The radio frequencies are:

2.5 megacycles (= 2500 kilocycles = 2,500,000 cycles) per second, broadcast from 7:00 P.M. to 9:00 A.M., EWT (2300 to 1300 GMT).

5 megacycles (= 5000 kilocycles = 5,000,000 cycles) per second, broadcast continuously day and night.

10 megacycles (= 10,000 kilocycles = 10,000,000 cycles) per second, broadcast continuously day and night.

15 megacycles (= 15,000 kilocycles = 15,000,000 cycles) per second, broadcast from 7:00 A.M. to 7:00 P.M., EWT (1100 to 2300 GMT).

Two standard audio frequencies, 440 cycles per second and 4000 cycles per second, are broadcast on the radio carrier frequencies of 5, 10, and 15 megacycles. The audio frequency 440 cycles only is broadcast on 2.5 megacycles. The 440 cycles per second is the standard musical pitch, A above middle C; the 4000 cycles per second is a useful standard audio frequency for laboratory measurements.

In addition there is on all carrier fre-

[Continued on page 10]

The ignition harness can well be described as an airplane engine's nervous system. One of Connecticut Telephone and Electric Division's latest war assignments is the production of this assembly for the manufacturer of a world-famous aircraft motor.

"Connecticut" war production also includes military field telephones, head sets, switchboards, electronic devices and special ignition parts.

A pioneer in communications and ignition systems, this division of Great American Industries, Inc. is geared for advanced engineering and manufacturing of precision electrical parts and equipment. When you are planning electrical or electronic improvements in your postwar products or manufacturing methods, our development engineers are ready to offer constructive help.

VICTORY AND JOBS AFTER VICTORY
depend on holding the line against inflation. Never bid up a price; never buy what you don't need; make war bonds your investment in tomorrow.

ARMY E NAVY

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

MERIDEN ★ GREAT AMERICAN INDUSTRIES CONNECTICUT

TECHNICANA

[*Continued from page 8*]

quencies a pulse of 0.005-second duration which occurs periodically at intervals of precisely one second. The pulse consists of five cycles, each of 0.001-second duration, and is heard as a faint tick when listening to the broadcast; it provides a useful standard of time interval, for purposes of physical measurements, and may be used as an accurate time signal. On the 59th second of every minute the pulse is omitted.

ELECTRONIC HEATING

★ One conspicuous peacetime benefit of wartime electronics lies in the field of high-frequency heating, using certain electronic tubes originally developed for war applications. These tubes, according to Westinghouse engineers, have made it possible to establish a family of practical radio-frequency generators. Covering almost the full range of high-frequency heating work, these standard oscillators are being built in 2, 5, 10, 20, 50, 100, and 200-kw sizes.

Some laboratory experimentation yet remains to be done in both induction and dielectric heating. Almost every product presents its own problems in frequency, power, coil and plate design. Much experimental work has been done in the Westinghouse laboratory recently in order to explore various war and post-war uses of this new branch of the industry.

Present methods for manufacturing hollow propeller blades for airplanes require a copper or copper-alloy fillet in the leading and trailing edges to alleviate sharp corners in these regions. Welding on the outside edge is not sufficient to hold the two pieces together and it is, of course, impossible to weld along the inside edge. With induction brazing (see *Fig. 1*), beads of brazing

[*Continued on page 12*]

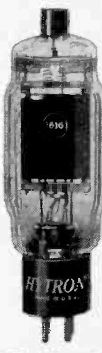
Fig. 1. Induction brazing a fillet

"Nothing Like Being Rugged, Eh Kid?"

Our mechanized Army must have brains, but brawn still counts. The big fellow wrestling interminably with 155 millimeter shells serves his greedy howitzer with the broad back developed by endless months of bone-tiring drill.

If it cannot take the jolts, vibrations, concussions, and extreme atmospheric variations of mechanized global war, the best electronic fighting equipment in the world is useless. Hearts of this combat equipment — electronic tubes — have two strikes against them from the start. Inherently delicate and fragile by nature, still they must be as rugged as the men who depend upon them.

Bump, vibration, immersion, life, and other punishing tests prove the mettle of Hytron tubes before they leave the factory. More important still, results of these tests form the basis for continual improvements in construction and processing. Throughout manufacture — in stem, mount, sealing-in, exhaust, aging, basing, and test departments — engineers, foremen, and skilled operators are ceaselessly striving to achieve in Hytron tubes not only the tops in electronic performance, but also the peak of dependable stamina which combat demands.



OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

HYTRON RADIO TUBES

BUY ANOTHER WAR BOND

TECHNICANA

[*Continued from page 10*]

material are laid along the inner edge. The propeller is then moved edgewise through the output coil of an oscillator and the beads are fused—this securely binds the edges together. This work has been done with a torch but it takes much longer. It requires greater skill and results in greater warpage of the blades.

Oil-well drill bits must be tough since they bore their way through solid rock. The tougher they are the longer they can stay on the job down in the earth. Each time they are brought up for replacement they are raised laboriously perhaps thousands of feet. Drill bits get their toughness from a layer of tungsten carbide deposited on the teeth under high heat. Common practice utilizes a torch for this work. The operator laboriously and slowly carbides each of the 20 teeth, one at a time.

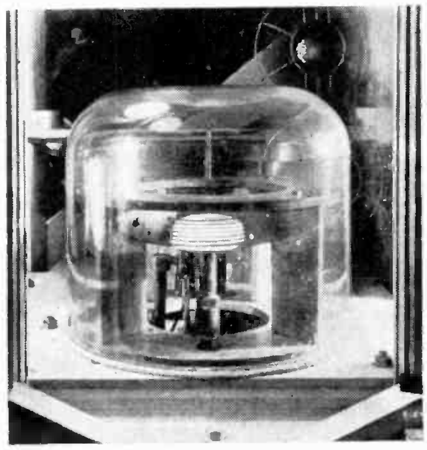


Fig. 2. Hardening a rock bit in an experimental induction furnace

Experiments in the high-frequency laboratory indicate that the whole bit can be carbided by a patented process in a few seconds by passing the toothed cutter into the field of a high-frequency oscillator (see *Fig. 2*). The carbide particles are held in place by an adhesive coating until they merge with the steel base. The new method heats all 20 teeth uniformly and cuts down the time required for the process. The operation can be high-speed and semi-automatic using unskilled operators. Protective gas atmospheres can be used to improve quality of the carbide surface.

Induction heating is ideally suited for soldering applications. For example, a terminal connector for a fighter plane has thirty wires soldered to it. This job, done by hand, one wire at a time, requires about fifteen minutes. In fifteen seconds induction heating

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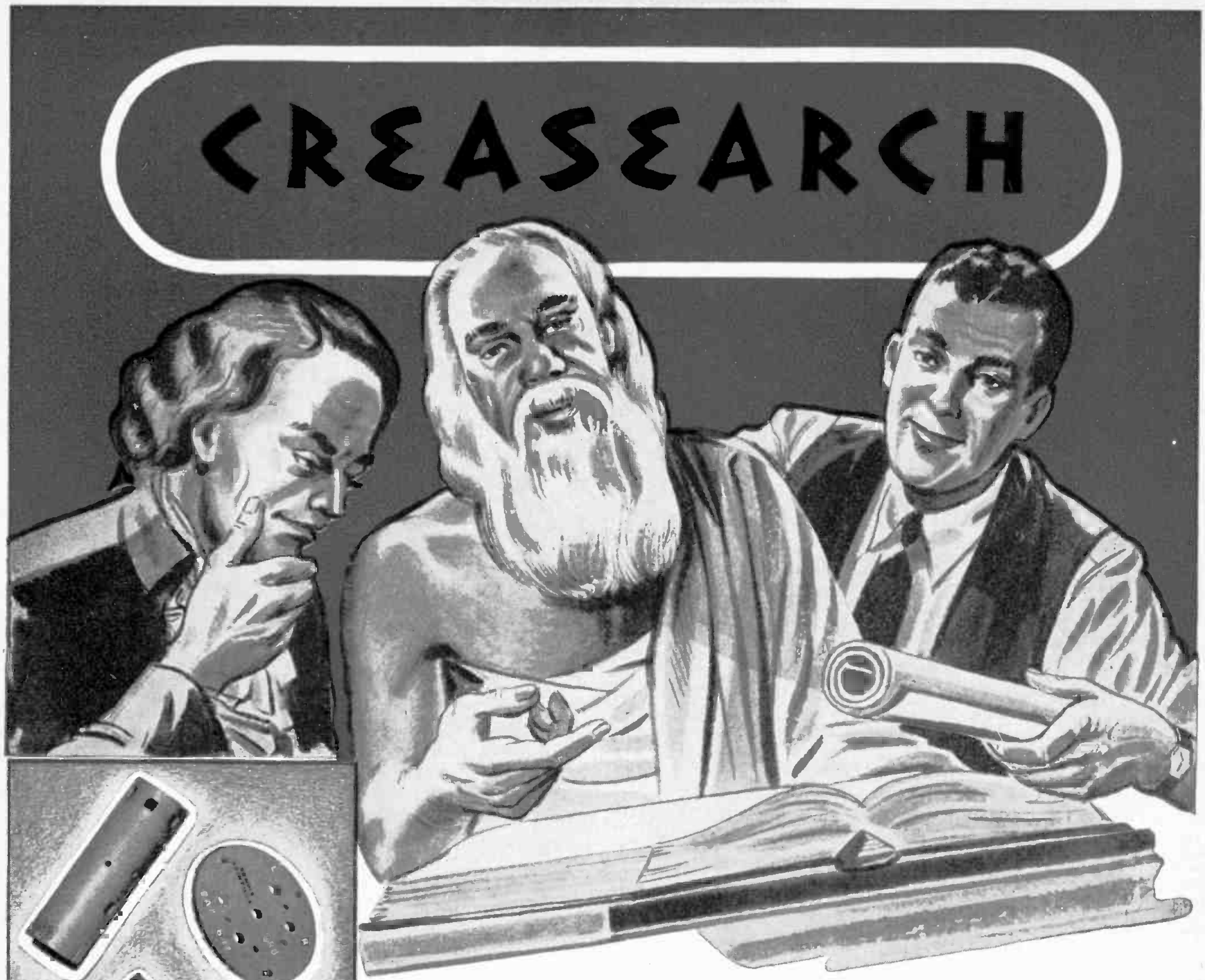
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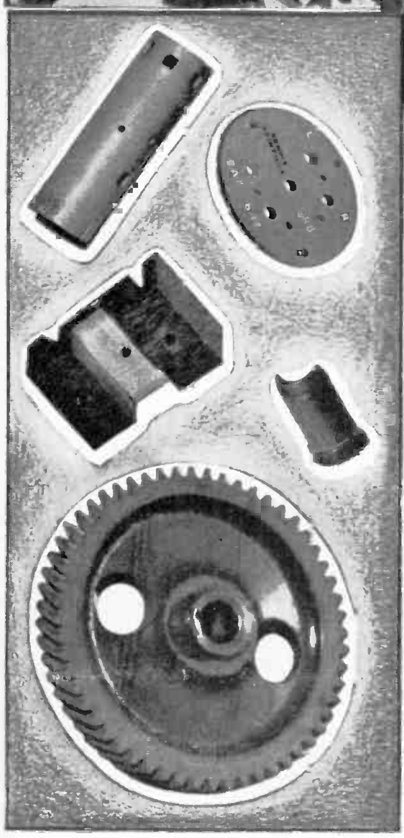

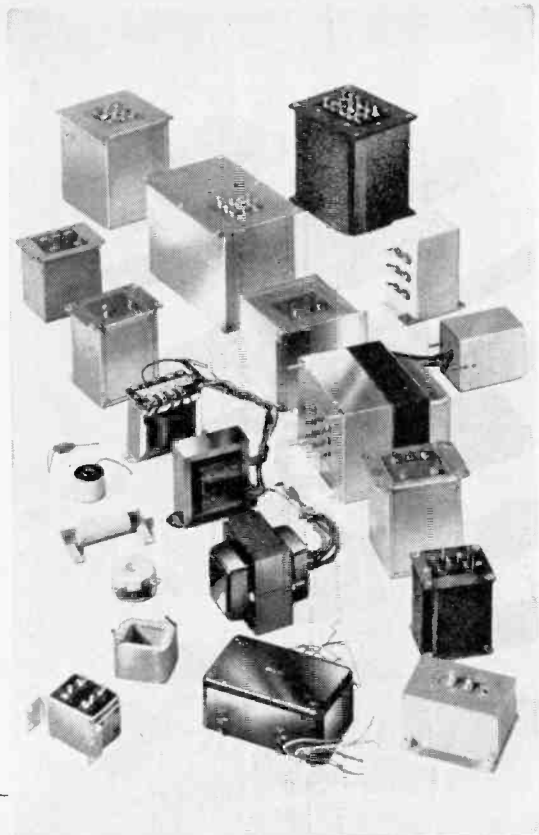

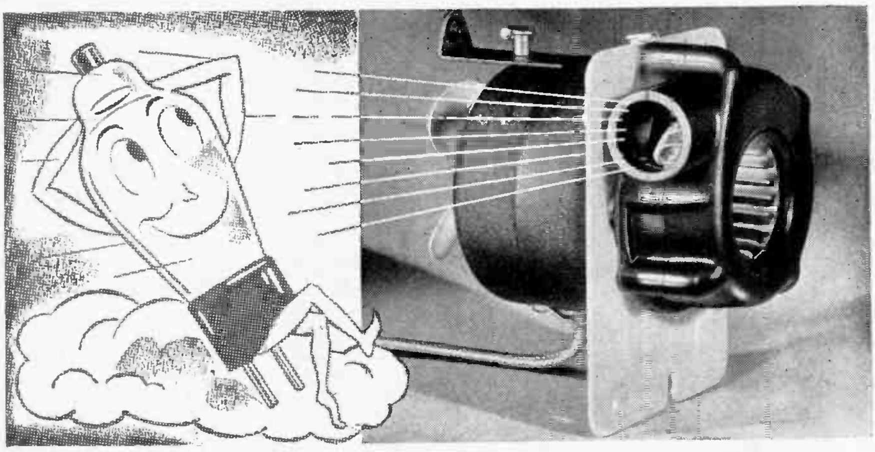

TECHNICANA

[*Continued from page 12*]

solders all connections at one time leaving all joints clean and uniform.

The induction process for flowing tin on tin plate to obtain a bright surface is now well known. Using the same principle, experiments were carried out applying induction heating to a new kind of plastic made in large sheets. Two surfaces are required to be absolutely smooth—previously this had been accomplished by heating the surface between two steam-heated platens. With high-frequency heating, it appears that by using thinner platens and about 200 kilocycles, the job can be done much more quickly. Delays required for heating and tooling the thick steam platens will, of course, be eliminated.

Much research work has dealt with the application of high frequencies to objects that are insulators—such usage is termed dielectric heating. In the future, dielectric heating may play an important role in curing plastics and in drying synthetic binders used for making large sheets of multi-ply plywood. Westinghouse engineers are at work on the problem of obtaining uniform voltage stresses over the large areas involved.

UNDERWATER TELEPHONE LINE

★ Unwilling to wait for the arrival of regular submarine telephone wire during the desperate fighting for Munda in July of last year, a Signal Corps detachment laid an underwater telephone line from Corps headquarters on Rendova Island to two divisions on the mainland with Spiral 4 cable. This cable is made to be used on land. This marked the first time its use for underwater communications has been reported.

Spiral 4 cable ordinarily is used by Signal men to establish semi-permanent wire channels to the front lines. It is utilized with carrier equipment and furnishes a number of voice and telegraph circuits to division and regimental command posts. It was used with great success in the North African and Sicilian campaigns and is playing its part in furnishing vital communications to the troops now fighting in Italy.

RADIO DISPATCHING

★ William J. Halligan, President of the Hallicrafters Company, manufacturers of short-wave and ship-to-shore radio telephone equipment, expressed pleasure that the nation's railroads had asked for immediate examination of public-safety possibilities in the proposed use of radio telephones on moving trains.

Passengers who have ridden on trains equipped with broadcast receivers are

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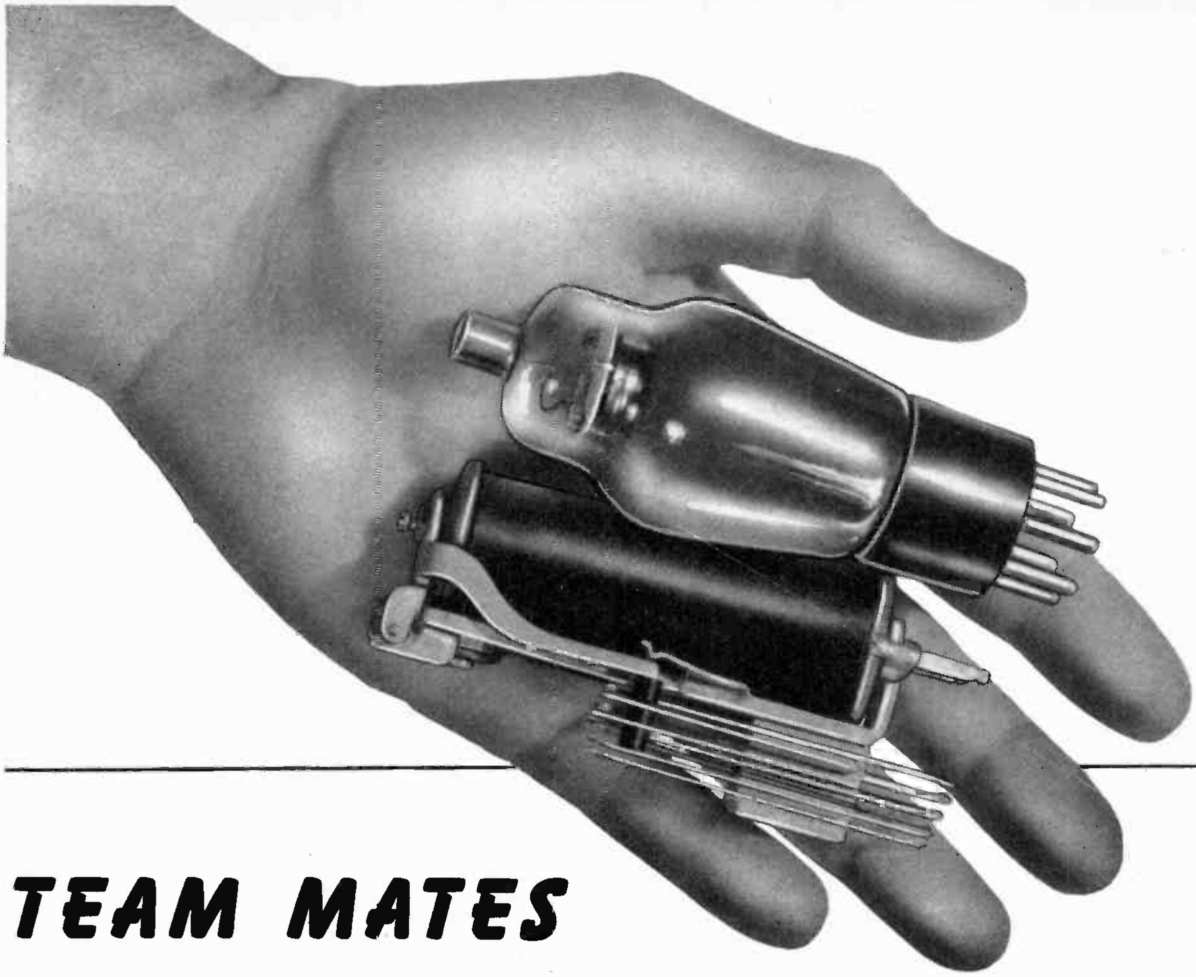

TEAM MATES

THAT MAKE ELECTRONS "GO TO TOWN"

Here are two partners that have taken the "impossible" out of hundreds of wartime control problems. One is the electronic tube in its infinite variety of types and applications. The other is Automatic Electric control apparatus—the relays, stepping switches and other devices which serve as "muscles" for the miracles of electronic science. Together, they are helping to speed new electronic ideas through the laboratory and put them to practical use on the production line and on the fighting fronts.

Automatic Electric field engineers are working daily with the makers of electronic devices of every kind, offering time-saving suggestions for the selection of the right control apparatus for each job, and extending the benefit of the technique which comes from fifty years of experience in electrical control applications.

Let us pool our knowledge with yours. First step is to get a copy of the Automatic Electric catalog on control devices. Then, if you would like competent help in selecting the right combination for your needs, call in our field engineer. His recommendations will save you time and money.

Relays
AND OTHER CONTROL DEVICES
by AUTOMATIC ELECTRIC

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MUSCLES FOR THE MIRACLES OF ELECTRONICS


CRYSTALS
Any Cut ★ Any Frequency
Meck skill and precision are performance-proved. Meck experience is proved by our completely diversified selection of crystals in a wide range of types—silver-plated, too. Our Special Crystal Service Division is today prepared to meet exacting requirements to any specifications on short notice.
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PLYMOUTH, INDIANA
EXCELLENCE IN
MUSIC AND VOICE
RECREATING INSTRUMENTS

Book Reviews

THE TECHNIQUE OF RADIO DESIGN, by E. E. Zepler. Published by John Wiley and Sons, Inc., New York, N. Y. 312 pages. Price $3.50.

Here is a practical book which covers radio circuit design from the viewpoint of the laboratory engineer. Dr. Zepler was formerly head of the Receiver Development department at Telefunken and also a Marconi research engineer. With this broad background he is able to present a common-sense approach in discussing circuit design problems and to point out pitfalls which are seldom, if ever, covered in general texts. As the author states, this is the principal aim of his book.

Throughout the book the author is careful to include such items as factors of safety and relative magnitudes in design work. This makes the book especially valuable to those engineers who lack broad experience in design work, and even those who are experienced can gain much from the practical points discussed.

We must, however, take exception to one minor point: On page 54, it is stated that the leakage resistance of an 0.1 μf wax-impregnated capacitor is between 5 and 50 megohms. If capacitors of European manufacture are that bad, American manufacturers of such items need have no fear of European competition in post-war markets.

J. H. P.

★

MANUAL FOR ON-THE-JOB INSTRUCTION OF SCREW MACHINE PERSONNEL. Published by National Screw Machine Products Association, 13210 Shaker Square, Cleveland 20, Ohio. 107 pages. Price $2.00.

This Manual represents the culmination of two years' intensive work by the Association on manpower problems. It presents easily understood instructional material in a highly original manner and covers all types of multiple spindle automatics, as well as cross-indexing the Brown and Sharpe 14-booklet series to the Association's suggested training method. In addition to functional machine operation, the Manual includes extensive data on grinding and setting tools, and comprehensive Trouble Charts.

The Association's approach represents a return to the highly successful pre-war method of training — instruction on the job and at the machine. By using this Manual as a standard, operators who act as teachers will not overlook some small step which may later cause trouble. Further, the use of this book should aid greatly in speedily reducing the shortage of skilled screw-machine personnel.

★

TIME BASES, by O. S. Puckle. Published by John Wiley and Sons, Inc., New York, N. Y. 204 pages. Price $2.75.

This is an authoritative discussion of the design and development of scanning generators, a subject in which the author specializes.

Among others, trigger circuits, blocking oscillators, inductive, polar co-ordinate, multiple and velocity-modulated time bases are thoroughly covered.

The latter portion of the book is devoted to a series of seven appendices and a bibliography. In this section are discussions of the cathode ray tube, in which a wide range of topics concerning the tube are dealt with clearly and concisely. Other appendices cover differentiating and integrating circuits, square wave generation, gas-discharge time bases and other pertinent subjects of interest.

The information given in this book will be found invaluable to anyone interested in sweep circuits. *J. H. P.*

★

FUNDAMENTALS OF TELEPHONY, by Arthur L. Albert. Published by McGraw-Hill Book Co., Inc., New York, N. Y. 374 pages. Price $3.25.

This elementary book, intended for beginning students and for telephone workers, is devoted exclusively to telephone communication. The principles of electricity and acoustics upon which telephone practices are based are presented in the first four chapters. These are followed by chapters on telephone transmitters and receivers, telephone sets, manual and dial telephone systems, transmission circuits, interference, and measurements. The last chapter, on repeater and carrier systems, includes a brief discussion of vacuum tube theory and applications in telephone systems.

The review questions and problems following the chapters add to its value as a text for home study or class-room work, for which it seems exceptionally well adapted.

Quotes

Post-War Distribution

★ Theories being advanced about the elimination of the middlemen in post-war days are impractical. The radio parts jobber will be essential to distribution; for providing the service and stock-carrying facilities that the middlemen offer.

These functions unquestionably add to the convenience and speed with which the public is served. Should the huge corporations succeed in eliminating the jobber, their costs of distribution will more than make up for the amount necessarily paid the middleman because the jobber has the smallest overhead.

John Meck, of John Meck Industries.

