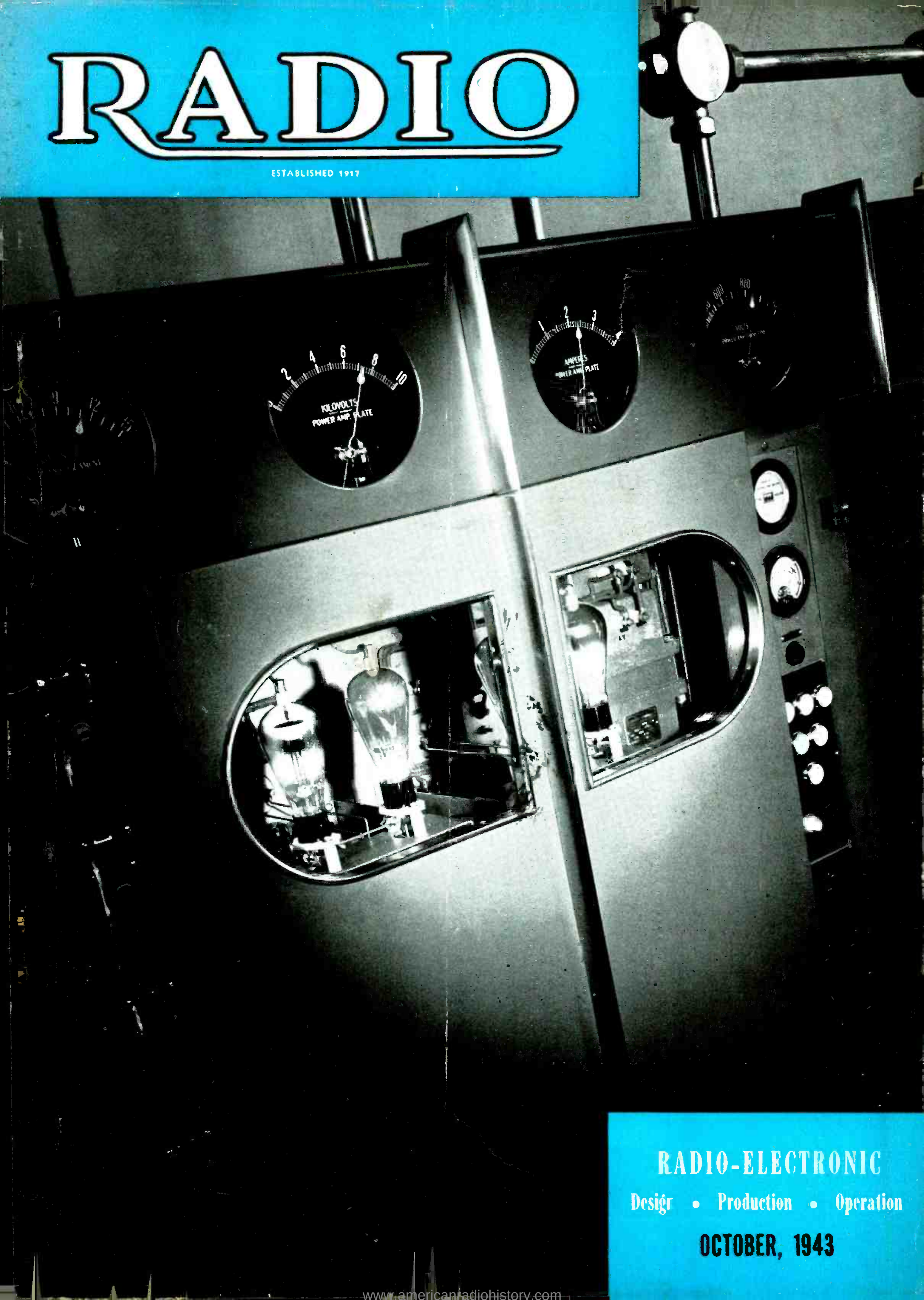
RADIO

ESTABLISHED 1917



RADIO-ELECTRONIC

Design • Production • Operation

OCTOBER, 1943

www.americanradiohistory.com

Outdated theatricals . . . they too served their purpose in their time . . . the ballyhoo, checkered vest, cane, and all the trimmings, some of these traits were adapted to merchandising . . . even to jobber dealer and servicemen . . . anyone can merchandise by power, the power of ballyhoo . . . but

THERE IS A DIFFERENCE

When recognized scientists collaborate in the production of precision devices or engineered tubes, to serve today's electronic principles there is no ballyhoo. America's destiny as world leader is based not so much on resources or population — but on ability — the ability to be so much farther advanced in technical matters and to so far outweigh other nations in the production of superior equipment that we become an inestimable force.