New Product Plans

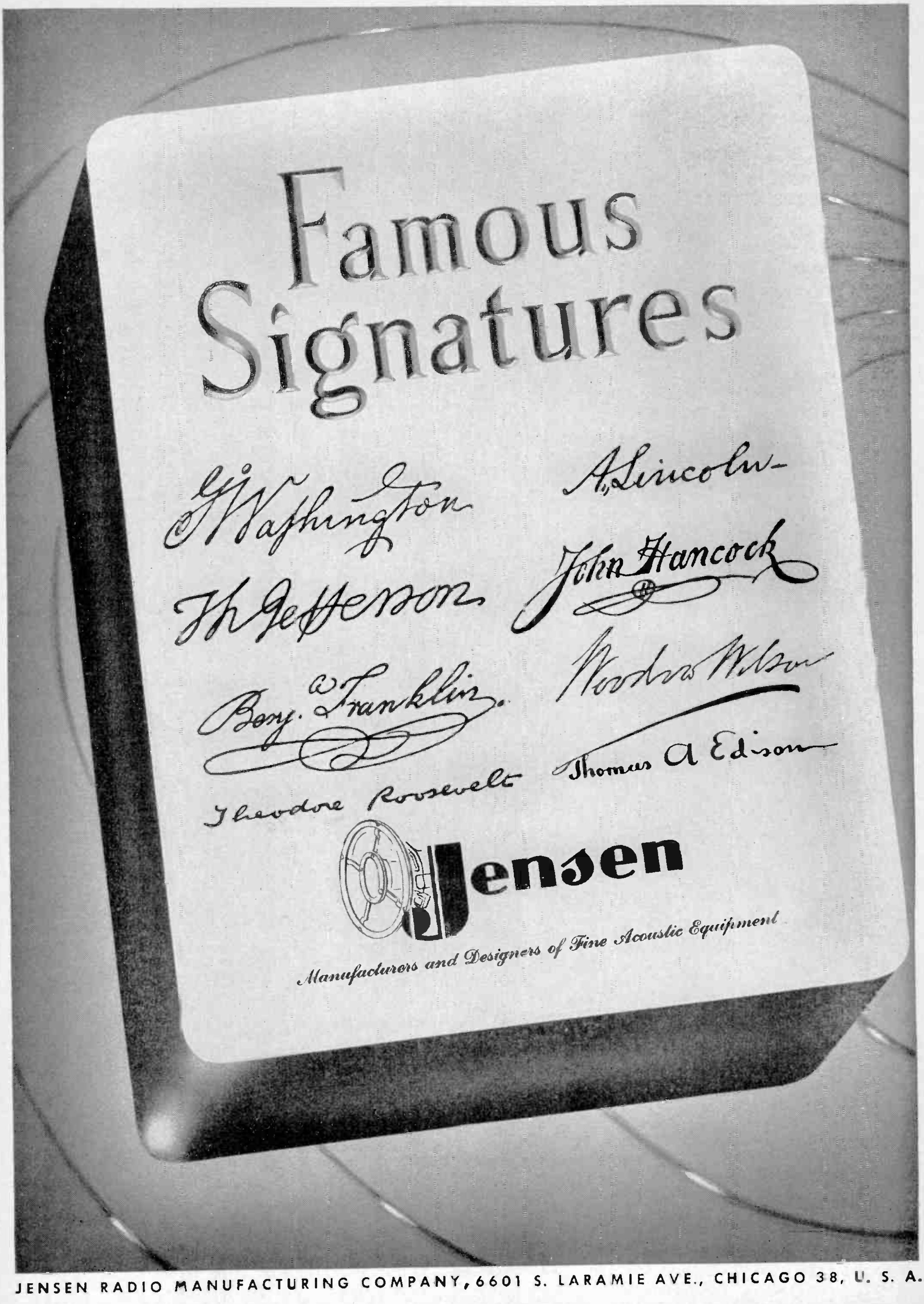
★ A total of 58 per cent of all companies interviewed in a recent survey are planning to bring out some kind of new product. The companies which have no new products in mind, most prevalent in the automobile, office equipment and aviation industry groups, feel that their biggest opportunity is to concentrate on the products they have now. Tire and rubber, paper and paper products, and the miscellaneous group have the highest percentage of companies reporting a new product. New products are planned by 56 per cent in the radio and phonograph industry.

Commercial Research Division, The Curtis Publishing Co.

Television Frequencies

★ During the present war, scientists have uncovered a wealth of information about higher frequencies. This has led many to the belief that all television problems can be solved at these high frequencies since many broad channels would be available. However,

[*Continued on page 59*]



JENSEN RADIO MANUFACTURING COMPANY, 6601 S. LARAMIE AVE., CHICAGO 38, U. S. A.

Aluminum Electrolytic Condensers*

P. ROBINSON and J. BURNHAM
Chief Engineer Research Engineer
SPRAGUE SPECIALTIES CO.

An authoritative treatment of the design, structure, and operating characteristics of electrolytic condensers

★ The aluminum electrolytic condenser derives its name from the fact that it comprises an aluminum anode which has been subjected to voltage in an electrolytic cell. When a d-c voltage is applied to such a cell, the surface of the aluminum is electrolytically oxidized. This process is usually referred to as "formation."[1]

There is a very large amount of data on aluminum electrolytic condensers in the literature, and much of it conflicting. The fundamental reason for this is, of course, that the electrolytic oxidation of aluminum is irreversible. Once the process starts and an oxide film is formed, then, while we can measure the current and the original electrode area, we no longer know the electrode area exposed to the electrolyte, and hence the term "current density" has only statistical significance. In turn, effects which are functions of current density, such as overvoltage, composition of the anolyte, have no definite significance. In addition, not only are the kind and number of impurities in the original aluminum anode important, but their distribution in the metal surface is also important. However, from the mass of conflicting data, a few facts and definitions emerge.

The thickness of the oxide film formed is a linear function of the voltage applied and is of the order of 10^{-4} cm. thick,[2] for 1.000 v. This extremely thin dielectric film accounts for the high capacities per unit of plate area obtained in electrolytic condensers.

In practice, the capacity per unit area is further increased by preliminary etching of the surface of the aluminum plate. This is the origin of the designation "etched-plate" and "plain-plate" condensers. The relative increase in surface obtained by etching is measured in terms of the "ratio" of the capacity of the etched plate to that of the plain when oxidized to the same d-c potential.

The electrical quality of the oxide film is determined by the maximum "formation" voltage and the leakage current per microfarad. A minimum leakage is desirable, and the lowest obtainable value depends on the chemical nature of the electrolytic solution in which it is formed. The maximum obtainable voltage is similarly dependent on the solution, and may be expressed as some inverse function of the concentration of the solute.

The rating of a condenser is usually a (large) fraction of the voltage to which the anode is formed. The voltage overloads that it can withstand are limited by the latter. Since thus the voltage breakdown of an electrolytic condenser can be accurately controlled, it is unnecessary to design it to take "flash" voltages of two and three times the rating, such as is the case in paper condensers. Limiting the overload voltages has the important advantage of increasing the capacity per unit volume relative to a condenser which is formed at a high voltage.

"Wet" and "Dry" condensers are differentiated by the kind of electrolytic solution in which they operate. The "wet" uses an aqueous electrolyte and the "dry" a non-aqueous electrolyte. The "wet" condenser usually has rigid electrodes which are comparatively widely separated. The "dry" condenser usually employs thin flexible metal strip electrodes, with thin, porous separators between them. This composite strip is wound up on a mandrel into a compact cylinder, and is subsequently impregnated with the electrolyte.

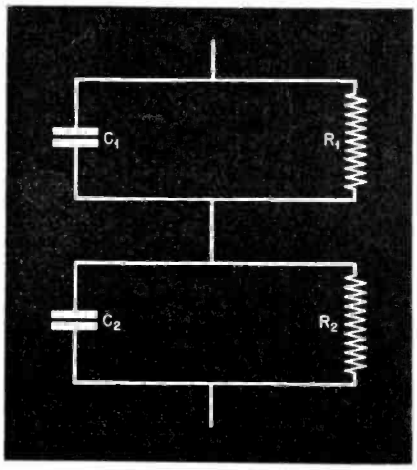
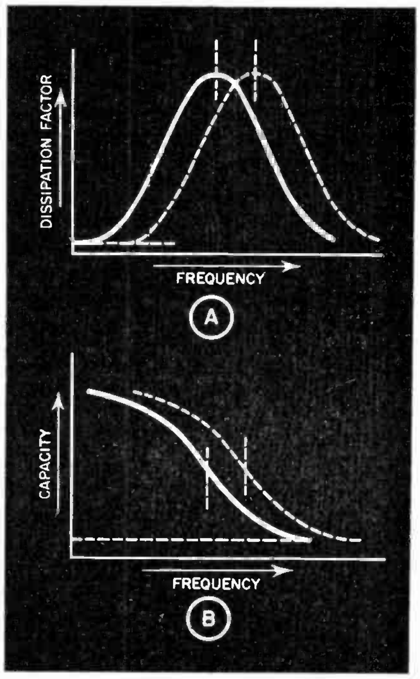


Fig. 1. Equivalent circuit of an electrolytic condenser



Frequency characteristics of the equivalent circuit (Fig. 1) for different values of R_2. The solid line in (A) above, and (B) below, shows the resulting curve when the resistivity of the electrolyte is decreased with respect to that represented by the dotted line

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* This article is based on a paper presented at the Eighty-Third General Meeting of The Electrochemical Society and is published with the permission of the authors, through the courtesy of The Electrochemical Society.

[1] Guntherschulze, Z. Physik. Chem. 143, 62 (1929).

[2] Van Geel, Physica (Nederland. Tijdsch. Natuurkunde) 1, 989 (1934).

Applications

The first large commercial use of electrolytic condensers was in the filter circuits of radio sets which derived their plate voltage from rectified a.c. The filters used for this purpose are low-pass filters with a cut-off frequency below that of the ripple frequency, which usually is 60 or 120 cycles. The early filters were iterative networks consisting of choke coils, and condensers of impregnated paper or mica dielectric. With the advent of the electrolytic condenser, which made possible large capacities in a small space and at a low price, these circuits were redesigned using progressively smaller coils, fewer sections, and larger capacities until, in 1941, a typical filter circuit consisted of two electrolytic condensers and one resistor, with the coils no longer used. The utilization of aluminum in this type of work is perhaps best illustrated in the filter circuit of the low-priced radios popular at that time. These comprised 30 microfarads of 150 volts d-c rated condensers, which consumed 2.2 grams of aluminum.

These condensers consisted of a formed aluminum anode, a spacer impregnated with electrolyte, and an unformed aluminum cathode. A condenser useful on a-c comprises two formed aluminum electrodes with electrolyte-saturated spacers between them. Such a condenser was completely described electrically in papers presented before The Electrochemical Society in 1904 by Zimmerman,[3] but it was nearly 30 years later before they found wide commercial use. They are used with single-phase fractional horsepower motors to provide essentially a two-phase motor at the instant of starting. The high starting torque so provided met a large need in driving compressors, pumps and hoists. Their use continued to expand up to the start of the present war, largely at the expense of the repulsion-induction type of motor.

The Equivalent Circuit

An electrolytic condenser can, like other electrical devices, be represented by a number of equivalent circuits. Of these the simplest and one which admits of the most straightforward physical interpretation is shown in *Fig. 1.* This R-C network is constituted as follows:

C_1 is the condenser with a dielectric consisting of the oxide film, with the anode as one armature plate, and an imaginary conducting layer as the other.

R_1 is substantially the leakage resistance of the condenser.

C_2 is the condenser with a dielectric consisting of paper saturated with electrolyte, with the cathode as one plate and the imaginary conductor of C_1 as the other.

R_2 is substantially the resistivity of the electrolyte.

The admittance of the network is represented by the following expression:

$$Y = \frac{1}{R} + \frac{\omega^2 C\infty\, kT}{1+\omega^2T^2} + j\omega C\infty \left(1 + \frac{k}{1+\omega^2T^2}\right) \quad \ldots\ldots(1)$$

where the parameters in terms of the circuit elements are:

$$R = R_1 + R_2$$

$$C\infty = \frac{C_1 C_2}{C_1 + C_2}$$

$$k = \frac{(C_1 R_1 - C_2 R_2)^2}{C_1 C_2 (R_1 + R_2)^2}$$

$$T = \frac{(C_1 + C_2) R_1 R_2}{(R_1 + R_2)}$$

When, in this case of the electrolytic condenser, actual values are assigned, these expressions can be reduced to simpler forms. For purposes of analysis, it is desirable to retain the expression, Eq. (1), for a short time.

Accepting Eq. (1), the imaginary part gives the effective capacity.

$$C(\omega) = C\infty\left(1 + \frac{k}{1+\omega^2T^2}\right) \quad \ldots\ldots(2)$$

Neglecting the effect of the leakage resistance, R_1, the real part of Eq. (1) is the reciprocal of the equivalent series resistance.

$$R(\omega) = \frac{1+\omega^2T^2}{\omega^2 C\infty\, kT} \quad \ldots\ldots(3)$$

The dissipation factor.

$$\tan\theta = \frac{Y(\text{real})}{Y(\text{imaginary})} = \frac{\omega\, k\, T}{1+k+\omega^2T^2} \quad \ldots(4)$$

This expression can be maximized with respect to frequency, where

$$\omega = \frac{\sqrt{1+k}}{T} \quad \ldots\ldots(5)$$

at which frequency,

$$\tan\theta \max = \frac{k}{2\sqrt{1+k}} \quad \ldots\ldots(6)$$

In an electrolytic condenser the ratio of C_1 to C_2 is about 10^2 and that of R_1 to R_2 about 10^9; it is thus possible to simplify the above equations.

If, then, taking R_2 to be small as compared with R_1; and C_2 small compared with C_1, then:

$$C\infty = \frac{C_1 C_2}{C_1 + C_2} \geqq C_2$$

$$R = R_1 + R_2 \geqq R_1$$

$$k = \frac{(C_1R_1 - C_2R_2)^2}{C_1C_2(R_1+R_2)^2} \geqq C_1/C_2$$

$$T = \frac{(C_1 + C_2) R_1R_2}{R_1 + R_2} \geqq C_1 R_2$$

Then the equations may be rewritten, the asterisks denoting the approximation:

$$C^*(\omega) = C\left(1 + \frac{1+\omega^2C_1^2R_1^2}{C_1/C_2}\right) \quad \ldots(7)$$

$$R^*(\omega) = \frac{1+\omega^2C_1^2R_2^2}{\omega^2C_1^2R_2^2} \quad \ldots\ldots(8)$$

$$\tan^*\theta = \frac{\omega\, C_1^2\, R_1}{C_2+C_1+\omega^2C_1^2C_2R_2^2} \quad \ldots(9)$$

$$\omega^* \text{ for max } \tan\theta = \frac{\sqrt{1+C_1/C_2}}{C_1 R_2} \quad \ldots(10)$$

$$\tan^*\theta \max = \frac{C_1/C_2}{2\sqrt{1+C_1/C_2}} \quad \ldots(11)$$

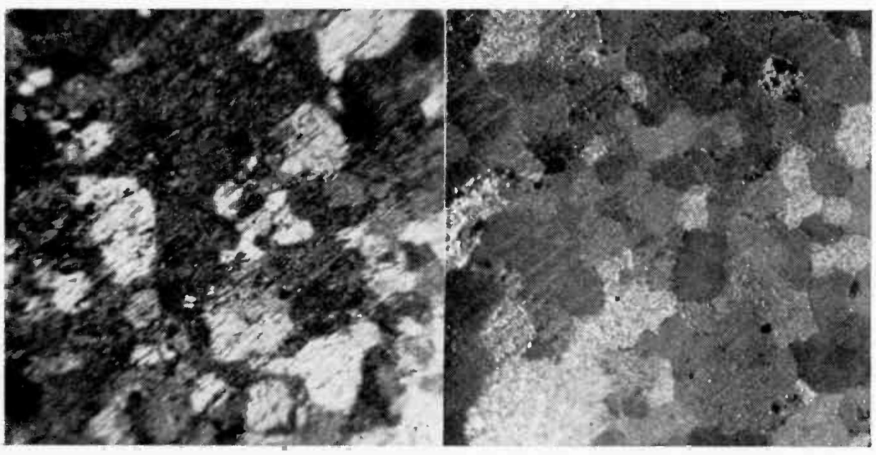


Fig. 3A (left) Photomicrograph of translucent oxide film placed between crossed polaroid discs (mag.=40), and B, (right), etched surface of aluminum foil by reflected light (mag.=75)

[3] C. I. Zimmerman, Trans. Electrochem. Soc. 5, 147 (1904); 7, 309 (1905).

From these equations, qualitative predictions of the characteristics of an electrolytic condenser can be made. Eq. 7, for the change of capacity with frequency, is shown graphically in *Fig. 2A* and Eq. (8), for the change of dissipation factor with frequency, is shown in *Fig. 2B*.

For example, as we decrease the resistivity of the electrolyte, keeping everything else constant, the frequency at which a power factor maximum occurs moves to the lower frequency. At frequencies below this, the power factor is decreased by lowering the resistivity, but not linearly by any means.

When the ratio of C_1 to C_2 is changed, for example, by decreasing the forming voltage, or by etching the anode, or by both, the maximum of the dissipation factor is increased enormously, but at frequencies well below this point the change in power factor may be and usually is quite small.

As the temperature is lowered, the resistivity of the electrolyte increases exponentially; and the frequency characteristic of capacity and dissipation factor are translated toward the lower frequency characteristic.

In the section which follows, these predictions are qualitatively borne out. For quantitative results, neglected variables must be taken into account. For example, the polarization capacity of the cathode usually is so large that it can be neglected. The leakage resistance of the film R_1 is far from constant but is a function of the voltage. The dielectric constant of the electrolyte changes with temperature, and the dielectric constant of the film to a much lesser extent changes with temperature and frequency. There are power losses in the film itself.

Applying Faraday's Law

The formation of the oxide film is an electrolytic process, and consequently Faraday's Law should be applicable. One may, on the basis of this law, calculate the electrolytic efficiency of the oxidation process, and at the same time, from agreement or disagreement between the theoretical and experimental results, formulate some idea of the mechanism of electrolytic oxidation.

The experimental results were obtained from the electrolytic oxidation of high purity aluminum in an aqueous boric acid solution of 120 g./L at 90°C. An electrode of 161 cm.² and weighing 6.0856 grams was used. The results are shown below:

Weight of raw aluminum electrode = 6.0856 g.
Weight of oxidized electrode = 6.1018 g.
Weight gain = 16.2 mg.
Coulombs required to attain 550 volts on the electrode = 168.
Coulombs required to produce a leakage current of 0.031 milliamp./cm.² of electrode surface = 36
Total coulombs to form = 204

The coulombs per gram of weight gained is 12.6 x 10^3 and this is to be compared with the theoretical value per gram of 1/2 O_2 which is 12.1 x 10^3. The close agreement indicates that the electrode process involves essentially a deposition of one gram equivalent of oxygen for each Faraday. The electrolytic efficiency obtained is 95% which is within the experimental error of the 100% expected on the basis that the electrolytic oxidation proceeds without evolution of oxygen (or any gas) at the aluminum anode.

Oxide Film Structure

The crystalline structure of the thin oxide film in the past has been supposed to be essentially cubic.[4] We have found that it is birefringent, consequently the crystal must be of lower symmetry. The birefringence is illustrated in the microphotograph, *Fig. 3A,* of the film taken with transmitted light and placed between crossed nicols.

The striking parallel between the mosaic pattern and that of the grain structure of the surface of the aluminum electrode shown in *Fig. 3B* is unmistakable, and leaves no doubt that the orientation of the Al_2O_3 crystal is determined by the crystal face which the metal presents to the solution. This result suggests further experiments on single crystals to determine whether different thicknesses of film are produced on different crystal faces at the same oxidation voltage.

The birefringence raises a question as to whether this crystalline form is entirely new or whether it is identical with one of the naturally occurring forms of Al_2O_3.

Thick films are optically homogeneous. This and other properties, such as the ability to adsorb dyes, etc., indicate that the oxide is probably of an amorphous nature.[4]

Breakdown Tests

The breakdown was investigated in aqueous solutions of citric acid, and boric acid mixed with ammonium borate. An aluminum electrode was formed in a solution of citric acid of 1.53 *g./L* of solution until the breakdown voltage was reached. The leakage current was then allowed to drop to 0.25 milliamp./sq. in. of surface. The breakdown voltage was determined as a function of pressure from the vapor pressure of the solution at room temperature up to 1,200 mm. of *Hg*. The pressure was controlled with a water pump below 1 atmosphere and air pressure introduced above 1 atmosphere. The breakdown voltage was found to increase almost linearly with the pressure and is expressed approximately by the equation.

$$V = 423 + 0.064\ P \qquad (12)$$

where V = breakdown voltage
P = pressure in mm. Hg.

The breakdown voltage at zero pressure is an extrapolated value.

Ammonium borate and boric acid electrolytes follow the same general Eq. (13).

$$V = V_0 + a\ P \qquad (13)$$

with the same value of "a" but a different V_0. The change of resistance effectively changes the magnitude of the constant V_0.

The breakdown changes only slightly with temperature, so one cannot as-

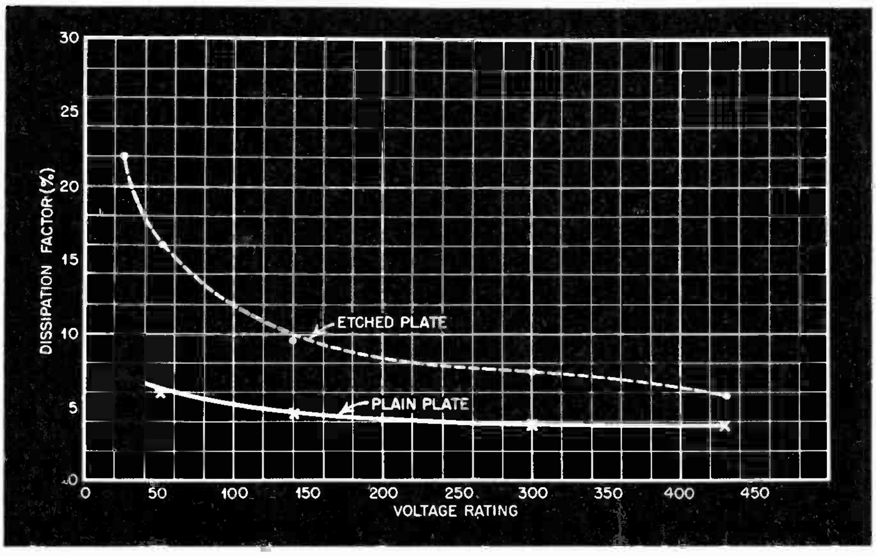


Fig. 4. Variation in dissipation factor with voltage rating for plain and etched plate dry electrolytic condensers at 25°C and 120 cycles

sume that the resistance *per se* has any physical significance in the breakdown mechanism.

The increasing breakdown with pressure indicates that at least part of the voltage drop across the oxide film is determined by presence of a gas layer at the instant of breakdown. The fact that the increment of breakdown is nearly independent of electrolyte resistance shows that the mechanism of the breakdown is left unchanged. The gas layer involved, however, is not trapped in film pores as has been supposed[5] because in thick films where pores have been definitely observed microscopically the breakdown voltages in aqueous solutions are of a lower order of magnitude.

The breakdown voltage increases with increasing resistance according to an exponential law.[6] For a range of resistance between 200 and 1,200 ohms in a mixed boric acid and ammonium borate aqueous solution, the relation between the breakdown voltage and the resistance of the solution is expressed approximately by Eq. (14).

$$lnR = 5.3 + 0.0171\ (V\text{-}245) \quad \ldots (14)$$

where R = specific resistance in ohms/cm.^{3}
V = breakdown voltage in volts.

The main source of experimental error lies in the determination of the voltage at which breakdown occurs. Another possible source of variation is the method of oxidizing the electrode. The electrodes used here were oxidized to 550 volts in a boric acid solution at 90°C.

Above and below the limits of resistance indicated, the curve of *lnR* vs. voltage deviates from linearity due to complicating factors. At high resistances the breakdown becomes so high that it approaches the voltage to which the electrode was oxidized, in which case the electrode starts oxidizing to higher voltages. At the very low resistances the electrolyte begins to react with the electrode surface and probably polarization effects at the solution-electrode interface also interfere.

Design Factors

(a) *Single Electrode Capacities.* The capacity of an electrolytic condenser depends on the kind of cathode used. This appears obvious to those who are familiar with a-c electrolytic condensers. However, this is equally true of d-c condensers, a fact which is not thoroughly appreciated. This has been overlooked probably because anode capacities are generally based on measurements in aqueous solutions in which the capacity of the cathode is generally of a very large order of magnitude and it is tacitly assumed to be infinite. This capacity is purely a polarization capacity.

In electrolytes of the "dry" type this polarization capacity is very much smaller and can no longer be neglected. For example, the polarization capacity of a plain aluminum plate may be derived from the absolute anode capacity and comes out to be 16 microfarads per sq. in., similarly a foil etched to its maximum ratio gives 125 microfarads per sq. in. in a glycol boric acid electrolyte. From these two figures it may be seen that the effective ratio of surface area of etched to plain foil is about 7.8.

These facts also indicate that the equivalent circuit (*Fig. 1*) may be more successfully applied to condensers of the "dry" type.

(b) *Effect of Ratio on Power Factor.* The power factor of electrolytic condensers is a function of the ratio of the surface area per unit of geometrical area. This is illustrated in *Fig. 4*, where the dissipation factor is shown as a function of voltage rating. In this experiment condensers with equal areas of anode were made. Consequently the capacities are different for each condenser and increase as the rating decreases. This means that the ratio of the effective surface area to the geometrical area increases in the same way. For comparison, plain plate condensers are also shown on the same graph (*Fig. 4*).

A similar change in power factor is obtained if electrodes are oxidized to the same voltage and the ratio is varied by etching to different degrees. In this case the power factor rises almost linearly with the capacity per unit area.

[*Continued on page 52*]

[4] E. T. Verwey, Z. Krist. Abt. A, 91, 317 (1935).
[5] A. Guntherschulze, Z. Physik Chem. 143, 62 (1929).
[6] A. Guntherschulze, Z. Physik 9, 197 (1922).

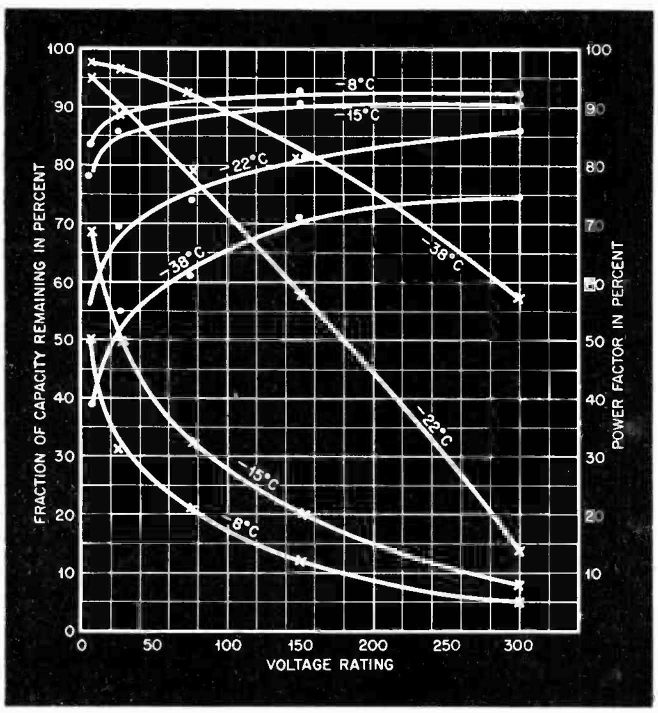


Fig. 5. Change with temperature of power factor (x) and capacity (dot) of dry electrolytic condensers as functions of voltage rating

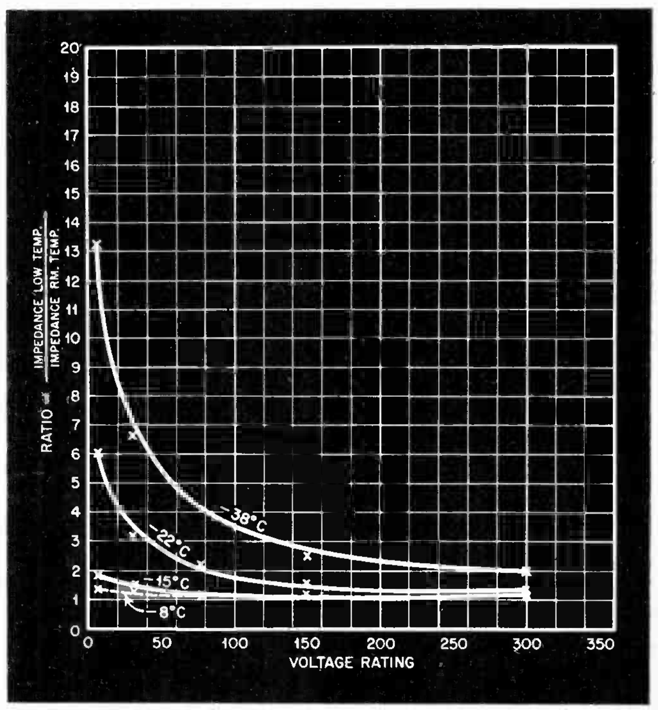


Fig. 6. Effect of temperature variation on impedance at 60 cycles of dry electrolytic condensers as a function of voltage rating

Multi-Range V-T Voltmeter

McMURDO SILVER
Vice Pres., Grenby Mfg. Co.

A line-operated instrument with ten linear a-c and d-c ranges from 1½ to 300 volts, full scale, usable at UHF up to 300 mc

★ Old as is the principle of the vacuum-tube voltmeter, it has up until recently enjoyed only a small portion of the popularity which it so justly deserves. What small usage it has enjoyed has been confined almost entirely to the more serious communication laboratories.

For some time past the writer has had need of means of stable r-f voltage measurements. In satisfying this need he has had recourse to the different vacuum-tube and electronic voltmeters today available, not to mention having devoted considerable time to a perusal of the literature of the art. The result of these investigations, which for all practical purposes began at the point of the performance to be had from the better existing instruments, is pictured, diagramed and described herewith.

This new "vacuum-volts," now available in commercial form, overcomes the disadvantages of previous instruments in a sufficiently adequate manner in terms of laboratory and field service use to be of interest. In order to appreciate the improved performance of which it is capable, it seems well to define what might be termed the minimum requirements which such an instrument must possess to be generally useful.

The principal benefit of the "vacuum-volts" to most engineers is its presumed high-impedance input. It may therefore be stated that the input impedance should be as high as is commercially practicable in long-time terms in order that it may load to a minimum degree the circuits to which it is to be applied. If it is to be useful in other than a restricted field it should be usable upon d.c. and likewise upon a.c. up to quite high frequencies. Ideally it should have no upper limit of frequency above which it is not usable. This ideal is unfortunately unobtainable today, and a compromise must be effected as to top-frequency limit. For general utility 300 mc seems a sensible compromise, for it may be attained by conventional circuit means discreetly employed. That the limit should not be lower seems inescapable, since frequencies up to 300 mc will unquestionably be in widespread use commercially after the war and will therefore be of concern to the average radio design laboratory, and even to the average service man.

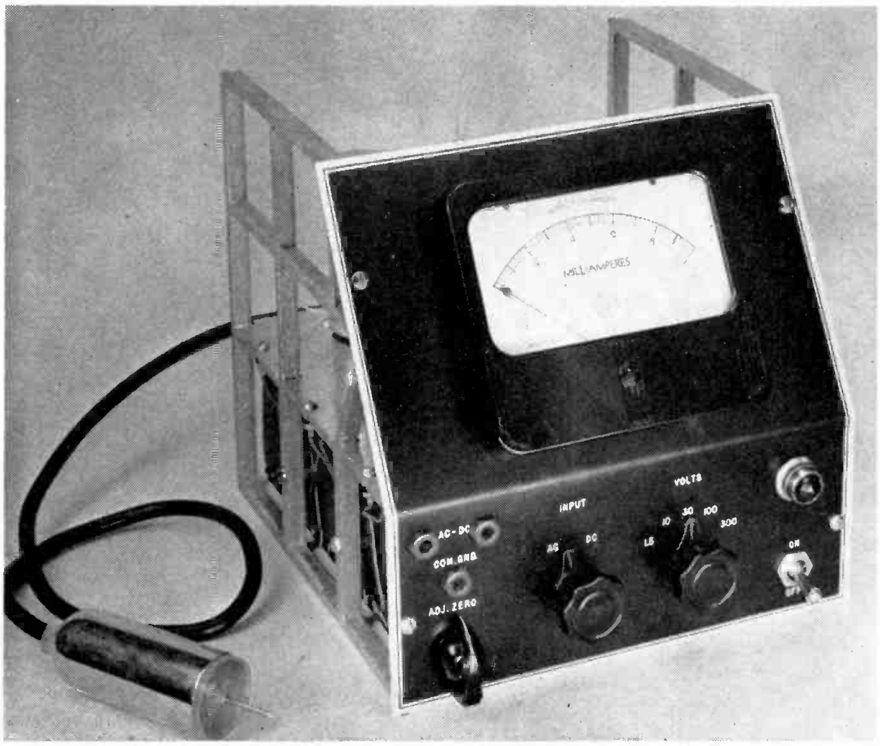


Fig. 1. Showing the "girder type" construction of the v-t voltmeter

Range Requirements

Voltage ranges provided should be enough so that readings may be made accurate to within a few percent on all ranges. Top and bottom limits should be such as to permit direct measurement of single-stage, as well as multiple-stage receiver gains. The same should be true for low and medium-power transmitters and audio systems. In practice this means the ability to read accurately down to around one-tenth of a volt, and on up to receiver plate-supply voltages if the instrument is to be sufficiently useful to justify widespread use. To the service man, who can ill afford investment in a multiplicity of instruments of partially duplicating functions, this is a significant advantage.

Scale linearity should be such that the very minimum of different meter scales conventionally needed to overcome non-linearity be required, since the greater the number of scales, the greater the confusion in reading, especially today when design or service time is "of the essence."

Both short-period and long-time stability must approximate that of the indicating meter alone, which forms an essential part of the vacuum-tube voltmeter. This requirement may be satisfied through the somewhat cumbersome device, in a necessarily portable instrument, of gaseous tube or other plate-supply voltage regulators, through the use of battery plate-supply, or through a dual-triode, balanced d-c voltmeter circuit if the latter be combined with heavy individual degeneration. This last combination provides not only stability versus line voltage variation, and excellent re-trace characteristics, but also the desirable operating feature of requiring but a single zero adjustment for all a-c or d-c voltage ranges.

Add to the above that quality of component parts must be such not only as to obviate failure, but high enough to preserve the above summarized essential operating characteristics throughout the presumably indefinitely long life of the instrument and the picture is about complete. Add again that construction must be rugged and substantial for laboratory or field service rigors, that the whole must be compact and capable of correct operation by the tyro and the sum-total requirements become just so stiff that, to the writer's knowledge, no such instrument has been available up to now.

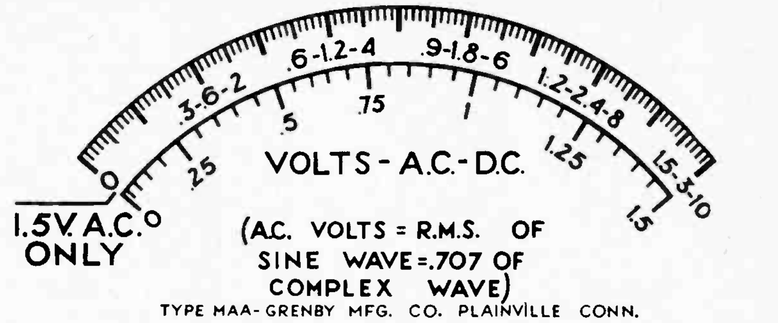


Fig. 2. The meter scale for the v-t voltmeter

Design Details

It is believed that the instrument herein described satisfies these requirements in full. *Fig. 1* illustrates a preproduction model with grey-enameled metal cabinet removed to expose the rigid, "girder type" of construction employed. The etched white-on-black metal panel is securely fastened to two cast aluminum frames, one at each end, with the chassis plate secured to horizontal members of each end-frame. This provides an unusually rigid structure practically free from the multiplicity of flexes and bends possible to the usual pan chassis construction. It additionally provides a protective cradle to prevent damage through leaning the assembly upon any of its more delicate components to support it when out of the cabinet. Further, the open-end frames and rear skirt permit greater accessibility. Still another advantage is that the panel need not be crowded with a number of screws to fasten the unit into its cabinet—it is positioned therein by the cradle construction, and held in place by two thumb screws tapped into the end-frames through the rear of the cabinet. In the model illustrated, neither the meter scale nor the probe for r-f measurements are "final." The former is illustrated in *Fig. 2,* while the latter is of plastic with two probe tips, one "ground" and one "hot," for most convenient use.

To the engineer familiar with the non-linearity of usual vacuum-tube voltmeter scales, *Fig. 2* should prove refreshing. It is reproduced to show the order of linearity which may be attained through modern design. It will be noted that of the five a-c and five d-c voltage ranges of the instrument, the slope of nine out of the ten total ranges is identical, and hence they require but a single properly numbered scale. Only one out of the ten ranges, the 1½-volt a-c range, departs from this linearity, and so requires a separate scale due to slight crowding at its lower end. It is felt that this order of linearity in ranges starting as low as 1½ volts and ranging up to 300 volts full scale may well serve as a criterion of excellence for future designs.

Fig. 3, the complete schematic diagram with values of individual components given, should convey sufficient information so that the interested engineer may build an equivalent instrument for himself. Within the dotted lines at the upper left is the circuit of the a-c measurement probe. For low-frequency a-c work, up to 10,000 cycles or more, the probe is inserted through an aperture in the left side of the cabinet so that its two prods correctly engage two matching jacks within the instrument. So arranged, a-c voltages to be measured are applied to the panel jacks labeled "AC" and "COM. GND."

For use at radio frequencies, where the inductance and capacitance of interconnecting leads are deleterious, the probe is removed, and at the end of its 3-ft. flexible shielded cable, has its prods applied directly to the circuit providing the voltage to be measured. This eliminates the effects of usual connecting leads, and allows measurements to be made up to above 300 megacycles. This figure has been established, largely arbitrarily, as the upper limit of measurement in terms of frequency. This is because, though the probe resonance is close to 600 mc with probe prods shorted at their bases, shunt capacitance becomes an increasingly serious factor as frequency is increased. The separate cathode-plate capacitance of the type 9006 diode, as well as its cathode-heater capacitance add their individual values of 1.4 and 2.2 μμf respectively to yield a basic shunt input capacitance of 3.6 μμf. This is negligibly diminished by the 500 μμf series d-c isolating input capacitor. It is increased to about double the actual tube capacitances by the "strays" associated with the necessary wiring, socket and diode load resistor. But even allowing a total of 7 μμf input capacitance shunting the diode itself and the 4-megohm load resistor, the input impedance is well above 1 megohm at 1 mc, falling to approximately 10,000 ohms at 300 megacycles by virtue of the combination of resonance and transit time effects.

Input Impedance

To the uninitiated this figure of only 10,000 ohms input impedance at 300 mc looks undesirably low. In a broad, general sense, this view is correct. In a practical sense, it has little application, for as frequency increases the effective tuned circuit impedances which may be produced today diminish very rapidly. In any event, the input resistance presented by this instrument at any frequency up to 300 mc has not been found so low as to destroy its utility, while the effective 10,000-ohm input resistance is believed to be significantly higher than has been heretofore commercially available.

In the range of 1 mc, where the input resistance is above 1 megohm, the experience of any engineer tells him that there are few circuits to be encountered in r-f amplifiers, receiver or transmitter, the behavior of which is materially altered by the addition of a 1-megohm shunt resistor. Input capacitance is another matter, and in receivers at least, trimmer capacitors must usually be readjusted when any r-f circuit is shunted by 7 μμf to compensate for the temporarily added capacitance.

The d-c input resistor is 23 megohms. This resistor might be omitted in either a-c or d-c operation, but is intentionally included in preference to allowing the measurement triode grid to float during d-c operation until it is connected to a closed-circuit voltage source. There are few d-c measurements which an input resistance of 23 megohms can seriously affect, while the elimination of this resistor, leaving a floating grid as the test prod was moved about, would tend to kick the meter off scale—not good for any meter, no matter how well protected or how carefully used. Nevertheless, if the user wishes, the d-c input resistance may be made infinite by disconnecting the upper end of the 23-megohm resistor from circuit.

The a-c probe seen in dotted lines in *Fig. 3* is switched out of circuit in d-c measurements by switching *S1a*, ganged to the same knob with *S1b* and *S1c*. The functions of *S1b* and *S1c* will be considered later. The sole function of the probe is to rectify unknown a-c voltages to produce d-c voltages which may be measured by the "vacuum-volts" itself. The vacuum tube voltmeter proper consists of the 6SN7GT dual triode vacuum tube, the 4⅝" d-c milliammeter of 1-ma full scale range, the power supply at the lower right and the resistors and switches immediately below the 6SN7GT in *Fig. 3*. This particular combination is the secret of the exceptional stability of the instrument.

Starting with the power supply, the small transformer at *T1*, feeds a full-wave 5Y3GT rectifier tube to develop a total of 300 volts d-c, approximately, across the load-bleeder resistors of 50, 10 and 40 kilohms shunting the two 8-μf, 400-volt plug-in dry electrolytic filter capacitors. In each cathode return is a 50-kilohm resistor operating to provide very heavy inverse feedback. The self-bias developed across these resistors is so great that satisfactory performance may not be had from the 6SN7GT if input voltage is applied between grid and B—, in the conventional manner. The excessive grid bias so developed is offset for measurement purposes by the opposing voltage of 142 volts, approximately, developed across the lower portion of the 10-kilohm, and across the 40-kilohm resistors between B— and ground.

The use of this inverse feedback, coupled with the two balanced triodes of the 6SN7GT, minimize greatly deviations in voltage readings despite appreciable variations in a-c line voltage.

This arrangement permits connecting the meter itself between the two triode cathodes, where it registers differences in cathode current caused by applied voltages, and where it is quite safe from damaging overloads.

Voltage Ranges

Voltage ranges corresponding to the meter scale calibration accurate to ± 2% of full scale, are basically selected for a-c or d-c by switch *S1b*, and for individual a-c or d-c ranges by switches *S2a* and *S2b*. These switches select individually hand-adjusted (and, for service, adjustable) wire-wound range-multiplying resistors, all of which are intimately associated with *S2a* and *S2b* in *Fig. 3*.

Reestablishment of meter calibration, should it ever be necessary, may be effected by applying known voltages equal to each full-scale range, and then simply setting the individual multiplier resistors with a screw-driver to give correct reading. This is about as simple as setting the mechanical zero on the conventional meter.

A very important point not so far mentioned is the matter of contact potential generated by the 9006 probe diode. This is a finite voltage which will operate to upset meter calibration unless it is compensated for. Compensation is provided by the duplicate 9006 diode at the upper right of *Fig. 3* arranged to supply a contact potential made equal by proper adjustment of its 10-megohm load resistor to that developed by the measurement probe diode. This balancing potential is fed in a-c operation only to the grid of the right, or balancing triode of the 6SN7GT which grid is grounded in d-c operation.

This shift from grounded grid for [*Continued on page 54*]

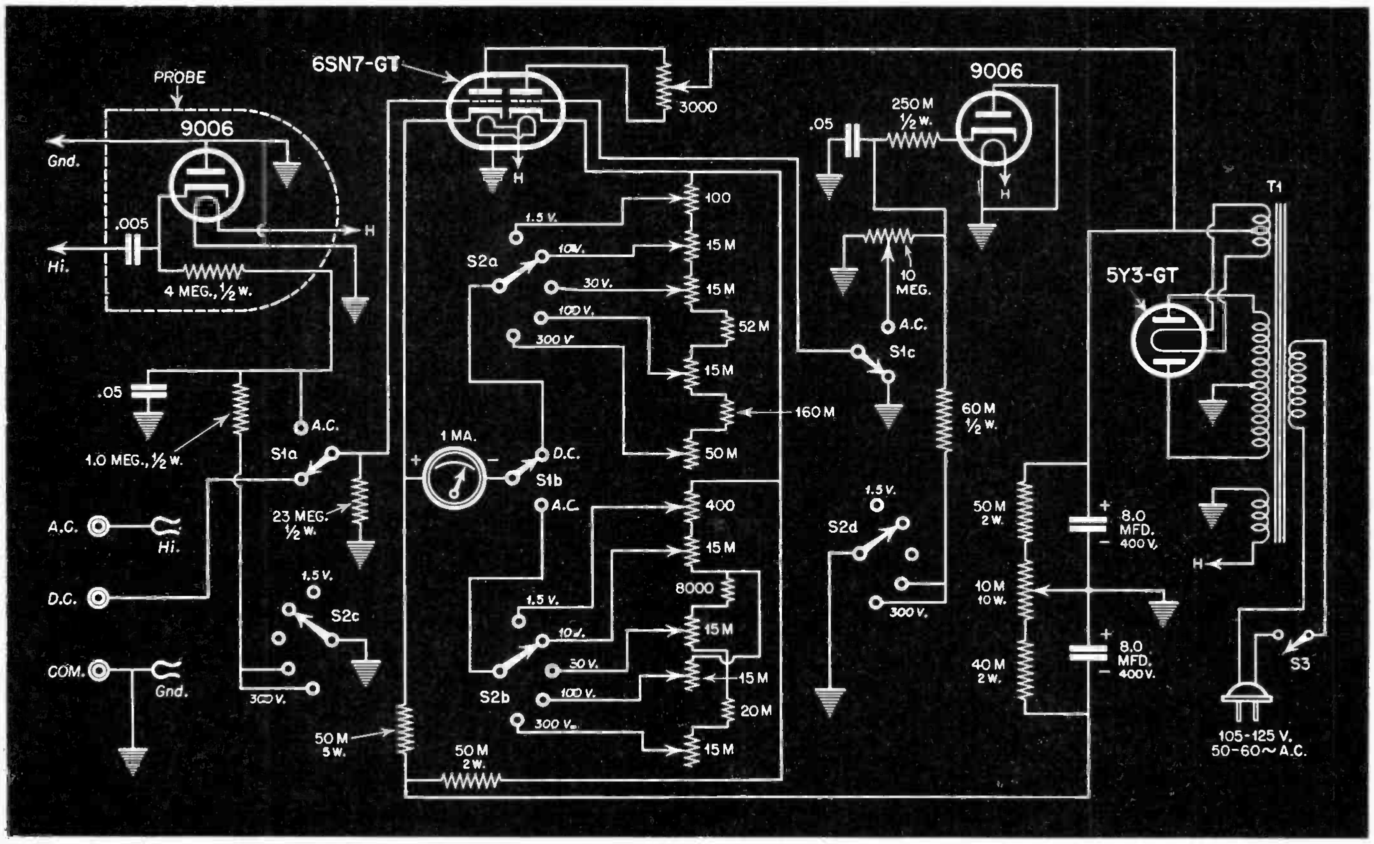


Fig. 3. Schematic diagram of the complete instrument

Automatic Test Recorder For Quartz Crystals

JOSEPH ANLAGE, Engineer, North American Philips Co., Inc.

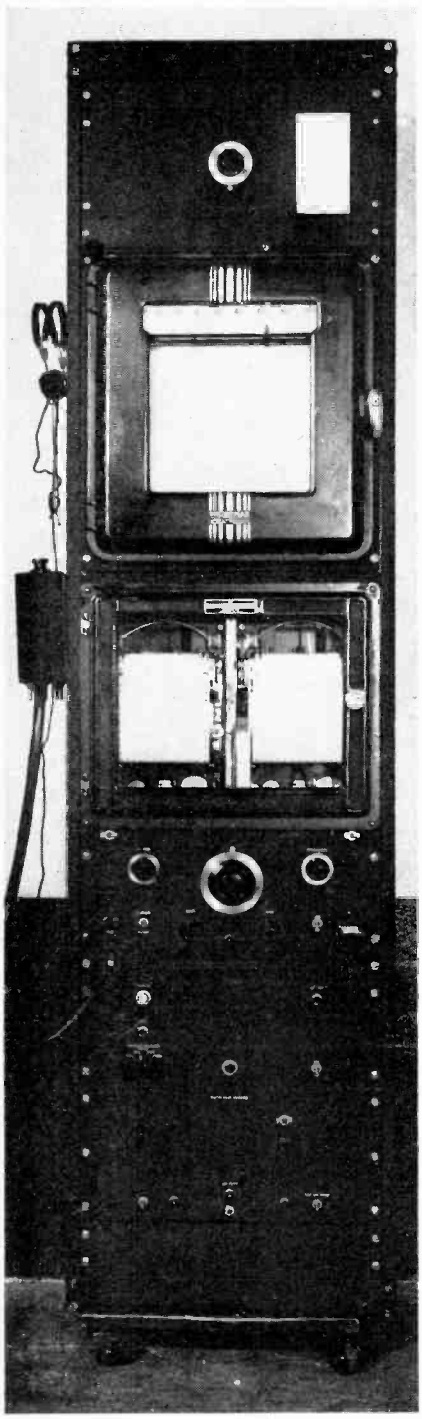


Fig. 2. Crystal test rack assembly

An improved instrument for automatically recording the characteristics of BT and AT type crystals

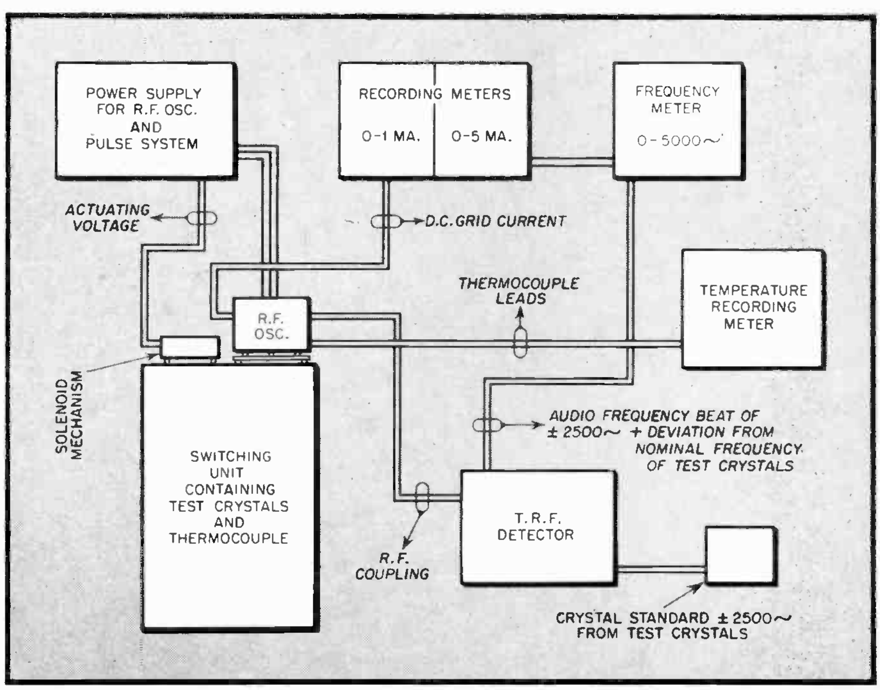
★ With the advent of mass production of quartz crystals and the need for production apparatus to meet this demand, new devices have been developed to speed up and simplify the processing of war-time quartz oscillator plates.

One of the most important functions in the manufacture of crystals is the final testing operation, where the condition of the completed crystal unit is revealed. Performance requirements are established through specifications that may vary from one crystal type to another and also in proposed applications where circuit conditions may influence the calibration accuracy; where temperature deviations may be unusual and where mechanical ruggedness may be important. All these factors must range between tolerances fixed by a specification for the manufactured type of crystal unit. In this article, apparatus designed to record automatically the characteristics of BT and AT type oscillator crystals will be described. Previous equipment had certain deficiencies, mainly from the point of view of:

1. Number of crystal units accommodated for test initially.
2. Validity of manually operated and recorded results.
3. Time required for a complete test.
4. Uniformity of tests and proper interpretation.

The test requirements for continuous recordings will not be more conveniently performed by any particular apparatus of this type but possibly equally well by all of them, depending upon the mechanical facility of each. The production methods used are known as intermittent recordings where the cir-

Fig. 1. Block diagram of complete test equipment



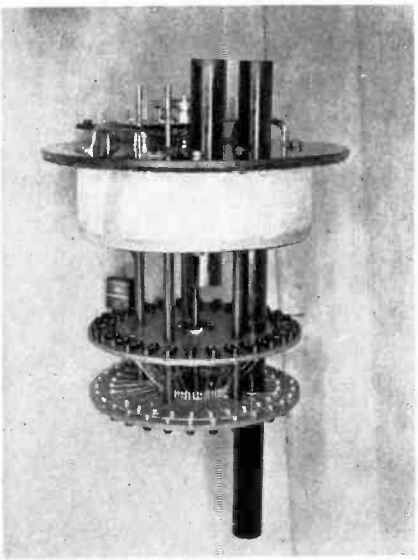


Fig. 4. Crystal switching unit

cuits are excited in succession, by a different crystal being switched into play, at time intervals depending upon the number of crystal units desired for test in a given time to meet the average specification requirements. It may be assumed that such a test will require the crystal to exhibit an activity of at least two-thirds its average maximum throughout a specified temperature range, all other factors held constant. Crystals may be exposed to temperatures ranging from —50° C. to +90° C. with a rate of temperature change not exceeding 3 degrees per minute. Characteristic measurements must take place sufficiently accurately and frequently to check crystal performance under the conditions stated.

The apparatus herein described will accommodate 59 crystal units of the same nominal frequency and type for test as a group. A sixtieth contact position is incorporated and contains a thermocouple. During a sequence of switching intermittently, this position allows a break in the series of readings plotted that can be identified as a reference, marking the interval between the first and fifty-ninth crystals.

Design

The general layout pictured in *Fig. 1* will illustrate the mechanical design and chassis arrangement. The elemental units that go to make up the final test rack and associated equipment may be identified from the photograph (*Fig. 2*) as follows:

1. Temperature recorder ("Micromax" Leeds Northrup.)

2. Dual strip recorder — (Esterline Angus Mfg. Co.)

3. T-R-F receiver.

4. Frequency recorder.

5. Pulse synchronizer and power supply.

6. R-F crystal oscillator.

Associated equipment includes an oven of sufficient thermal capacity to raise the temperature of the crystals undergoing test to the required value. This pre-heating is accomplished apart and separate from the actual recording equipment. At the beginning of recording the crystals under test are at the high-temperature limit of the test requirement. This pre-heater consists of an insulated closed circulating chamber wherein air is warmed by passing through temperature-regulated electric heater elements. See *Fig. 3.*

A switching unit device designed to hold 60 crystals of a particular type is illustrated in *Fig. 4.* This double-decked circular frame fits into a thermos jar of equivalent proportions. Its fit is sufficiently tight to prevent appreciable leakage to the room temperature air, from the joint at the mouth of the jar. Cold or warm air, as the case may be, is circulated through the thermos container by connections for intake and outlet sources, allowing a change in ambient temperature to occur around the crystals enclosed in the thermos jar. On the top side of the switching unit is a supporting socket for mounting the r-f oscillator used in conjunction with the crystals under test. A sixty-point rotary contact switch is fitted to the lower circular crystal bank, with the contact shaft centered through the switching unit. The opposite end of the contactor rod is actuated, a single contact at a time, by a solenoid plunger connected to a ratchet type gear mechanism. This also appears on top of the switching unit, and obtains its operating current through a common cable connecting the oscillator circuit to the main recording rack

In addition to solenoid current and

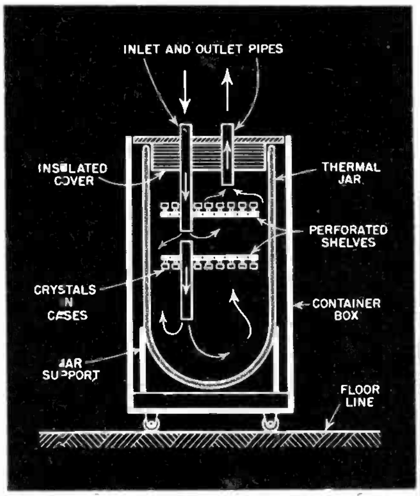


Fig. 3. Details of crystal oven

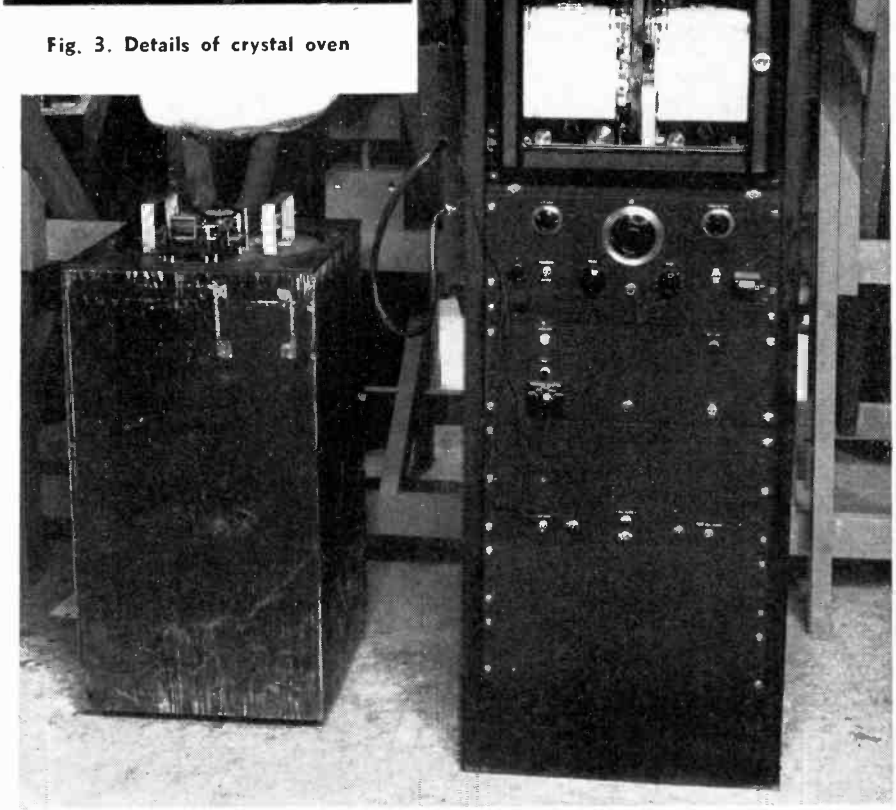


Fig. 5. In this crystal test rack the electronic temperature indicator unit is shown at the top and the crystal oven at the side

oscillator power connections, the d-c grid current developed by the crystals is coupled through the connecting cable to record directly upon the strip recorder on the left-hand side of the Esterline-Angus instrument.

Temperature Recorder

Temperature-indicating thermocouple leads are run through the connecting cable to the temperature-recording instrument. The source of the thermocouple lies in a place equivalent to that of the crystals. It is highly important to have a mass presented to the thermocouple equal to that encountered at the quartz crystal plate itself, to result in an accurate set of values under test of various temperatures. A continuous set of leads must be maintained, that is, no connections between the source and temperature recording instrument terminals may be contacted with connecting sockets, etc. if accurate transfers are to be maintained. A copper-constantan pair of thermocouple leads are used with a "Micromax" recorder made by The Leeds Northrup Company.

A second type of electronic temperature indicator is used for recording the temperature gradient of the test chamber. Similar thermocouple connections may be used as mentioned. The electronic temperature indicator is illustrated in the rack assembly *(Fig. 5)* and indicates temperature directly upon a temperature-calibrated milliammeter.

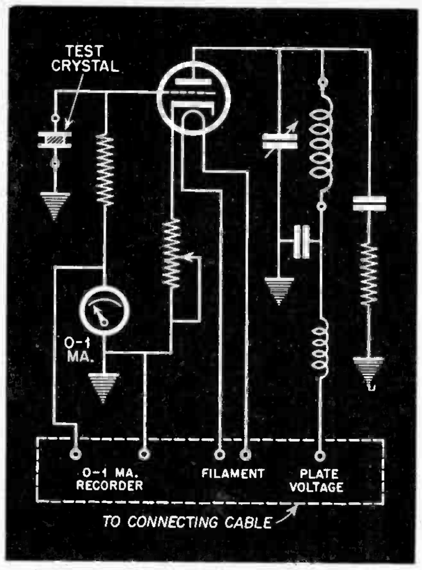


Fig. 6. R-F oscillator circuit

Local Crystal Oscillator

Connections from the rack power supply furnish filament and plate potentials for the operation of the r-f oscillator connected to the top side of the switching unit and thermos chamber. It is a conventional tuned-plate oscillator circuit fitted with a plug-in type of inductance which will allow changes in frequency ranges as desired. The tuning condenser and a 0-1 ma milliammeter are mounted at the top of the oscillator box to permit convenience in tunnig. (See *Fig. 6*).

To arrange the oscillator circuit for proper oscillation during the interval of test, a standard crystal is connected to the circuit through a socket provided at the side of the oscillator box. This standard crystal is one that has its nominal frequency carefully calibrated, and so establishes the exact tuning for the remaining crystals about to be tested. The tuning is made with the oscillator in place and proper load obtained at the open crystal position. As the beginning of the test is started at a remote temperature, the frequency calibration of the testing crystals has deviated from their nominal frequency calibration.

During the sequence of the test the oscillator adjustment must remain undisturbed if accurate recordings are to result. Insofar as practical, the oscillator circuit is designed to be similar to the particular equipment in which the crystals will finally operate.

Dual Strip Recorders

Mounted in the recording rack is a set of two recording instruments; the left-hand milliammeter has an 0-1 ma movement while that on the right is an 0-5 ma meter (*Fig. 7*). As indicated previously the crystal grid current is so adjusted that a direct indication of the relative activity of the crystal being tested is measured. The 0-5 ma meter records the frequency deviation of the crystals being tested. This is accomplished through current excitation from a direct-reading frequency meter.

Chart paper on both instruments is fixed to track in an endless fashion, that is, the starting trace is again marked when the paper length has made a complete revolution and so synchronized with the crystals being switched into the circuit one at a time. The repeat traces are directly over the previous ones corresponding to the same crystal every time. The chart moves at a speed of 3 minutes per revolution, its length being 18 inches. During this movement, a telechron clock arranged with a switching cam pulses the switching unit contact arm to a new position once every 3 seconds. One of the three seconds applies the solenoid current while the remaining two allow for pen orientation and for correction of drag. Pen response is very good when ink and weight are carefully considered. As illustrated for any particular crystal, the deviations that occur with time and temperature are traced plus and minus the starting trace. The limits are established by specifications so that any traces exceeding these limits are easily observed.

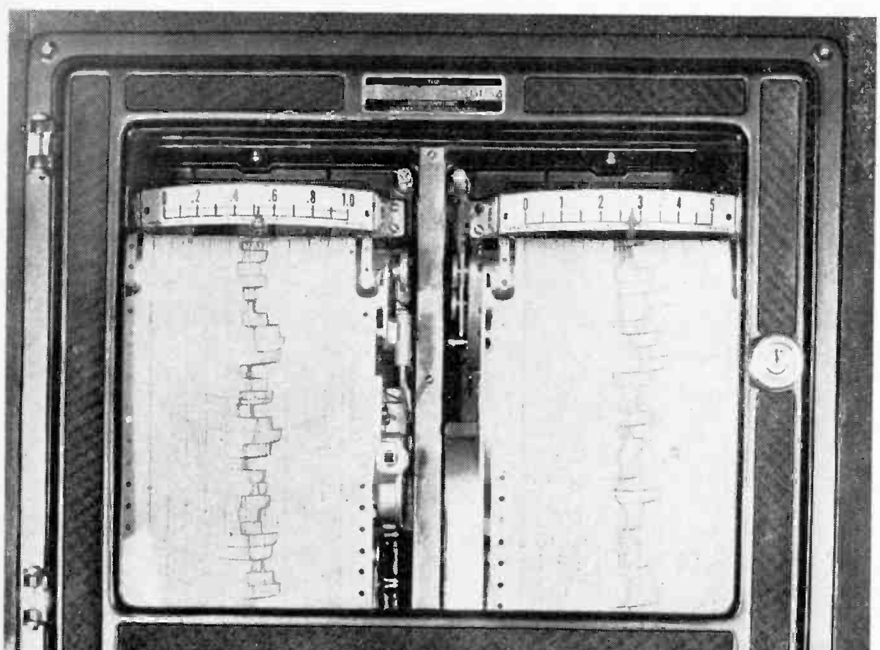


Fig. 7. The dual strip recorder. The meter on the left indicates oscillator grid current (crystal activity). The other meter records crystal frequency deviations

Frequency Meter

The frequency-meter application in the crystal test apparatus serves as a translator of small differences in audio frequency from a rectifier beat note input of a radio frequency detector. These audio frequencies are plotted on the 0-5 ma strip recording meter, during a period of time determined by the switching sequence of crystal units under test. The chief advantages in the application of this frequency meter to its desired functions are its ability to convert variations in frequency to current values with excellent accuracy and almost instantaneously. Another important requirement is sufficient output to operate a recording instrument such as the 0-5 ma recorder. The heterodyne beat note to be measured is applied to the input circuit of the frequency meter with an amplitude of at least 0.2 volt. As this instrument operates on the principle of voltage pulse generation, its characteristic operation maintains an average amplitude of operating wave-shape independent of input level, and frequency through proper amplification in the frequency meter. The voltage impulses are fed to an RC differentiating circuit, the resultant of which is rectified and coupled to the recording instrument. Bias adjustments and voltage stability are important considerations, as well as careful trimming of the frequency range calibration in the RC network.

T-R-F Receiver

The heterodyne detector or t-r-f unit (shown in the schematic diagram, *Fig. 8*) receives excitation from a link coupling situated at the r-f oscillator. In connection with the detector and built upon the same chassis is a second crystal oscillator circuit. This crystal oscillator contains an external crystal holder socket where may be plugged in a standard frequency crystal. The purpose of this standard crystal which is ground with a frequency difference of ±2500 cycles from a nominal frequency desired for test, is the establishment of a heterodyne. The beat produced is applied to the frequency meter which in turn runs the 0-5 ma recorder.

Referring to a previous statement to the effect that when adjustment is made for the start of recording, a crystal of nominal frequency is used for adjustment of the r-f oscillator: simultaneously an adjustment of the trimmer across the standard crystal will provide a frequency recording of 2.5 kc on the strip recorder. It is easy to realize now that any crystal being tested that has deviated from nominal frequency due to temperature or otherwise will create a beat note, plus or minus the established nominal value. Being adjusted at a value of 2.5 ma for 0 cycles deviation a linear deviation of ±2.5 ma represents a frequency change of ±2500 cycles. Headphones may be connected for an aural adjustment when in the process of tuning the detector.

Power Supply

In the power supply, a voltage source for filament and plate potentials is made available for the crystal r-f oscillator. An electrically driven telechron motor is connected mechanically through a circular multipoint cam to a micro switch which in turn supplies power to an oxide rectifier, the output of which actuates the solenoid switch mechanism. The pulsing current is timed for three-second intervals. With 18-inch chart lengths and 60 contact positions in the switching unit, a paper speed of 6 inches per minute will result in a series of 60 individual traces per 3 minutes. This cycle repeats itself throughout a test run. The number of revolutions obviously depending upon rate of change of temperature and length of temperature range to be included.

All other units are made with self-contained power supplies.

With each unit in complete adjustment, the crystal test run should not be interrupted for danger of upsetting the synchronization of the recordings being traced as well as altering the rate of change of temperature which must be maintained at a uniform degree. Time required for an average test consistent with requirements as described will be about two and one half hours including adjustment.

While this equipment is ideal for automatically testing crystal characteristics, its use may be extended to include an adaptation to any other electrical components required by specification to meet electrical performance tests under the conditions mentioned.

QUOTES

Physical Science

★ Physical science can provide a tonic for the ills of unemployment in the post-war world. New products are resistant to depression psychology, and experience has shown that they can be sold when old products can't. In this way, physicists can contribute to the all-important job situation.

The screen-grid tube can be cited as a yardstick for the value of new products. Radio receivers were made without it, and could be now, but they would require twice as many tubes and circuit elements and would cost twice as much. The American people spent 400 million dollars for radio receivers in 1941. Without screen-grid tubes, the cost would have been double that value. Hence the screen-grid tube saves the public $400,000,000 a year.

Dr. A. W. Hull, assistant director of the General Electric Research Laboratory, speaking as retiring president of the American Physical Society.

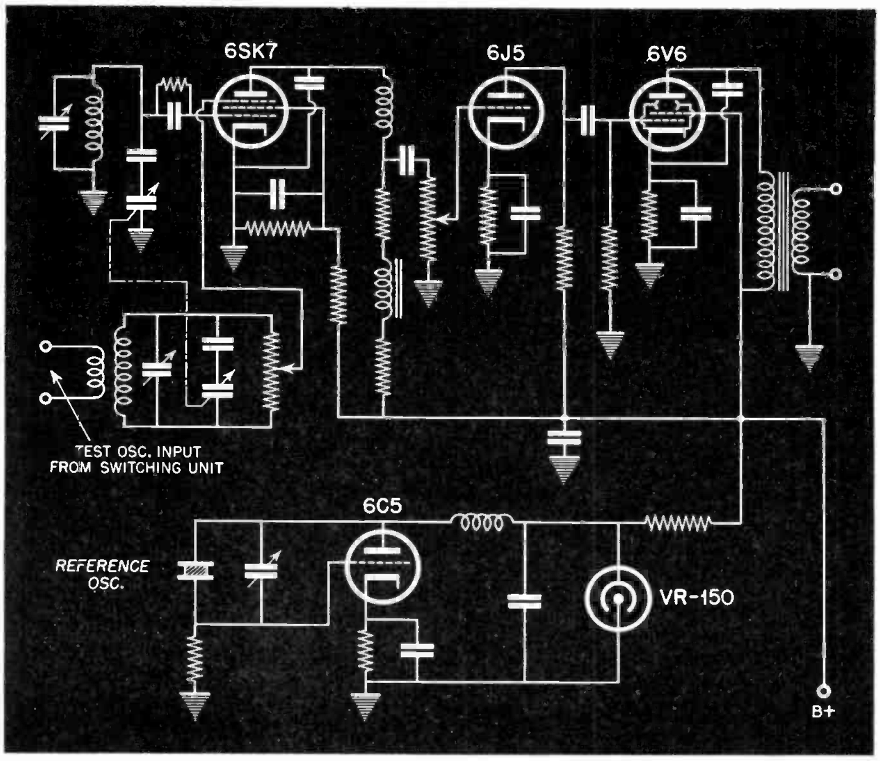


Fig. 8. Basic circuit of the heterodyne detector, or t-r-f, unit

Loop Antenna Design

A. C. MATTHEWS

An analysis of the factors which enter into the design, construction, and ultimate performance of loop antennas

★ The energy in a radio wave is equally divided between an electrostatic component and a magnetic component which are always at right angles to each other. A plane containing these lines of force represents a wave front whose direction of travel is always perpendicular to the plane as shown in *Fig. 1.* The direction of the lines of force determines the polarization of the wave. Waves are normally either vertically or horizontally polarized. A discussion of wave polarization is beyond the scope of this article, except to point out that at low frequencies the polarization of an antenna is the same as that of the waves leaving it. At high frequencies this is not strictly true, since the wave usually splits into several parts which follow different paths, thus changing the polarization from vertical or horizontal to circular or elliptical.

The energy received from a wave by an antenna will be greatest when the polarization of the receiving and transmitting antennas are the same; except for high frequencies where the polarization may change, as previously mentioned. Neglecting the electrostatic component for the moment, it is evident then that a coil of wire placed in the proper inductive relationship to the magnetic lines of force will intercept them and will serve as an antenna.

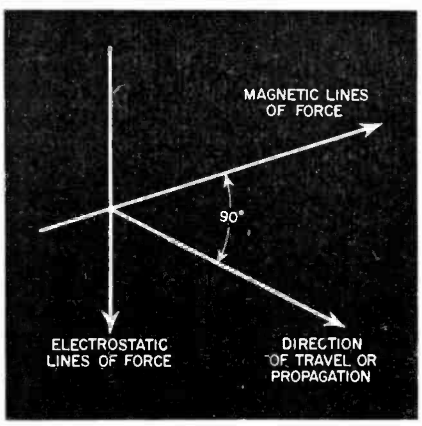


Fig. 1. Direction of wave travel with respect to its energy components

Loop Types

A loop antenna can consist of any number of turns of wire and may be in the shape of a circle, square or rectangle. It can be wound in the form of a solenoid, or flat with the turns in a spiral. A diagram of a solenoid type loop antenna is shown in *Fig. 2.* The voltage induced in a loop antenna when the wave is polarized in the plane of the loop is

$$E_L = \frac{2\pi NA \cos\theta}{\lambda} E_m \qquad (1)$$

Where E_L = voltage induced on loop, volts
N = number of turns in loop
A = area of loop, square meters
E_m = field strength, volts per meter
θ = angle between plane of loop and direction of transmitted signal
λ = wavelength in meters

The maximum induced voltage will occur when $\theta = 0$ ($\cos\theta = 1$) or when the plane of the loop lies along the direction of the transmitted wave. This is illustrated in *Fig. 3A,* where the plane of the loop is shown to be parallel to the direction of wave propagation of a vertically polarized wave. For simplicity we have shown two unequal lines representing induced voltages of slightly different phase due to the time it requires the wave to travel from one side of the loop to the other. Theoretically, no voltage is induced in the horizontal arms. Since the voltages in the vertical arms do not cancel each other, they produce a voltage which circulates a current around the loop.

In *Fig. 3B,* the loop is at right angles to the oncoming wave. Here equal voltages are induced in the two vertical arms. These voltages being equal but opposite in phase cancel each other, so that no current flows in the loop. This is not rigorously true because of ground currents, as will be explained later, however, it does serve to illustrate the action of a loop antenna.

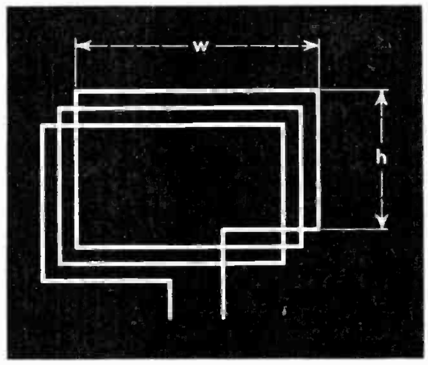


Fig. 2. Diagram of solenoid type loop antenna

Neglecting geometric shape there are several types of loop antennas, namely: high-impedance, low-impedance, shielded and unshielded. Each has its particular application, as will be pointed out directly.

High-Impedance Loop

A high-impedance loop may consist of as many as 70 turns of wire, depending on the desired operating frequency. It should be located as far away as possible from metal objects, in order to reduce losses due to eddy currents. However, the leads between the loop and the input of the receiver should be kept short in order not to introduce excessive losses due to lead capacity. Long leads have inductance as well as capacity, and obviously the two in combination prevent the use of a maximum number of turns in the loop proper, thus reducing the signal pickup. A compromise is therefore necessary between the loop location and lead length.

These factors alone are not all that need be considered in the design of a high-impedance loop. The large number of turns required increases the distributed capacity of the winding which in turn decreases the Q of the loop. A high distributed capacitance plus high-capacity connecting leads also limits the tuneable frequency range of the circuit. The frequency range is determined by the percent capacity change in the circuit. This is shown in *Fig. 4* and equation (2) where C_o = circuit capacity (including distributed loop capacity, lead capacity, etc.), f_1 = low-frequency end of range and f_2 = high frequency end of range.

$$\frac{C_1 + C_o}{C_o} = (f_2/f_1)^2 \quad (2)$$

Then

$$C_1 = C_o\,[(f_2/f_1)^2 - 1] \quad (3)$$

and

$$C_o = \frac{C_1}{(f_2/f_1)^2 - 1} \quad (4)$$

From the above it can be appreciated that the circuit capacity should be kept to a minimum. As C_o increases it is necessary to use a larger tuning capacitor to cover a given frequency range, or assuming the tuning capacitor range as being the highest practical value obtainable, then to satisfy the equation the frequency range would be decreased.

The voltage impressed on the grid of an r-f amplifier or detector tube when the loop is tuned to resonance by a variable tuning condenser can be calculated as follows:

$$\text{At resonance } -X_c = X_L \quad (5)$$

The voltage across the capacitor or coil is

$$E = \frac{i}{\omega C} \text{ or } i\omega L \quad (6)$$

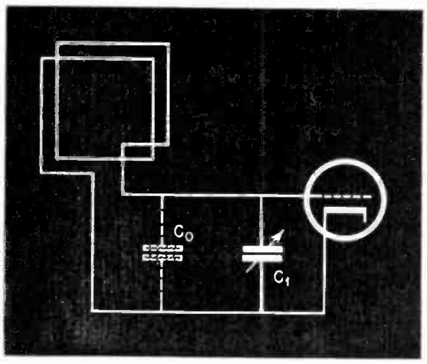


Fig 4. High impedance loop circuit

Substituting for current in the coil we have

$$E = \frac{e}{R}\,\omega L \quad (7)$$

We know that the Q or figure of merit of an inductor is

$$Q = \frac{\omega L}{R} \quad (8)$$

Substituting Eq. (8) into Eq. (7) we have

$$E = eQ \quad (9)$$

This assumes that the radiation resistance can be neglected, which is true for most cases. Thus it is seen that the voltage delivered to the grid of an r-f amplifier or detector is equal to the voltage induced into the loop *(e)* multiplied by the Q of the loop. It is desirable then to have as high a loop Q as possible since the signal delivered to the receiver input is directly proportional to the Q. Also, the higher the loop Q the better the signal-to-noise ratio. This is particularly important when the loop is to be used for direction-finding purposes, since a high noise level makes the null point obscure and very difficult to determine.

A high-impedance loop has certain disadvantages which must be considered when selecting the type of loop for a particular application. The most serious disadvantage is its susceptibility to moisture. The insulation must be of the highest quality throughout, otherwise moisture will increase the distributed capacity and decrease the leakage resistance across its terminals, reducing its high Q and thereby its effectiveness.

Another disadvantage occurs when it is necessary, because of interfering objects, to locate the loop at some spot remote from the receiver. The long connecting cable introduces additional circuit capacity which effectively impairs the performance. When the loop must be located within the radio cabinet, as in home radio receivers, the presence of the metal chassis and the wood cabinet appreciably reduces the loop Q. Here, also, the effect of moisture is noticeable, since most wood cabinets are not waterproofed on the inside and moisture is readily absorbed. It is not uncommon for the Q of the loop to be reduced 50% or more when mounted in a wood cabinet in close proximity to the receiver chassis. Of course, in many low-priced receivers, particularly where size is an important factor in the salability of the unit, it is sometimes desirable to regain sensitivity, lost through the reduction in loop Q, by increasing the i-f or r-f amplifier gain. Under these conditions a good null point is practically nonexistent, but this unfortunately is the price one must pay when a high-impedance loop is mounted within a small cabinet in close proximity to the chassis.

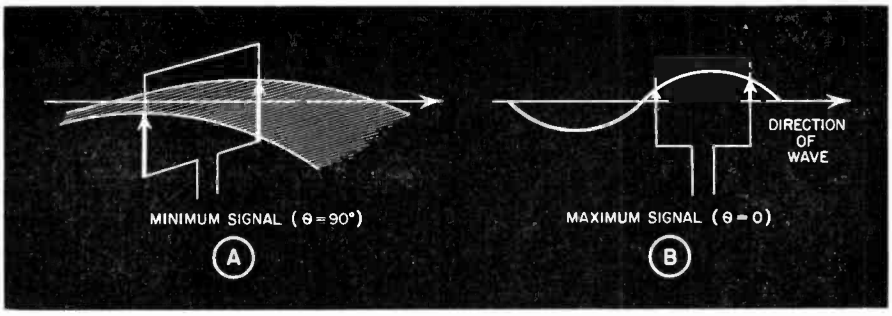


Fig. 3. Manner in which a loop antenna operates

Low-Impedance Loop

A low-impedance loop consists of from 2 to 6 turns of large diameter wire (usually No. 10 B&S or litz equivalent) wound in a circle, square or rectangle. Since the inductive reactance is comparatively low, it is commonly known as a low-impedance loop. As shown in *Fig. 5* the loop may be connected to the receiver by means of a coaxial transmission line or cable. Rubber dielectric may be used, since the connection cable need not be of low-capacity construction.

The receiver input circuit consists of a powdered iron core coupling or matching transformer with its secondary tuned by a conventional variable air tuning condenser. On the design of the coupling transformer depends the performance of the low-impedance loop. Without going into a detailed mathematical analysis, which would involve numerous engineering approximations, an attempt will be made to describe physically the design of a typical coupling transformer.

Design of Transformer

The primary inductance should be approximately equal to the inductance of the loop antenna and the primary Q should be as high as possible. The transformer can be made either with a separate primary and secondary or as an auto-transformer having a primary tap for the loop. The winding should consist of litz wire having from 7 strands of No. 40 to 45 strands of No.

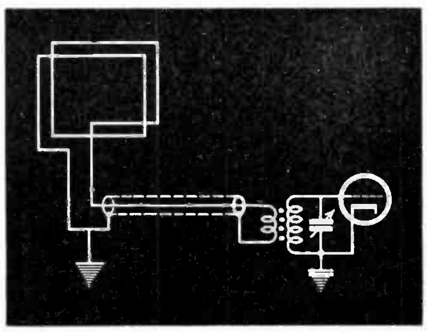


Fig 5. Low impedance loop circuit

41; the latter is about the maximum size of commercially procurable litz.

The coupling between primary and secondary should be made as high as possible, or until the secondary Q starts to decrease quite rapidly with increased coupling. The coefficient of coupling of a typical design averages approximately 85%. This is attained by the use of high-quality powdered iron as the core, with a minimum of spacing between the core and the winding. The winding may be concentrated by employing a universal-wound coil, as shown in *Fig. 6*. Some designs make use of cup shields made of the same material as the core. This increases the coupling somewhat at the expense of added capacity and a slight loss of Q. However, a shielded coil can be located in close proximity to metal parts without loss in Q, whereas the unshielded coil should be spaced at least 1½ times its diameter from the metal chassis or other parts. This is oftentimes a factor in the design of small receivers.

Besides the coefficient of coupling between primary and secondary and the high Q of both windings, the ratio between primary and secondary reactances is important. Offhand this would indicate that the greatest voltage gain would be obtained by using a single-turn loop and a very high ratio of primary-to-secondary turns in the coupling transformer. This is not strictly true, because a one-turn loop would have such a low reactance that the characteristics of its connecting cable could no longer be neglected. Therefore a compromise must be effected between the reactance of the loop and the characteristics of the connecting transmission line. The loop winding, as mentioned previously, is usually made of No. 10 B & S gauge solid wire or equivalent. The large size was chosen for its low resistance, thus improving the Q of the loop. Copper-clad steel is often employed because of its rigidity, since it is only necessary to have sufficient copper over the steel core to satisfy the equation for the skin depth of r-f currents.

Briefly, the low-impedance loop has the following advantages over the high-impedance type. It is less susceptible to humidity effects, is not seriously affected as to Q when placed near a metal chassis (except for directivity pattern), the mechanical construction is more sturdy and the loop does not necessarily have to be installed near the receiver input.

Directional Patterns

Two factors influence the directivity pattern of a loop antenna. One is the antenna effect caused by capacity between the loop and ground which makes the loop act as a vertical antenna. The magnitude of this effect is determined by the physical dimensions of the loop and is independent of the position of the loop. The other factor influencing the directivity is dependent on whether the loop is of the solenoid or spiral-wound construction. In the former the voltage developed in one turn will differ slightly from that in every other turn, since each is at a slightly different distance from the signal source. Because of the capacitance between turns, a current will flow across the loop which produces a voltage 90° out of phase with the current. Since the loop is tuned to resonance, the desired signal voltage and current are in phase, so the resultant of the two voltages produces a distorted field pattern, as shown in ***Fig. 7.***

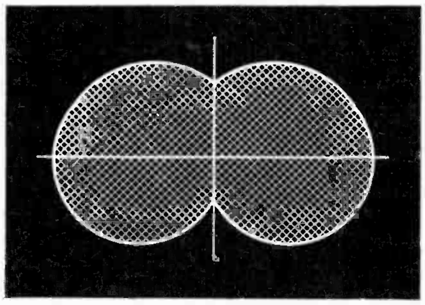


Fig. 7. Field pattern of high-impedance solenoid loop antenna

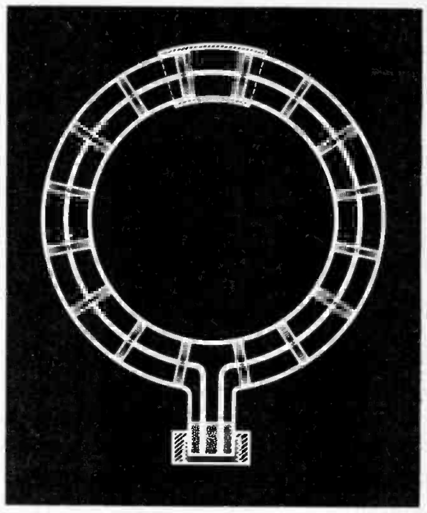


Fig. 8. Cross-sectional view of shielded low-impedance loop antenna

A spiral-wound loop will have a similar directivity pattern, part of which, as in the solenoid type, is due to the antenna effect; the remainder, which is in quadrature with the main loop effect, is due to the winding pitch. The smaller the number of turns, and the closer the spacing between turns, the less noticeable the effect.

These factors may be effectively eliminated by the use of an electrostatic shield around the loop. This not only solves the electrical problem but also provides mechanical strength, stability and weather protection for the unit. *Fig. 8* shows a typical shielded loop construction. The shield consists of non-magnetic metallic tubing (preferably aluminum) formed into a circle with a break at the top. The circle is completed by the insertion of insulating material at the break, thereby preventing the shield from becoming a closed turn. The turns are spaced in the center of the tube by means of insulators and the shield is grounded. Since the shield is not a closed circuit, the magnetic field which produces a voltage across the ends of the loop will not produce any current flow in the shield but will penetrate it and induce a voltage on the loop conductors. However, the electrostatic field will cause currents to flow from each side of the shield to ground. These currents induce voltages in the loop in such a manner that a current flow opposite to that in the shield results. Since the currents are nearly equal and flow in opposite directions, they cancel each other and do not produce a voltage across the loop terminals. Furthermore, since the electrostatic voltage producing these currents is within the loop, no ground currents will be produced which will distort the field pattern when the shield and one side of

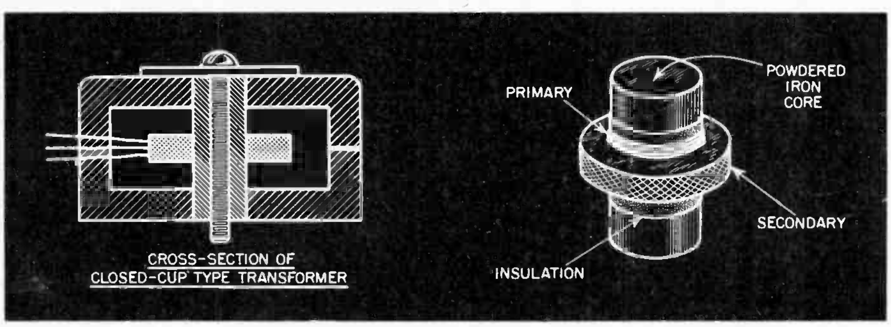


Fig. 6. Low-impedance loop coupling transformers

the loop are grounded. See *Fig. 9* for a typical pattern.

An additional advantage of the shielded type loop is its noise-reducing properties. As mentioned previously, the desired signal has equal magnetic and electrostatic components, and since the majority of noise sources are known to have a predominance of electric components their elimination by means of an electrostatic shield greatly reduces the noise pickup. Of course, the shield does reduce the signal pickup slightly (approximately 3 db) due to a reduction in the loop Q. This is more noticeable in high-impedance loop systems, since the overall circuit is more affected because of the higher initial loop Q. However, this loss in signal pickup can be easily regained in the r-f or i-f amplifier.

For direction-finding applications it is often undesirable to have a figure-eight field pattern, which obviously has two maximum and two minimum positions. This can be overcome very easily by combining the signals derived from the loop (in proper phase relationship, with a signal received on a vertical antenna. The resultant field pattern is a cardioid which has only one maximum and one minimum, as shown in *Fig. 10*.

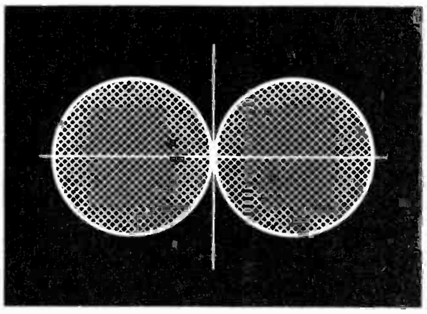


Fig. 9. Shielded low-impedance solenoid type loop antenna pattern

Measuring Receivers

The most commonly used method of measuring receivers employing a tuned loop as the antenna is given in the Institute of Radio Engineers "Standards on Radio Receivers: 1938."

A transmitting loop is employed to create a known inductive field into which the loop or receiver is placed. The field pattern of the transmitting loop is shown in *Fig. 11* under conditions as set up for receiver measurements. The inductive field is at right angles to the radiation field, so the loop being measured must be placed coaxially to the transmitting loop. This is, of course, not true when greater distances separate the two antennas, since the inductive field decays rapidly. The natural frequency of the transmitting loop and its associated leads should be several times that of the signal frequency employed.

The relation between the current in the transmitting loop and the equivalent standard-antenna voltage can be easily calculated from Eq. (1) as given in the IRE Standards. Eq. (1) in the IRE Standards when rewritten becomes,

$$E = \frac{18.85\ Nr^2\ I}{X^3} \qquad (10)$$

Where E = field strength at the receiving loop antenna (μv/m)
N = number of turns in the transmitting loop
r = radius of transmitting loop (centimeters)
I = current through transmitting loop (milliamperes)
X = distance between transmitting and receiving loop (meters)

From Eq. (10) we can rearrange and evaluate the current, thus,

$$I = \frac{X^3}{18.85\ Nr^2} \qquad (11)$$

Assuming the transmitting loop to be fixed as to size and turns and spaced at a fixed distance from the receiving loop, then the current is proportional only to the field strength.

For convenience of operation it is desirable to design the transmitting loop such that the field strength can be read directly from the test signal generator by dividing its output by 10. Since most signal generators are capable of one volt output, this would give us an equivalent field strength of 100,000 microvolts per meter for measurement purposes. Such a field strength is adequate for most cases.

The distance between loops should not be too great, otherwise metal objects in the vicinity of the measuring setup will affect the results. However, the spacing should exceed twice the largest dimension of either loop, otherwise an error will result. A choice of one-half meter should be a satisfactory value for most cases. However, where loops have a dimension greater than 12 inches, the spacing should be increased. Remember, the field strength is inversely proportional to the cube of the distance, so it will no longer be one-tenth of the signal generator output voltage if the spacing is changed from one-half meter.

Suppose the transmitting loop has a radius of 10 centimeters and two turns of quarter-inch copper tubing spaced ¼ inch comprise the coil. (This would give us a fairly low reactance for broadcast frequencies.) Substituting the chosen values in Eq. (11) we have,

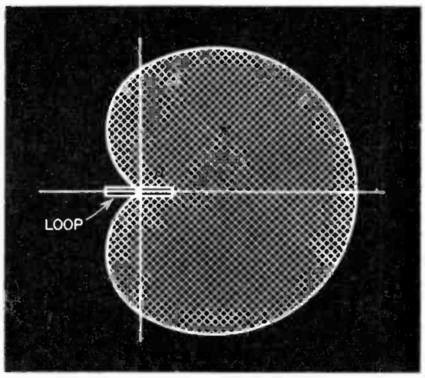


Fig. 10. Pattern obtained from a loop and vertical antenna combination

$$I = \frac{100{,}000 \times 0.5^3}{18.85 \times 2 \times 10^2} = 3.31 \text{ ma} \qquad (12)$$

Since our original intention was to use a one volt r-f output from the signal generator to give us 100,000 μv/m field strength it will be necessary to put a resistor of 302 ohms in series with the transmitting loop to limit the current to 3.31 ma. This resistor is high enough in comparison with the loop reactance so that the latter has only a negligible effect on the impedance. The output impedance of the signal generator should be low, otherwise the loading effect of the resistor will introduce an error in the measurements. All measurements should be made with the low-potential side of the transmitting loop facing the receiver, in order to minimize electrostatic coupling effects. The receiving loop should remain in its cabinet together with the chassis and any batteries employed, since these will simulate normal operating conditions. This procedure should also be adhered to when checking the loop characteristics alone. Here we are interested in the loop Q and its figure of merit.

The figure of merit is obtained by dividing the first grid sensitivity of the receiver by the overall sensitivity with the loop connected.

The Q is usually measured by the

[*Continued on page 56*]

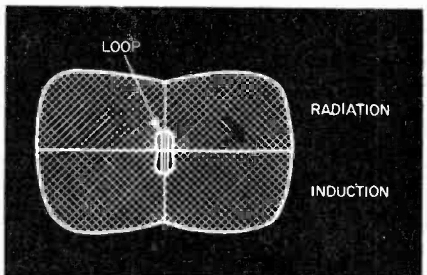


Fig. 11. Field pattern of loop antenna at a distance of less than one-tenth wavelength

Radio-Electronic Design and Distribution Problems

SAMUEL S. EGERT

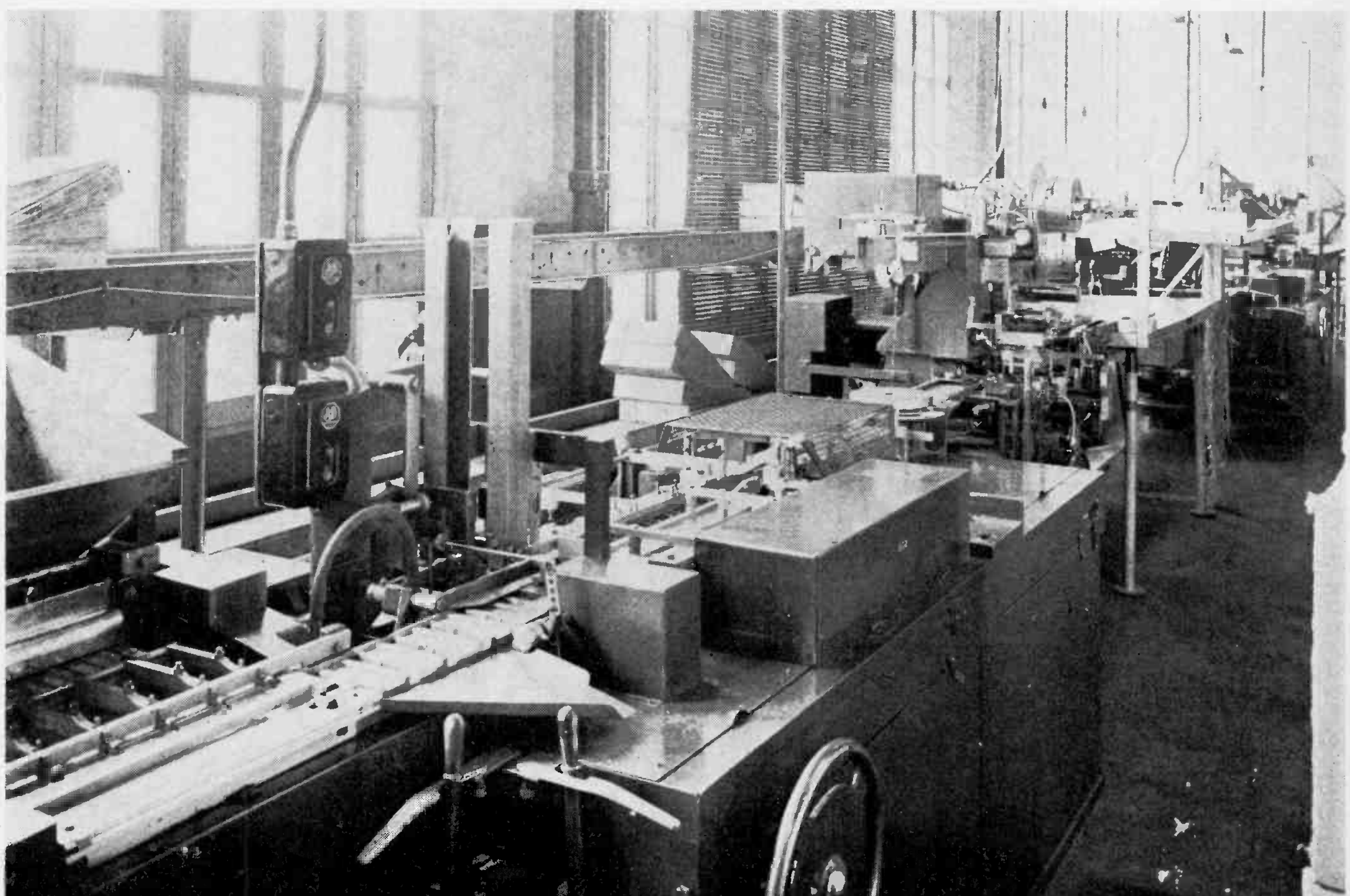
Basic considerations which should be investigated before a product design is undertaken, and the specific engineering features that are affected by the general field of application of the device

★ The purpose of this article is to analyze some of the problems which will arise in the design and distribution of industrial electronic devices. As the engineer will bear the greatest portion of responsibility for the execution of this work it will be to his advantage to understand some of the factors involved. This holds true for both general product design and distribution.

It was felt that rather than approach the subject from a general viewpoint, a much greater understanding of what is involved could be obtained, if the discussions centered on some specific item, which would be typical of a wide variety of the equipment that will be produced in the industrial electronic field. The best item for this particular application that has come to the writer's attention, is the photocell relay.

The photocell relay falls into the category of an item which is usually too inexpensive to sell through direct channels, and at the same time too complex to sell directly from a catalog, without full technical data. As a matter of fact, in most cases, to complete the sale, actual engineering services are required.

Our discussion therefore, will be on the type of product which should have reasonably good production possibilities, and which must be set up for distribution through an outside agency, having the necessary technical personnel to complete the sale.



Packaging machines equipped with General Electric Co. photocell relays in plant of American Chicle Co.

Product Design

The fundamental circuit of the photocell relay is relatively simple, yet the engineer has a difficult problem confronting him when attempting to design a unit which should have reasonably good production possibilities and which can easily be distributed. Basically, there are two ways to design such a unit.

1—So that it will have universal use in a wide portion of industry.

2—So that it has specific use for a patricular application that will have good production and distribution possibilities.

In the design for universal use attention must be centered on physical requirements such as ruggedness, underwriter's acceptance, mounting facility, appearance, etc. Electrically, careful attention must be given to the type of tubes employed, so that easy replacement is assured; need for the ability to vary the focal length of the beam to take in a wide range of possible uses; a good relay construction to insure against possible overloads in the output circuit, etc.

In the design of a photocell relay for specific use the chief problem is to find the application. Once a specific use has been discovered, which has a market that will allow reasonably good production, the problem of the engineer is more straightforward. All mechanical and electrical ideas to be incorporated are designed for the specific application, in accordance with good engineering practice.

It is interesting to note that the number of possible designs of photocells in the specific application group are unlimited, depending principally on the ingenuity of the engineer to find them. In much the same manner specific items for other fields, such as electronic heating, alarm circuits, sound equipment, etc., also have the same degree of possible distribution and use, depending on the ability of the engineer to find uses.

Distribution

Our two types of basic designs of photocell relays; namely, (1) for universal use, and (2) for specific use, also require different distribution methods.

In merchandising a photocell relay for universal use a wide portion of industry must be covered. Also, each problem for photocell relay application will vary. Advertising publicity, literature and distribution houses must be selected to attract and handle the varied problems which will arise.

In merchandising a photocell relay for specific use, the engineering problems and customer's needs are known factors, making the distribution problem much simpler.

G. E. photocell relays controlling toothpaste-tube fillers in Bristol-Meyers plant

From a distribution standpoint, therefore, the photocell relay design for specific use is the most desirable. To a large extent this is one of the basic problems in the industrial electronic field as a whole. If engineers are able to create electronic devices for specific use and merchandise them properly, they will succeed in converting industry to the use of electronic tools far more rapidly than by depending on industry to adapt general designs to their own particular applications.

Distribution Agency

There are four qualifications required of a distribution house or agency to distribute a line of photocell relays properly. They call for (1) financial responsibility, (2) ability to merchandise the device, (3) ability to apply and install the equipment, and (4) ability to handle service problems.

The four qualifications are difficult to find in one organization. Financial responsibility usually ties in with the ability to merchandise; while the ability to engineer and apply ties in more with service. Necessity may require tying in a technical agency with a distribution house. The available supply of technical men or organizations suitable for such work is pitifully small. Below are some of the methods that might be employed to accomplish the purpose. No set rule can be adhered to, as conditions will vary depending on territory to be covered and the type of outlets available.

1—Independent electronic industrial consultants can be tied in with neighboring distribution houses to supply technical data.

2—Often an electronic specialist can be employed directly by a good distribution house. This is the ideal combination.

3—Independent engineering-minded factory representatives can supply the sales and engineering needs for distribution.

4—Specialty engineering service accounts acting as factory branch service stations can be created in certain territories to aid selling jobbers.

In the final analysis, however, the most important function required at the present time is the ability of a man

[*Continued on page 52*]

Radio Design Worksheet

NO. 22—QUARTER-WAVE LINES; CONVERSION FORMULAE

QUARTER-WAVE LINES

The input impedance Z_1 looking into a quarter-wave transmission line is

$$Z_1 = \frac{Z_0^2}{Z_2}$$

where Z_0 is the characteristic impedance of the line and Z_2 the terminating impedance. *(Fig. 1)*.

If the termination is open-circuited, i. e., $Z_2 = \infty$, then

$$Z_1 = Z_0^2/Z_2 = Z_0^2/\infty = 0.,$$

i. e., the input to the lines has the same effect as a short circuit. This, of course, holds only for that frequency or wavelength at which the line is one-fourth wavelength long.

If the termination is a short circuit, i. e., $Z_2 = 0$, then

$$Z_1 = Z_0^2/Z_2 = Z_0^2/0 = \infty.$$

The input impedance of such a line has the same effect as an open circuit. Actually, due to line losses, etc., it has about the same effect as a high-Q antiresonant circuit.

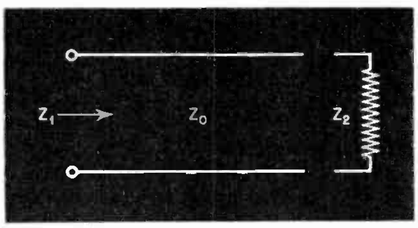


FIG. 1

A quarter-wave line is often used as an impedance transformer to match a non-resonant transmission line to an antenna. For this condition, let Z_a = impedance of the antenna at the point to which it is desired to connect a transmission line, and let the impedance of the non-resonant transmission line be Z_L. See *Fig. 2*.

To match both the line and the antenna, as would a transformer of proper ratio, we must have the quarter-wave line impedance $Z_0 = \sqrt{Z_a Z_L}$, whence the input impedance to the quarter-wave line will be

$$Z_1 = Z_0^2/Z_2 = Z_a Z_L/Z_2.$$

But $Z_a = Z_2$, whence $Z_1 = Z_L$, i. e., the impedance is matched both to the antenna and to the non-resonant transmission line.

An application of this is frequently used to match a grounded half-wave radiator to a coaxial line, as shown in *Fig. 3*. This is the familiar J antenna.

C. R. Nelson

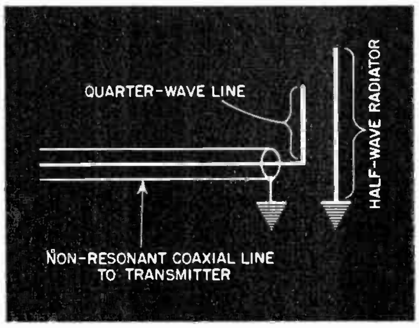


FIG. 3

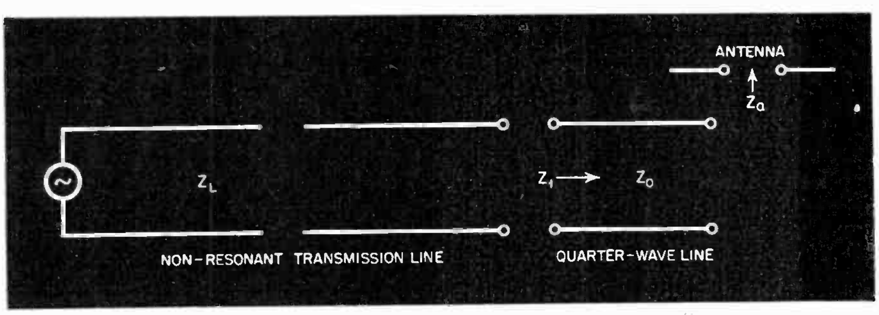


FIG. 2

EXACT CONVERSION FORMULAE FOR SERIES AND SHUNT CIRCUITS

In certain types of network problems it is desirable to convert an equivalent series circuit to its equivalent parallel circuit and vice versa. Certain formulae are available which can be used where the power factor of the circuit is low, but these equations will introduce appreciable error where the power factor becomes large.

The following conversion equations are exact and can be used in all general solutions both for RC and LC circuits.

The foundation for these formulae is that in the equivalent circuits shown in *Figs. 4A* and *4B* $Z_a = Z_b$.

From circuit theory the following relationship can then be established.

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

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

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

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

(5) $$X_2 = \frac{R_1 R_2}{\sqrt{R_1(R_2 - R_1)}}$$

(6) $$X_1 = \sqrt{R_1(R_2 - R_1)}$$

(7) $$R_1 R_2 = X_1 X_2$$

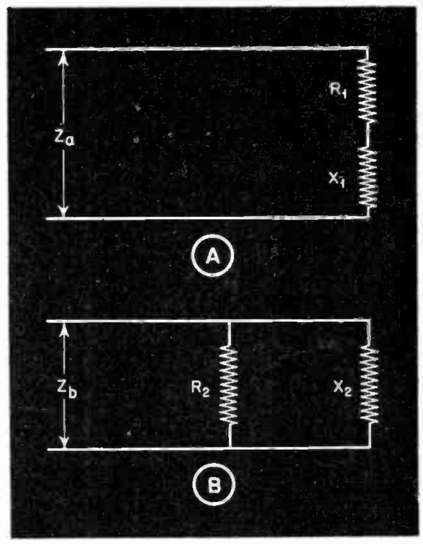


FIG. 4

Equations 1 to 4 are the ones most generally used, while those from 5 to 7 often find special application.

Only numerical values of reactance are used in the formulas, thus obviating the use of the (j) operator.

A numerical example is given to show the use of the equations.

Given a series circuit of

$R_1 = 5$ ohms

$X_1 = 10$ ohms (for example capacitive)

$$R_2 = \frac{R_1^2 + X_1^2}{R_1} = \frac{5^2+10^2}{5} = 25 \textit{ ohms}$$

$$X_2 = \frac{R_1^2 + X_1^2}{X_1} = \frac{5^2+10^2}{10} = 12.5 \textit{ ohms, capacitive}$$

In all cases where these equations are used, X_1 and X_2 are of the same type of reactance.

William Vissers, Jr.,

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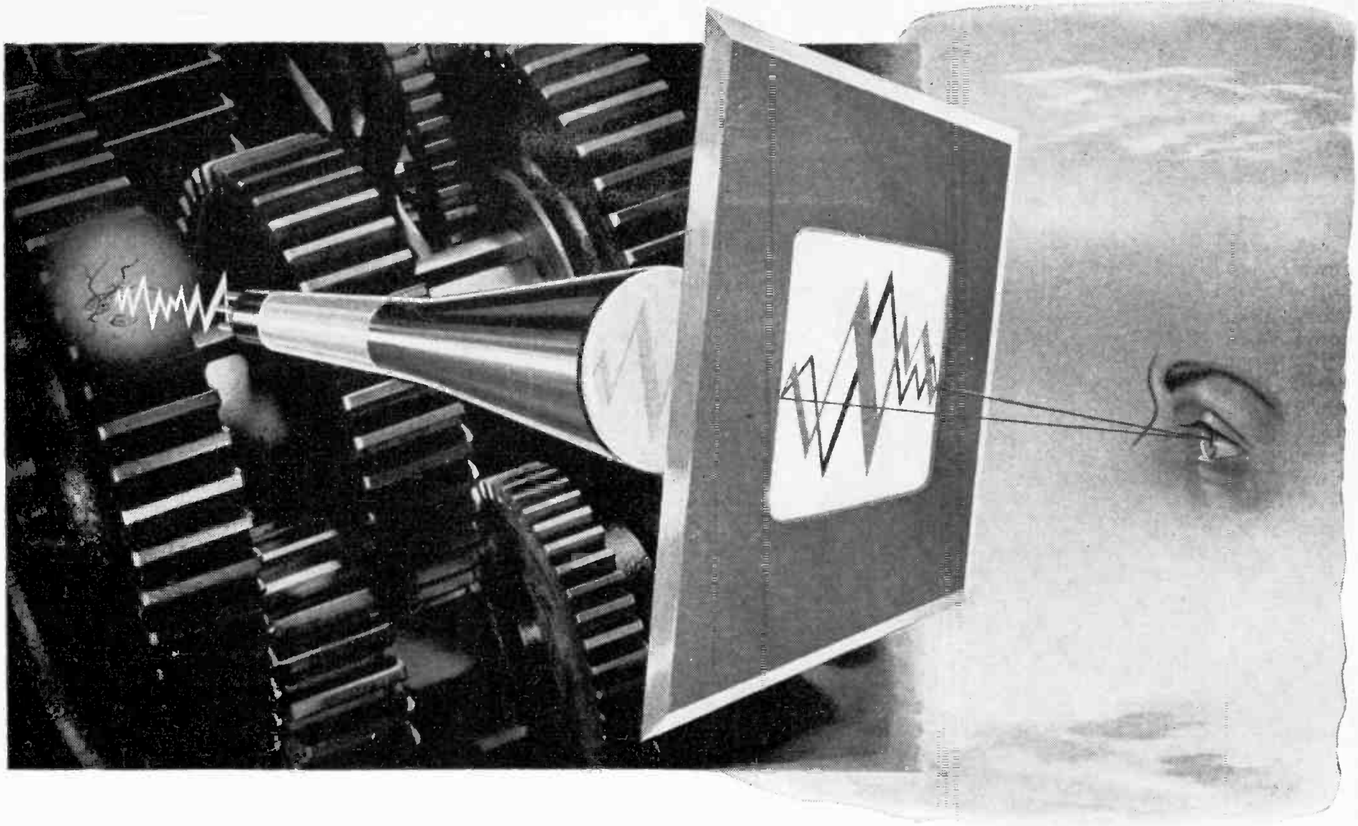

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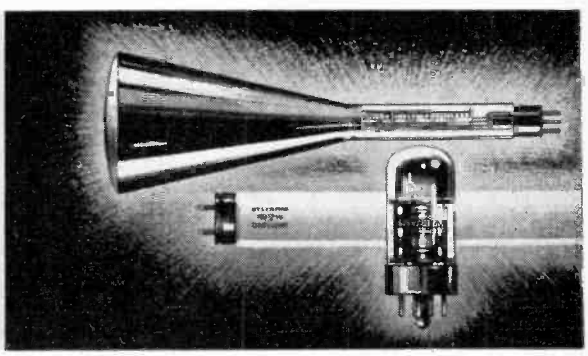

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Rating Radio Receivers—A. H. Grebe—*Radio Broadcast,* Vol. 16, March 1930, page 276.

Rating of Broadcast Receivers—D. B. Green—*Radio Engineering,* Vol. 10, Aug. 1930, page 27.

High-Frequency Amplification—W. Greenwood—*Model Engineering,* Vol. 62, Feb. 6, 1930, page 131.

The Selectivity of Wireless Receivers—W. Greenwood—*Model Engineering,* Vol. 62, Jan. 2, 1930, page 17.

The Selectivity of Wireless Receivers, Part II—W. Greenwood—*Model Engineering,* Vol. 62, Jan. 16, 1930, page 63.

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The Cooperative Radio Laboratory—D. Grimes—*Radio-Craft,* Vol. 1, May 1930, page 584.

How to Test Radio Receiver Performance—S. Harris—*Radio-Craft,* Vol. 1, June 1930, page 621.

What is Detector Overload?—S. Harris—*Radio-Craft,* Vol. 1, April 1930, page 514.

Single Tuned Circuit in 5-Tube SW Set—H. E. Hayden—*Radio World,* Vol. 17, Aug. 9, 1930, page 6.

Tuned Impedance RF—H. E. Hayden—*Radio World,* Vol. 18, Oct. 18, 1930, page 5.

Constructional Details of a Popular Set Modified to Use Battery Valves—F. H. Haynes—*Wireless World,* Vol. 27, Dec. 17, 1930, page 672.

Engineering Trends in Receiving Sets at Atlantic City—K. Henney—*Electronics,* Vol. 1, July 1930, page 176.

Thorough Filtration and Matching in Double Push-Pull AF—H. B. Herman—*Radio World,* Vol. 17, Aug. 16, 1930, page 6.

Engineering the Battery Radio Set—W. H. Hoffman & D. R. Mix—*Radio Engineering,* Vol. 10, Oct. 1930, page 38.

Aircraft Radio Receivers and Broadcast Service—J. C. Hromada—*Airway Age,* Vol. 11, July 1930, page 922.

Essential Tests for Component Parts of Electrical Radio Receivers—H. E. Kranz—*Radio Engineering,* Vol. 10, Nov. 1930, page 41.

The Design of a Portable Signal Generator—R. S. Kruse—*Electronics,* Vol. 1, Sept. 1930, page 285.

[*To be continued*]

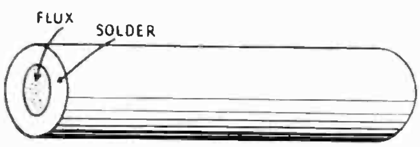
NEW PRODUCTS

FLUXRITE SOLDER

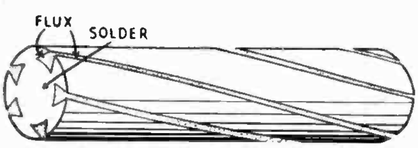
A new type of fluxed wire solder, which contains flux in longitudinal grooves on the surface rather than in the conventional core, has just been placed on the market. According to the manufacturer, the product represents the first basic improvement in fluxed wire solder design since the introduction of this type of material a number of years ago.

The new material, called Fluxrite and put out by National Lead Company, 111 Broadway, New York, is said to overcome completely an inherent disadvantage of regular cored solders which supply flux and solder to the surface simultaneously. Since the flux in the new product is outside rather than inside, it liquefies and flows onto the work before the solder melts. This insures thorough and complete fluxing and results in stronger and better solder joins.

In addition to pre-fluxing, the new solder also is said to guarantee an unbroken flow of flux. Interruptions in the flow sometimes occur with cored solders due to gaps or voids in the flux core. Since the new product has more than one flux-filled groove, there is naturally a continuous flow at all times.



CONVENTIONAL FLUX-CORE WIRE SOLDER



NEW TYPE OF WIRE SOLDER WITH FLUX IN GROOVES

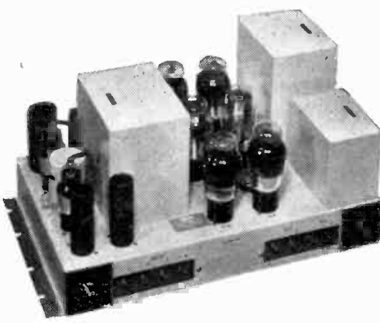
An additional advantage claimed comes from the fact that the flux supply being outside the wire, is always visible to the user and can be checked quickly and readily. Gaps or voids in ordinary cored solders are not detectable until after soldering begins.

The new product, which contains a recently developed special flux, comes in the same diameters as regular cored solder. It is available in two compositions designated as Red Stripe and Green Stripe. These designations refer to the color of the flux which has been specially dyed in each case for easy identification.

LANGEVIN A.F. AMPLIFIER

The Langevin Company, Inc., of 37 West 65th Street, New York, N. Y., has just announced a new amplifier known as Langevin Type 101-A. Its outstanding virtue is excellent low-frequency waveform at high output levels, which makes it unique among commercial amplifiers.

Volume range is excellent, inherent noise



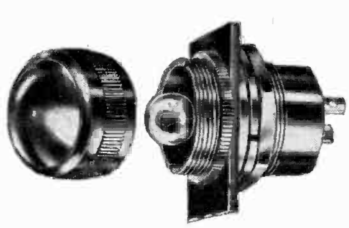
level being 68 db unweighted below full output of plus 47 vu at 2% rms harmonic distortion. With the input impedance of 600 ohms, the gain is 60 db. Using bridging input, the gain is 46 db. Output impedance is adjustable 1 to 1000 ohms. Gain vs. frequency and power output vs. frequency characteristics available upon request.

"COMPACTO" PILOT LIGHT

The Dial Light Co. of America, Inc., 90 West St., New York, N. Y., announces a new pilot light assembly known as the "Compacto." It is intended to adapt a large jewel holder to a panel where mounting space behind the panel is limited, and to provide a large surface light on a low-voltage panel.

It is made of brass or aluminum, with bakelite socket housing. The screw-in type jewel holder facilitates bulb replacement from front of panel. Trademarks, numerals, letters, or special signals may be incorporated in the jewel assembly. A wide variety of finishes, lens types and colors, are available.

The unit has silver-plated vibration-proof terminals, and may be had grounded or ungrounded. The socket accommodates the following lamps in all voltages: T3¼ single contact, TS-53, and Mazda No. 51 G3½. All are miniature, bayonet-base types.



Complete information and catalog available on request to manufacturer.

WEBSTER VOLTAGE REGULATORS

Data on a new, high-wattage voltage regulator has just been released by Webster Products, 3825 W. Armitage Ave., Chicago 47, Ill. Known as the VR-2200 Series, these carbon-pile voltage regulators were developed for air-borne applications. They dissipate 300 to 400% more power than previous conventional designs, yet occupy the same chassis space . . . with 8% less cubic volume . . . only 6% heavier.

Many different applications are possible. In one the resistance of the carbon pile is in one side of the line and the regulator operates to vary this resistance automatically so as to produce constant voltage across the load. In another typical application, the voltage regulator varies the field excitation of an inverter, alternator or special dynamotor in such a manner as to produce constant output voltage across the load. Where the machine is delivering a.c., a rectifier may be provided to supply the regulator solenoid circuit.

The VR-2200 Series units will handle 100 watts in the pile with an air flow through the fins of approximately 25 cubic feet per minute, and up to 50-75 watts without air blast. Piles can be provided with a resistance range of the order of 20 to 1, the total range or maximum values being from less than 1 ohm to about 100 ohms.

"COPROX" RECTIFIERS

"Coprox," a group of copper oxide rectifiers, has been announced by Bradley Laboratories, Inc. Gold contacts on the copper oxide "pellets," highly adaptable mountings, and pre-soldered lead wires,

[*Continued on page 46*]

A problem solved, designed, and produced in ninety days — and made possible by longstanding research and experience.

RATING DATA

Voltage and Wattage Ratings:—

TYPE 1

Resistance Value	Maximum Wattage Rating	R.M.S. Voltage Rating based on wattage
Up to 1.9 megohms	12 watts	9 kv. max.
2.0 to 10 megohms	9 watts	10 kv. max.
Above 10 megohms	based on voltage	

TYPE 2

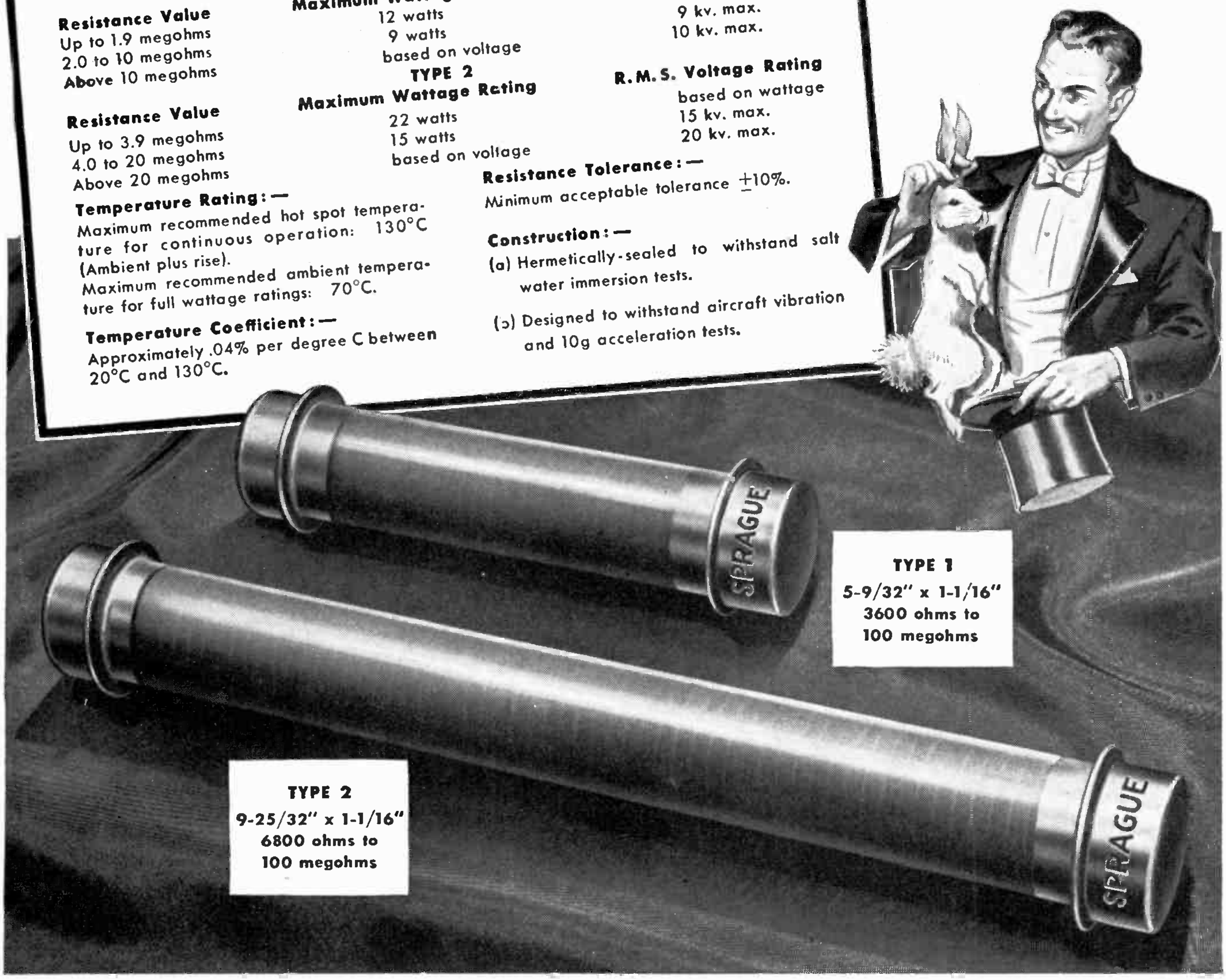
Resistance Value	Maximum Wattage Rating	R.M.S. Voltage Rating based on wattage
Up to 3.9 megohms	22 watts	15 kv. max.
4.0 to 20 megohms	15 watts	20 kv. max.
Above 20 megohms	based on voltage	

Temperature Rating:—
Maximum recommended hot spot temperature for continuous operation: 130°C (Ambient plus rise).
Maximum recommended ambient temperature for full wattage ratings: 70°C.

Temperature Coefficient:—
Approximately .04% per degree C between 20°C and 130°C.

Resistance Tolerance:—
Minimum acceptable tolerance ±10%.

Construction:—
(a) Hermetically-sealed to withstand salt water immersion tests.
(b) Designed to withstand aircraft vibration and 10g acceleration tests.



SPRAGUE MEG-O-MAX

HIGH-RESISTANCE, HIGH-VOLTAGE RESISTORS

Less than 3 months from the presentation to Sprague Koolohm Resistor engineers of the problem of designing high-resistance value units capable of dissipating power at voltages up to 20 kv. and at high ambient temperatures, the first Sprague Meg-O-Max Resistors were on the job! Moreover, they used practically no critical materials, were of smaller physical size, and presented a degree of resistance stability and mechanical ruggedness not available in other units, exclusive of costly wire-wound meter multiplier types!

Entirely unique in construction, Meg-O-Max Resistors are formed of a series of molded segments. These are joined non-inductively, and the assembly is then encased in a hermetically-sealed, rugged glass envelope provided with ferrule terminals to withstand aircraft vibration tests, salt water immersion tests, and tests for mechanical shock produced by rapid acceleration.

In addition to use as a high-voltage bleeder and as a broad accuracy meter multiplier for a voltage indicator, Meg-O-Max Resistors find many applications in measuring instruments, rectifier systems, high-voltage dividers, and as broad accuracy meter multipliers. Specify Meg-O-Max for High-Resistance—High-Voltage requirements.

Data sheets gladly sent upon request. Samples sent only on firm's request, giving details of application.

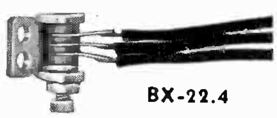
SPRAGUE SPECIALTIES COMPANY
Resistor Division • North Adams, Mass.

A NEW DEVELOPMENT BY THE MAKERS OF KOOLOHM INSULATED WIRE-WOUND RESISTORS
TRADEMARK REGISTERED

or other arrangements to prevent overheating during assembly of equipment using these rectifiers, are innovations.

BX-22.3

BX-100

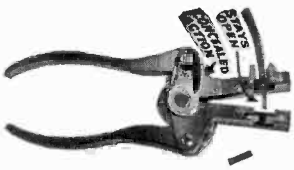


BX-22.4

BX-100, a center tap, full-wave rectifier is completely enclosed in Bakelite and rectifies high-frequency current, operating in special circuits up to 8 megacycles. BX-22.3 is a double bridge rectifier, with excellent temperature and temperature-current characteristics. BX-22.5 is a single half-wave rectifier, BX-22.2 a full wave, and BX-22.4 a double half-wave. Conservative ratings show very low forward resistance, combined with high leakage resistance. Full information can be obtained from Bradley Laboratories, Inc., 82 Meadow Street, New Haven 10, Conn.

NEW WIRE STRIPPER

A new model of the Speedex Wire Stripper incorporating an improved automatic "stay open" feature provides an important time-saving advantage when stripping the insulation from very fine stranded wires. The mechanism of the new tool is designed to hold the jaws of the stripper open until the wire is removed.



A new handle design makes easier operation possible when the stripper is used as a production tool by girls with small hands. The stripper removes insulation from all types of solid or stranded wire, without crushing, over a wide range of sizes from No. 8 to No. 30. It can be used to cut wire when desired. 750 to 1000 wires can be stripped per hour by the average operator without fatigue. Hardened steel precision ground cutting blades can be purchased separately. Manufactured by General Cement Mfg. Co., Rockford, Illinois.

PORCELAIN-CLAD CAPACITORS

For high voltage d-c applications where space is limited, new solder-sealed porcelain-clad type FPC Inerteen Capacitors are announced by Westinghouse Electric and Manufacturing Company.

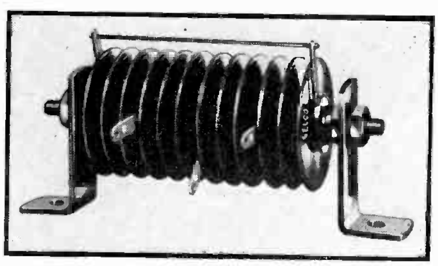
From 7,500 volts up to and including the 200,000-volt class, the capacitor elements are hermetically-sealed in a tubular, wet-process porcelain body with solder sealed end closures. The end closures act as the capacitor terminal by connecting the element leads at opposite ends, utilizing the porcelain tube as insulation.

By eliminating the large metal case and bushings required by metal case capacitors, the new porcelain-clad capacitors help maintain minimum over-all dimensions. Larger types are furnished with or without cast mounting flanges. Where castings are used, the capacitors are solder-sealed, then castings are cemented on with mineral-lead compound.

Additional information on type FPC Capacitors may be secured from Dept. 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

"SELCO" POWER RECTIFIERS

The "Selco" line of power rectifiers is announced by Selenium Corporation of America, 1800-04 West Pico Boulevard, Los Angeles 6, Calif.



Seven disc sizes ranging from ¾" to 4½" in diameter are available.

All the units are stated to be moisture proof and to have permanent characteristics. Assemblies with output up to 1000 amperes can be supplied.

Rectifiers are of the selenium type and are claimed to offer the advantages of high efficiency, high overload factor, unlimited life, maximum output per unit weight and advantageous temperature characteristics.

Selco rectifiers are available for bolt or stub mounting direct to equipment or with mounting brackets as per specs.

"EC" CAPACITRONS

The new "EC" oil type Capacitrons are designed as standard components to replace many similar types of special capacitors used in the production of war equipment. They are being manufactured in several capacity ranges with d.c. working voltage ratings from 600 to 1,500 to meet U. S. Signal Corps and Navy specifications.

The new units are locked on the chassis by means of a solid nut and lockwasher through a single hole to clear the ¾"-16 threaded bakelite neck. The bakelite neck is lock-spun into the extruded, insulated

metal container, making possible a 100% hermetic seal. Grounding of either insulated terminal is readily accomplished with a special groundlug. Dimensions of the 3-mf. and 4-mf. size units are 1½" in diameter by 4½" in height. Capacitrons, Inc., 318 West Schiller Street, Chicago 10, Ill.

INDUSTRIAL X-RAY UNIT

Searchray Model 150, second in a series of safe, self-contained, easily operated X-ray units for industry, is announced by North American Philips Company, Inc., through its Industrial Electronics Division, 100 East 42nd Street, New York City.

Searchray 150 is designed for inspection of parts, assemblies and finished products of metal, hard rubber, plastic, bakelite, ceramics, dielectric materials, etc. It makes possible the taking of highest quality sharp radiographs quickly by plant personnel under controlled conditions, without the expense of a skilled X-ray technician or the cost of a lead-lined room.

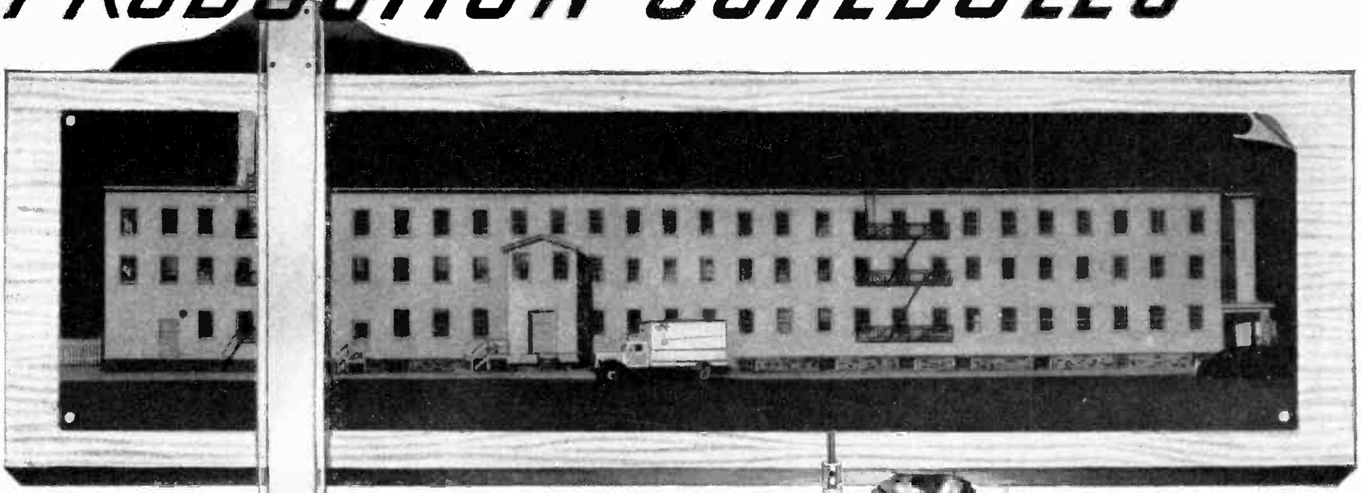
Searchray has a continuous kilovolt regulator which permits adjustment during viewing operation at any point from 0 to 150 Kv, so that, depending on density and thickness of the part under observation, greater clarity on the fluoroscopic screen can be obtained. The apparatus can also be set for correct metal thickness on a direct-reading scale when radiographs are to be taken.

Long tube life on continuous or intermittent operation is assured by an electrical circuit so arranged that high tension can only be applied at a relatively low value. An automatic, electrically operated water valve controls the cooling of the tube.

Searchray's overall height is 82 inches, the radiographic compartment being 25¾ inches high, 35 inches long and 25 inches deep. It is designed for operation on 220 volts, single phase, 60 cycles. Weight is approximately 600 lbs.

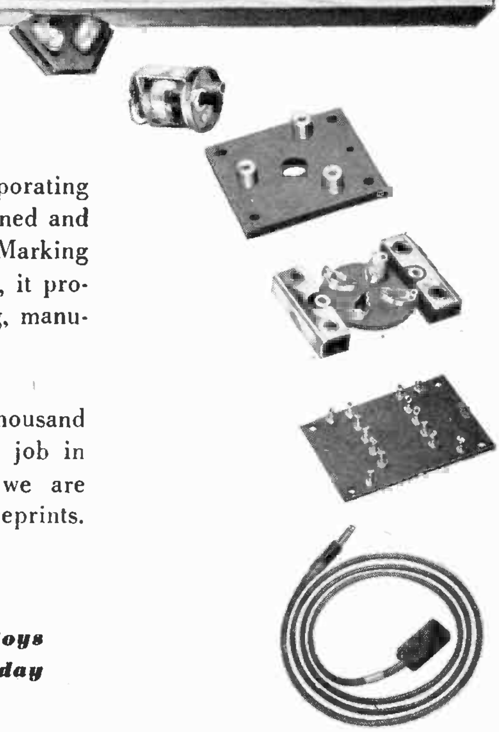
Designed for *urgent*

PRODUCTION SCHEDULES

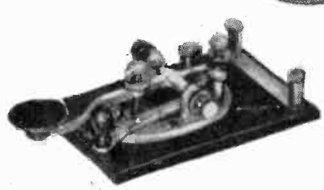


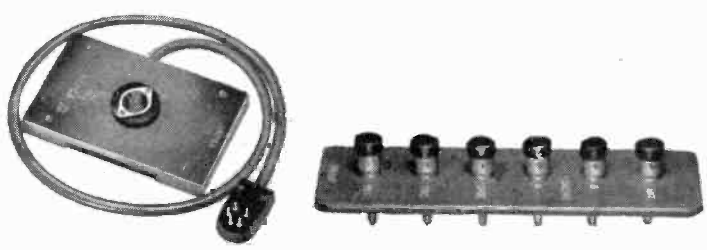
THIS is the new ARHCO plant. Incorporating more than 60,000 square feet of space, it was planned and designed for today's urgent production schedules. Marking another milestone in our successful 21-year growth, it provides even better facilities for research, engineering, manufacturing and delivery.

Out of this new ARHCO plant come over two thousand individual components . . . each one doing a big job in radionic and industrial applications. Moreover, we are equipped to produce special parts from your blueprints. Quotations and advice furnished upon request.



Put more dollars to work . . . tell the Boys you mean it by buying more War Bonds today





ARHCO RADIO PRODUCTS

American Radio Hardware Co., Inc.

152 MACQUESTEN PARKWAY SOUTH • MT. VERNON, NEW YORK

MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT

THIS MONTH

RMA "MID-WINTER CONFERENCE"

All industry resources were marshaled at the three-day RMA "Mid-Winter Conference" toward delivery of the 1944 war radio-electronic program officially stated as 50% larger than last year. More than one hundred leading industry executives attended the semi-annual RMA conference, including many group meetings, at the Stevens Hotel, Chicago, January 11-13.

President *Galvin* of RMA and other industry leaders predicted that the greatly increased war production program would require utmost industry mobilization, with manpower difficulties a major bottleneck. There appeared no prospect of any civilian radio production this year and the industry probably will be among the last for reconversion from war production.

Plans to meet the stepped-up war program, approaching $5 billion in 1944, predominated at the Chicago conference. Manpower problems, including larger employment of new workers and also returning servicemen; war contract terminations and financing problems were major measures for the work outlined.

New and expanded services for RMA members, including additions to the RMA headquarters staff in Washington, also were authorized and much new RMA committee work arranged. Cooperation with the various government agencies on the military program, as well as on the distant industry reconversion problems, also were planned. Several officials, including Army and Navy, and Director *Ray C. Ellis* of the WPB Radio & Radar Division, participated in the industry conference.

TELEVISION GROUP FORMED

The following group of organizations were represented at a meeting at the Palmer House in Chicago and formed an organization known as Television Broadcasters Association, Inc.:

Allen B. DuMont Laboratories, Inc., Balaban and Katz Corp., Columbia Broadcasting System, Don Lee Broadcasting System, Earl C. Anthony, Inc., General Electric Co., General Television Corp. (Boston, Mass.), Hughes Tool Co., Intermountain Broadcasting Corp., International Detrola Corp., The M Journal Co. (Milwaukee Journal), KFRE, Fresno, Calif., Midland Broadcasting Co., N. W. Ayer & Son, Inc., National Broadcasting Co., Philco Corp., Television Productions, Inc., WGN, Inc. (Chicago Tribune), WOR (Bamberger Broadcasting Service, Inc.).

The meeting was proposed and organized by the Society of Television Engineers, an organization of engineers with headquarters in Los Angeles and represented at the meeting by *Philip G. Caldwell* and *Curtis Mason*.

The principles and organization code under which the group would operate were decided upon and an organization committee of the following individuals was selected: *Allen B. DuMont*, Chairman, *F. J. Bingley, Robert L. Gibson, O. B. Hanson, E. A. Hayes, C. W. Mason, C. W. Miner, Paul Raibourn, Lewis Allen Weiss.*

In awarding this plaque to UTC's president, his employees have not only recognized his cooperation but have gone out of their way to show it

Necessity for the organization was found in the prospects for the immediate development of large scale television activity after the war.

The object of the organization is to foster and promote the development of the art of television broadcasting.

Two classes of membership have been arranged for, namely, active voting members, a group to which all organizations operating a commercial or experimental television broadcasting station, who have a construction permit therefor, or who have an active application therefor with the F.C.C., are eligible. Affiliate, non-voting memberships were arranged for all others interested in television.

WAC Sergeant Mary J. MacGuire and W. J. Halligan, president of Hallicrafters, with display model of Signal Corps mobile radio, the Hallicrafter SCR-299.

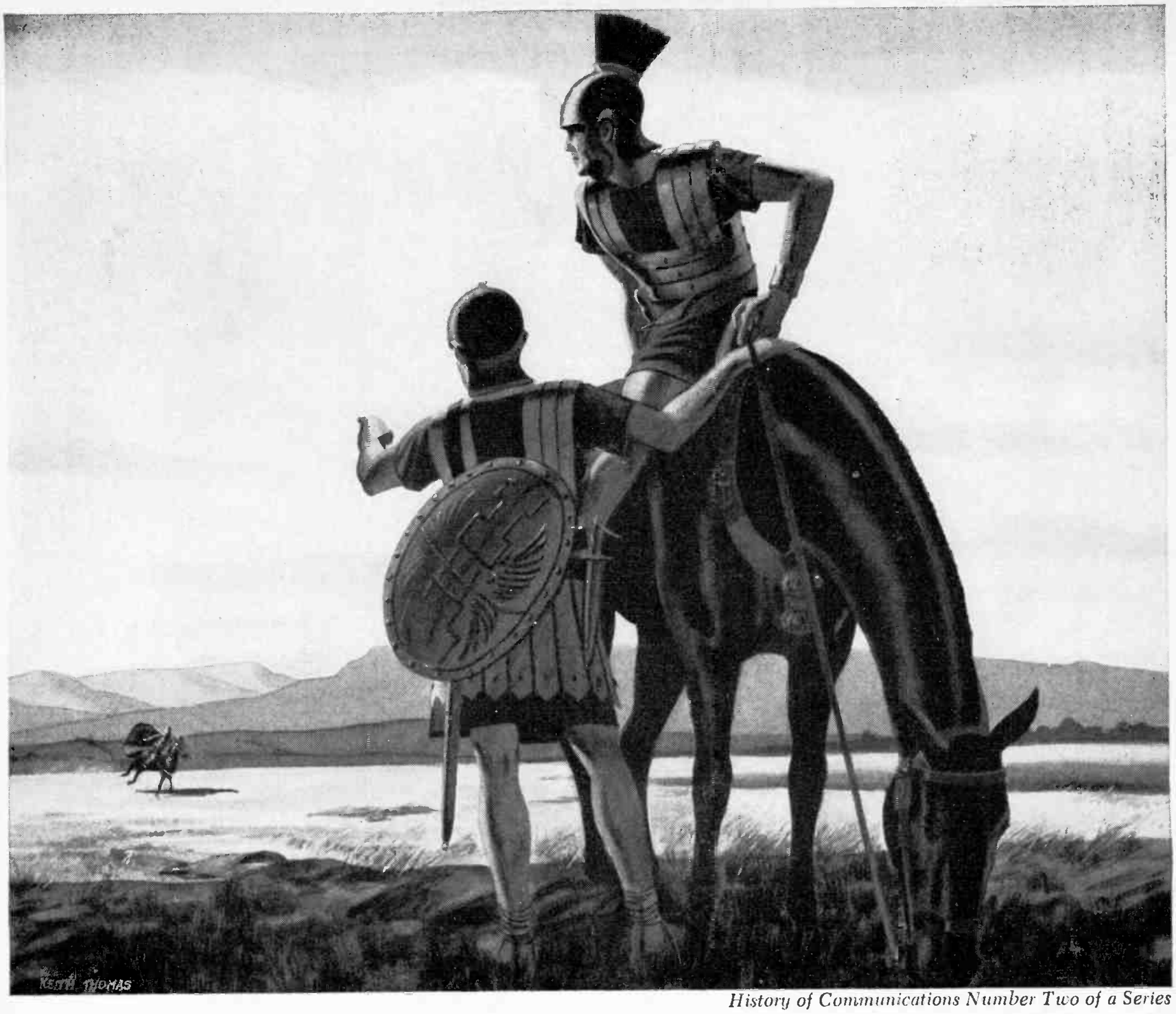
NEW ASA STANDARDS

The American Standards Association has announced the approval of a new American War Standard for Glass Radio Insulators (C75.8-1943), developed by a group of representatives of the radio industry in conjunction with representatives from the U. S. Army Signal Corps and the U. S. Navy Bureau of Ships. This work was undertaken at the request of the WPB.

This standard should be vitally important in the preparation of new manufacturing facilities for glass insulators and will facilitate their production as well as simplify their procurement by the Armed Services.

These specifications cover the performance requirements, test methods, and standard dimensions for a standard series of glass insulators of the quality required by the Army and Navy. The basic specifications for glass material is the American

[*Continued on page 50*]



History of Communications Number Two of a Series

COMMUNICATIONS BY ROMAN POST RIDERS

In the early days of the Romans and Phoenicians the fastest means of communication was the post riders, who carried news and War dispatches from the battle front. As fleet as their horses might have been, their speed does not begin to compare with electronic voice communication. The twist of a dial and the pressing of a button—in the flash of a second the message comes through. Clear cut speech transmission with Universal microphones reduces error and expedites the delivery of the message.

Today Universal microphones and voice communication components are being used throughout the world on every battle front filling a vital need and "getting the message through."

< 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

INGLEWOOD, CALIFORNIA

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

War Standard, Ceramic Insulating Materials, Class L, C75.1-1943.

RCA SPREADS KNOW-HOW

Union officials have joined with factory executives at RCA Victor's Camden plant in a unique program to help expedite delivery by sub-contractors of essential parts used in building radio and electronic equipment for the armed forces.

The idea, which was advanced by the labor-management War Production Drive Committee, consists simply of passing along to other labor-management committees of sub-contractors methods which have been successfully employed in RCA's own war production. In the process they are helping to expedite shipments by these sub-contractors of vital parts and sub-assemblies which RCA Victor workers need to complete their own production schedules.

NEW TREATING EQUIPMENT AT FORMICA PLANT

Capacity of the Formica Insulation Company, Cincinnati, manufacturers of laminated plastics, to use raw materials for fabrication will be increased between 20 and 25 per cent by installation of new treating equipment involving the infra-red principle of heating, *D. J. O'Conor,* president, has announced.

Simultaneously, *George H. Clark,* vice president and chief engineer of the company, disclosed that high priorities have been granted for the manufacture and installations of the new treating equipment, which in cooperation with Cincinnati contractors is expected to be completed around March 15.

Clark, describing the technical advantages of the infra-red treating equipment, reported that its use will enable the Formica plant to handle more raw materials and consequently expand the over-all capacity of production.

FCC ACTIONS

The Commission en banc amended Sections 10.123 and 10.153 relating to "coordinated service" of municipal police and state police radio stations, respectively, so as to delete the requirement that applicants or licensees in these services must file with the Commission copies of contracts with other municipalities, counties, or governmental agencies to which coordinated service is rendered. It should be noted, however, that it still remains necessary to apply to the Commission for specific authority to render coordinated service, and any applicant or existing licensee proposing to furnish, or now furnishing, such service, who has not already obtained such specific authorization, should file a notarized request therefor promptly. Such request may be in the form of a notarized letter, in duplicate, setting forth the information prescribed to be furnished in the new rules, effective January 1, 1944.

The Commission effected this simplification of the rules because of the difficulty experienced by municipal and state police applicants and licensees in complying with the previous requirements.

The Commission added to the rules a new provision indicating that licensees rendering coordinated police service may accept, for the cooperative use of the stations, contributions to capital and operating expenses on a cost sharing basis from those to whom it renders coordinated service. It is the intention of the Commission that no licensee rendering such coordinated service shall do so on a profit basis.

The Federal Communications Commission has also announced the adoption of an amendment to its rules and regulations looking toward the issuance of standard broadcast licenses for a normal license period of three years, the maximum period authorized under the Communications Act of 1934. The present license period is two years.

Initial renewals will be 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. In this way the plan will be placed in operation in such manner as to spread the work load incident to examination of applications for renewals over the full three-year period. Stations are grouped in order of the different license expiration dates in such manner as to include in each group a fair cross-section of the entire industry. This will automatically accomplish a fair distribution of the work load on renewal applications.

Christened Battlin' Benny, this shrapnel-torn RCA loudspeaker was aboard the USS Boise when it sank six Jap ships. In photo is Franklin Bowman, RCA worker who served on the Boise

Sir Robert Watson-Watt (left), head of a Radio Mission to this country, visits a Philco plant and discusses latest radio manufacturing techniques with Joseph H. Gillies, vice president in charge of radio production at Philco

NEW ELECTRONIC GROUP

Over sixty of the leading electronic and component parts manufacturers in the west have recently formed an organization to be known as the West Coast Electronic Manufacturers Association. *Sol Smith* has been appointed Secretary-Manager.

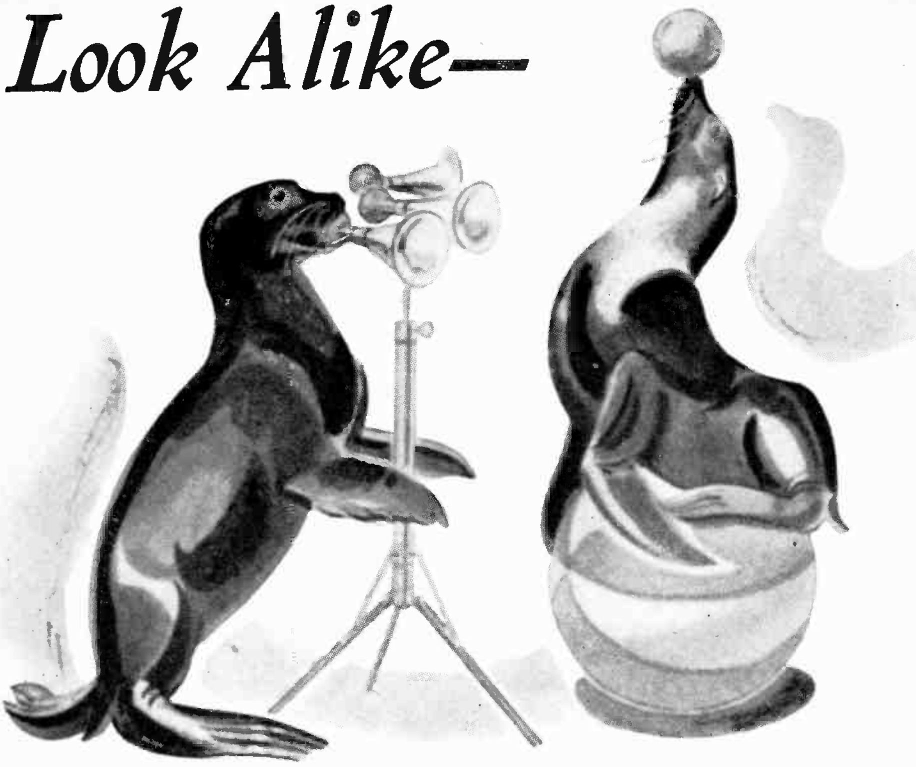
The newly formed West Coast Electronic Manufacturers Association which has the full approval of the United States Army Signal Corps and also of the War Production Board, will function as a complete West Coast Unit at the formal induction of officers immediately following the January meeting of the group.

The present prime objective of the members in the Association are:

1. Full utilization of existing manpower and manufacturing facilities of the electronics industry in the West.

[*Continued on page 61*]

They Look Alike—

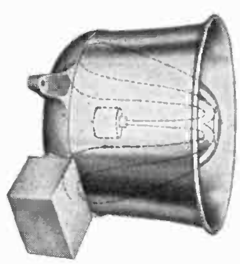


. . . But What a Difference in Performance!

★ Many seals, many brands of air-column horns, loud speakers and driving units look alike—but what a difference in performance!

★ RACON won its position as World's Largest Manufacturer of air-column horns, speakers and units because of outstanding product performance. Outwardly some other speakers look quite like RACONS, but that's where the similarity ends. All RACON products contain top-quality materials, assembled by skilled craftsmen. RACONS deliver more output per watt of input. And *only* RACONS can supply patented Stormproof, Weatherproof Acoustic Material which prevent resonant effects while being impervious to any weather condition.

★ There *is* a difference in loud speakers so be sure you get the best—get RACONS. A type is available for every conceivable sound distribution requirement.



MARINE HORN SPEAKERS

MARINE CONE SPEAKERS

RACON P. M. HORN UNITS

RE-ENTRANT TRUMPETS

The MARINE HORN SPEAKER may be used as a loud-speaker or microphone, comes in several sizes; is approved by the Bur. of Marine Inspection, Dep't. of Commerce. MARINE CONE SPEAKERS are the re-entrant type, suitable for indoor or outdoor use. Storm-proofed for all weather conditinos. Sizes for 2, 3, 5, 8 and 12 inch speakers.

RE-ENTRANT TRUMPETS are compact, of the double re-entrant type which in a small space affords a long air column enabling them to deliver highly concentrated sound, of great clarity, over extremely long distances. Available in 6', 4½', 3½' and 3' air column sizes. RACON P-M HORN UNITS are available in operating capacities of 5 to 50 watts.

RACON ELECTRIC CO. 52 EAST 19th ST. NEW YORK, N. Y.

ELECTROLYTICS

[*Continued from page 22*]

The deviation from linearity in the graph is probably to be ascribed to the greater inherent leakage as the voltage to which the electrode is oxidized decreases. This is borne out by the increase in the power factor for plain plate electrodes.

This change in power factor may be explained qualitatively in terms of the equivalent circuit and in terms of Eq. (11) where the power factor increases directly with the square root of the ratio C_1/C_2. This is, however, a slower increase than is actually found.

(c) *Effect of Low Temperature.* The variation of capacity and power factor with temperature for condensers of different voltage ratings is shown in *Fig. 5.* These two factors are combined in *Fig. 6,* showing the relative impedance of the condensers at low temperature, using room temperature as standard. The following characteristics may be noted:

The lower the voltage, the worse the condenser behaves at low temperatures, the largest change occurring from 50 v. down. The greater proportion of the relative increase in impedance is due to the increase in power factor. The loss in capacity is secondary. It is this fact that makes the behavior of plain plate condensers much better at low temperatures because the power factor is much lower. As an illustrative example, a plain plate 25-volt condenser, other things being equal, has an impedance ratio of about 1.8 at —38°C., whereas the graph shows a ratio of 7.5 for the etched plate.

It is obvious that these curves allow one to obtain any predetermined capacity or impedance at any low temperature desired. Furthermore, by changing the kind of electrolyte used, widely varying results in low-temperature characteristics may be obtained.

DISTRIBUTION

[*Continued from page 35*]

to apply and properly install the photocell relay. The man who can utilize the photocell relay to demonstrate such things as, new methods of safety, methods of lowering production costs, etc., is the man who will create the demand for such units. To a large extent the success of selling other industrial electronic items follows the same pattern. The key to the problem is "Find the specialty man for the job."

Sales Engineers

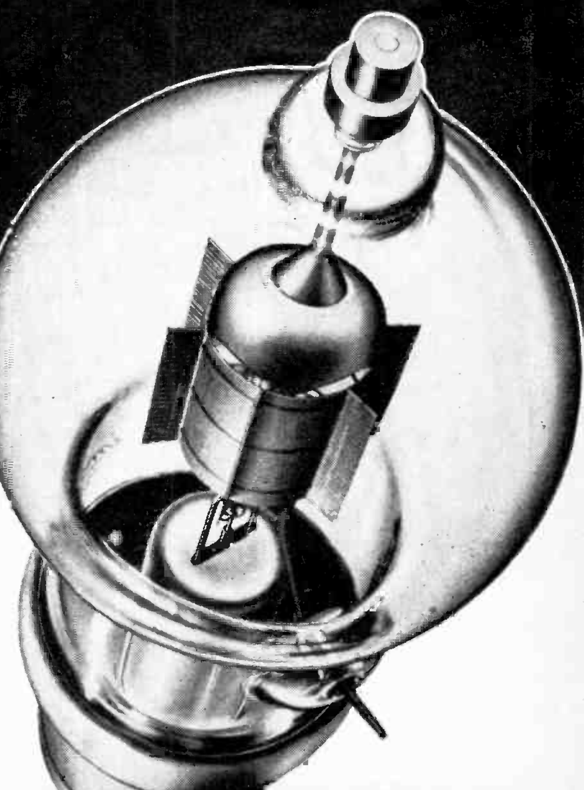
A study of the qualifications necessary for the man who must apply and direct the installations of photocell equipment and other industrial electronic equipment, is important. They call for two talents. One is for a man of wide selling experience; as, in the main, top executives must be contacted; and secondly, the man must be well qualified as an engineer or practical technician with a sufficiently experienced background to recognize the need for photocell equipment in different applications. He must also be capable of specifying and installing the correct type of unit for each application.

Such men are difficult to find at present. As the industrial electronic field expands sales engineers of this character will develop as the work will offer excellent possibilities in remuneration.

Literature

Preparation of sales literature for a photocell relay designed for industrial use can be divided into two categories. First, there is educational literature to inform prospective users of general or specific applications possible with the relay. Secondly, technical specification literature is required. It should be made up in technical form for use by the field sales engineer who will sell the equipment. Complete data showing

[*Continued on page 54*]



Eimac 250T

the full capabilities of the relay are mandatory.

Publicity

Tied in closely with the preparation of literature is the publication of articles. Scientific and production developments in all fields have found a medium of expression through technical publications, and industrial electronics is no exception. In the case of the photocell relay, articles can be written in a wide variety of publications. Photocell relays are being used in industries such as paper, chemical, petroleum, mining, restaurant, railway, etc. Informative articles written in the publications covering each of these industries describing actual installations made in each respective field will pay dividends.

Service

Service is an integral part of the design and merchandising plan of an electronic industrial item such as the photocell relay. No expense in the initial design is too high, if it will avoid unnecessary service when the equipment is in the field. This point cannot be over-stressed. Photocell relays are often installed in production machinery where a single breakdown might prove very costly.

Handled properly, the service of industrial equipment, such as the photocell relay, can be a profitable venture instead of a headache. Several companies have devised service contracts which are sold as an integral part of the initial equipment, calling for a flat fee per year in payment for periodical inspection by the vendor of the equipment.

A complete and well-written service manual which can be understood by the engineer in charge of the plant in which the photocell or other electronic unit has been installed, often avoids needless service calls. Many engineers in other industries are conscious of electronic devices in general and if given an even chance, will do their part.

Also, to facilitate rapid service in case of breakdown, a complete spare equipment set should be kept on hand to replace units which fail in operation. This avoids the necessity of tampering with the internal circuits when time is at a premium. It also allows a man who is not too familiar with the equipment to make the change. The defective unit can then be returned to the factory for repair.

V-T VOLTMETERS

[*Continued from page 25*]

d-c to contact potential applied to the grid in a-c operation is effected by *S1c*. Switches *S2c* and *S2d* between them change the a-c measurement diode d-c load, and contact balancing potential diode, circuits in such a way that in a-c operation the 100-volt a-c range is measured by the 30-volt d-c range, and the 300-volt a-c range by the 100-volt d-c range. This arrangement is incorporated since it has been determined that the 6SN7GT grid will not satisfactorily handle the rectified d-c provided by the probe diode with 300 volts rms a-c input. It is one of the devices employed to extend the top voltage ranges to double what is believed to have been obtained in previous instruments.

The a-c meter scales are calibrated in rms volts. This meter calibration holds good for most uses, since sine, or essentially sine waves are usually being dealt with. In a-c operation the instrument is basically a peak voltmeter.

Military experience has indicated too completely the fallacy of the usual penny-pinching component selection found in service test equipment. In a laboratory or commercial/military field test instrument such as that described, nothing much less than military standards may be considered. Hence all

[*Continued on page 56*]

TO EXACTING LABORATORY STANDARDS..

Quick and efficient comprehension of the production of laboratory equipment comes naturally to us of ECA. We're rich in the fundamental experiences arising from specialization in the development, design and manufacture of "tailored-to-order" radio and electronic equipment. Our facilities, geared to exacting laboratory standards, permit our engineers and technicians to approach a problem confident that the ultimate result will prove ultimately satisfactory.

An example of the work we do is the ECA Laboratory Oscillograph. This is a 7-inch, direct current, general purpose device built to provide features not ordinarily available in any commercial unit. This Oscillograph has seen continuous service in the ECA laboratory for more than a year, and it has been employed for such varied purposes as photographing transcient phenomena, measuring time delay circuits, checking the fidelity of mechanical recorders and oscillographs, and so on.

INVASION! *This is no time for complacency. It's still necessary to buy War Bonds . . . still necessary to save scrap metal . . . still necessary to be a regular patron of the Red Cross Blood Bank . . . to hasten Victory and save lives.*

eca

ELECTRONIC CORP. OF AMERICA

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metal parts are durably finished to resist corrosion, capacitors are either plug-in electrolytic, wax-impregnated moulded mica, or oil-impregnated hermetically sealed types. The power transformer is open-mounted, yet through a construction believed new, comparable to potted and poured types in humidity resistance. Fixed resistors are either wire-wound or moulded high-quality metalized; all range-multiplying resistors are wire wound. In every case operating currents and voltages are kept well below the continuous duty rating of component parts.

LOOP DESIGN

[*Continued from page 33*]

band-width method at two points near the ends of the frequency band. The loop to be measured is tuned by a variable condenser and spaced as far away from the transmitting loop as possible while still maintaining an adequate reading on a vacuum tube voltmeter. The band width at 2 times the normal input from the signal generator is measured and substituted in Eq. (13) to determine the Q.

$$Q = \sqrt{3}\,(f/W_2) \qquad (13)$$

Where f = center frequency in kilocycles
W_2 = band width at 2 times input in kilocycles

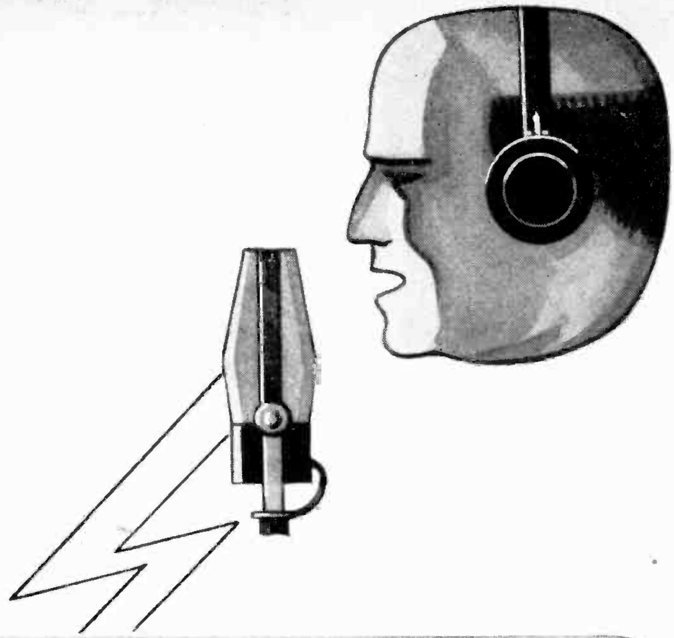
A typical value of loop Q in a cabinet for a small compact table model receiver might vary from 50 to 85 while the Q of a larger console type loop would be of the order of 90 to 120, the higher values being for the lower frequencies. The figure of merit from 0.5 to 0.7 for the small variety to for corresponding loops would range 0.7 to 1.2 for the larger console type.

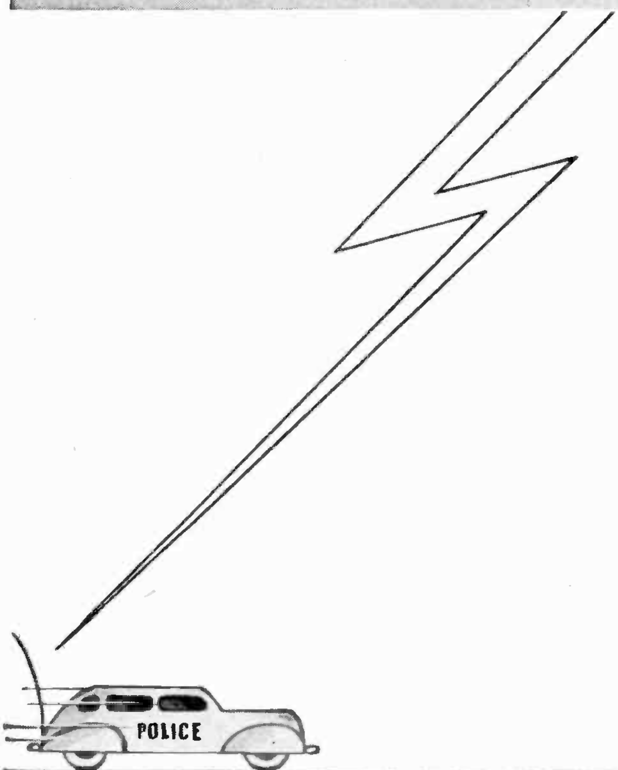
TECHNICANA

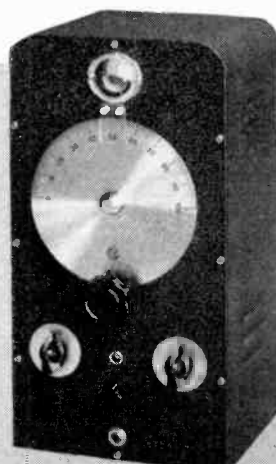
[*Continued from page 14*]

familiar with the large amount of background noise that disturbs their enjoyment of programs. Citing this as one example of the technical problems to be overcome, Mr. Halligan said he is confident that the radio industry's engineers, if given the opportunity, can make radio telephone dispatching entirely practical. "Perhaps," said Halligan, "placing a carrier on the telegraph wires now paralleling all railroad tracks would help to solve this problem. In fact, this would mean that the train's radio equipment would have to transmit and receive only the few feet between the train and the telegraph wires." Halligan suggested that a trial be given present-day ship-to-shore equipment.

[*Continued on page 59*]




POLICE



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"The problem is a complicated one," stated Halligan, "but not primarily because of the technical difficulties. The greatest part of the problem is to convince the railroad operators that such equipment will be of value, and to secure government approval, priorities and licenses. The sooner such a problem is started, the sooner our complete transportation systems—air, land, and sea—will be utilizing modern communications."

QUOTES

[*Continued from page 17*]

the work in connection with the war has been almost exclusively confined to point-to-point transmission and reflection. The problems in television broadcasting where signals must go out in all directions and be satisfactorily received at all reasonable distances, are quite different.

These problems, which are likely to be encountered in an aggravated form at higher frequency levels, are indicated in the results of a recently completed and extensive measurement of reception conditions from present television and frequency modulation stations in the New York area made by the Allen B. Du Mont Laboratories. In general, the survey indicates that reception is excellent but that multipath signals constitute the industry's number one reception problem. These multipath signals become rapidly worse as frequencies become higher.

Paul Raibourn, president of Television Productions, Inc.

Electronic Research

★ Electronic research, which already has beaten a scientific path into the 1960's, has created a vast reservoir of technique which waits to be tapped by the demands of the public and industry. Research and development in radio during the present war is perhaps a thousand times that of the last war.

We will end up this war with a simply terrific amount of technique, know-how and facilities. All that's needed to start a few new industries is to know what service—as yet unborn—what facility yet unknown, would be useful in the American home, in industry, transportation or in the amusement field.

That is the sixty-four dollar question—the one that we engineers are not equipped to answer. That kind of question is in your field, and if you can produce the answer, it's an even break we can work it out.

Walter Evans, vice president, Westinghouse Radio Division, in an address before the Radio Executives' Club of New York. [*Continued on page 61*]

Electronics a Science

★ Electronics is not a product, such as an airplane, a turbine, or a locomotive. Like chemistry, electronics is a branch of science. Just as chemistry is not limited to the manufacture of synthetic rubber or plastics, neither is electronics limited to radio, or television, or communications or locator systems.

Dr. Walter R. G. Baker, vice president, Electronics Department, General Electric Co., in an address before The Economic Club of Detroit.

Post-War Service

★ Knowledge and experience that will be of great value in the post-war "Age of Electronics" are being gained by field service engineers of the radio and electronic industry in their wartime assignments.

The installation and maintenance of radio and electronic equipment for the armed forces have made it difficult to keep up with increasing service needs in civilian life. However, in the long view, civilian users of electronic equipment will benefit in terms of better installation and maintenance service.

W. L. Jones, vice president and general manager, RCA Service Co.

Freedom of Choice

★ In the post-war world, I believe we should have the right to suspect any nation of unfriendliness, even of potential enmity, and to apply sanctions to it, that denies its people the right to choose for themselves what they shall import, read, listen to, or look at.

Let me repeat. Re-education of Germany and its satellite nations is necessary for an enduring peace. Re-education depends on two factors: First, the control of free enterprise of newspapers and motion pictures, of radio and television networks, so that our programs, as well as any others, will have an opportunity to be heard and seen; and second, making certain that our programs possess sufficient merit to win and hold audiences on an entertainment basis while emplanting a true picture of American democracy in looking-listening minds.

Paul Raibourn, president of Television Productions, Inc., in an address before the American Television Society.

THIS MONTH

[*Continued from page 50*]

2. Insure all proper information to the interested Government Agencies which will allow this area to make full contribution to the war effort.

3. Clarifying various Government regulations and rulings and disseminating the information to all members.

4. Attempt to secure uniform consideration on problems affecting renegotiation and termination of contracts, selective service, wage stabilization, and other matters of mutual interest.

5. The distribution of information amongst the membership as to commodities manufactured by them, thus enabling them to utilize the facilities of West Coast manufacturers to the fullest possible extent by their Purchasing Departments.

FOUCH W.C.E.M.A. CHAIRMAN

James L. Fouch, president of the Universal Microphone Co., Inglewood, Calif., has been appointed chairman of the membership committee for the recently organized West Coast Electronics Manufacturers Association, composed of coast electronics and component parts manufacturers.

WILLYARD TO NEW POST

Les Willyard, since 1931 with the Universal Microphone Co., Inglewood, Cal., has been appointed Chief Engineer, a post vacant the past five years. Originally assigned to microphones, he later was placed in charge of recording machines and blank discs. He later returned to the microphone division and, since Pearl Harbor, has been technical engineer in charge of research and testing laboratories.

NEW HAZELTINE OFFICERS

Announcement has been made by *Mr. William A. MacDonald*, President of Hazeltine Electronics Corporation, of two important executive appointments within the corporation. *Mr. Fielding Robinson* has been elected Vice President and *Mr. John D. Grayson*, Treasurer.

Fielding Robinson

Mr. Robinson joined forces with Hazeltine in 1941 as coordinator with various Government agencies in Washington and other locations. Formerly he managed the Crosley Company of New York. He is a native of Norfolk, Virginia, a graduate of Virginia Military Institute, and served as a Captain in the Marines during the last war.

Mr. Grayson also joined forces with Hazeltine in 1941 as Comptroller. Prior

[*Continued on page 63*]

John D. Grayson

to this, he was Comptroller of Bellows and Company, and prior to that, Asst. Treasurer of Devoe-Raynolds Company, Inc. He is a native of Monroe City, Missouri, a member of the Controllers Institute of America, and the New York Society of Certified Public Accountants.

ALTEC APPOINTMENTS

George L. Carrington and *Harry M. Bessey* have been elected president and vice-president, respectively, of Altec Service Corp. Carrington succeeds L. W. Conrow, who died here recently.

In addition to his duties as president, Carrington will retain his position as general manager, a post he has held since the inception of the company in 1937. He will also function as president of Altec-Lansing Corp., west coast manufacturing subsidiary, which operates three factories in the Los Angeles area.

Carrington was previously associated with Western Electric Co., in the Erpi division, and with the Southwestern Bell Telephone Co., before joining Altec.

Bessey assumes the post of vice-president after serving as secretary-treasurer of Altec Service Corp. since 1937. He is a director of Altec companies, as well as an officer of Altec Lansing Corp.

TEMPLETONE APPOINTMENTS

Captain *Robert Adams*, recently retired from the Signal Corps for reasons of medical disability, has joined Templetone Radio Company, Mystic, Connecticut, in the capacity of Production Manager of the Radio Division.

"Bob" Adams is well-known throughout the radio industry, having been engaged in the production of radio receivers, transmitters, and television for eighteen years. Prior to entering the Armed Service he 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.

Dr. *Gregory Timoshenko*, who is Associate Professor of Electrical Engineering at the University of Connecticut, and specialist in electrical measurements, is now connected with the development work of Templetone Radio Company in a research capacity.

DUMONT ELECTED PRESIDENT OF T.B.A.

Allen B. DuMont, president of Allen B. DuMont Laboratories, Inc., was elected president of the newly formed Television Broadcasters Association, Inc., at a meeting of the organization committee in New York.

Other officers elected were: *Lewis Allen Weiss*, Don Lee Network, vice-president; *Jack Poppele*, Station WOR, New York, assistant secretary-treasurer.

A.M.P. APPOINTS NORDEN

Appointment of *Alexander Norden* to further product development and post-war merchandising research is announced by Aircraft-Marine Products, Inc., 1521-31 North Fourth Street, Harrisburg, Pa., manufacturers of solderless wiring devices.

Mr. Norden has been in the radio and automotive industries for many years. He was active in forming the Norden-Hauck Electric and Manufacturing Company of Philadelphia. For the last ten years he has been executive vice-president of L. A. Brach Manufacturing Company of Newark, New Jersey.

VIA JOINS MECK

Lester Via, who has had well over 10 years experience in the radio field, has been appointed to the engineering department of John Meck Industries, of Plymouth, Indiana. Mr. Via will have charge of special crystal research.

Lester Via

BENDIX CONSOLIDATION

Bendix Aviation, Ltd., of North Hollywood, Calif., is now operating as the Pacific Division of Bendix Aviation Corporation, following recent announcement of the change-over by *Ernest R. Breech*, corporation president.

Actually, the change-over from Bendix Aviation, Ltd., organized seven years ago by Bendix Aviation Corporation as a California Corporation, will affect only administrative and legal considerations, according to *Palmer Nicholls*, who has been made a vice-president of the parent company.

He and *Mel M. Burns* will continue to play the executive roles in the new division, operations and personnel remaining unaffected. Principal reasons for the change, Nicholls pointed out, were to streamline corporation activities and to avoid confusion which has existed because of the similarity in names of Bendix Aviation, Ltd., Bendix Aviation Corporation, Bendix Products and other Bendix subsidiaries.

G. R. OPENS CHICAGO OFFICE

To assist users in the Chicago and middle western area, the General Radio Company has opened a Chicago engineering office at 920 South Michigan Ave., Chicago 5, the phone number being Wabash 3820.

In charge of this office is *Lucius E. Packard* who for the past three years has been in charge of the New York engineering office.

Succeeding Mr. Packard at the New York office is *Martin A. Gilman* of the factory engineering staff.

NEW B & W CATALOG

A new catalog just issued by Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa., gives complete information on the line of B & W Type CX Variable Air Condensers for heavy-duty requirements.

Features of these B & W Condensers include perfect electrical design symmetry, built-in neutralization with mounting of standard B & W coils in such a way that lead lengths and resulting lead inductance are reduced to an absolute minimum, and extreme mechanical durability.

A copy of this new catalog will gladly be sent upon request to the manufacturer. Ask for Condenser Catalog 75C.

LONG JOINS UNIVERSAL

Floyd Long, radio engineer and instructor for United Airlines at the Oakland Airport, is a new addition to the technical staff of the Universal Microphone Co., Inglewood, Calif. He is assigned to the production control laboratory in charge of all company test equipment.

ADVERTISING INDEX

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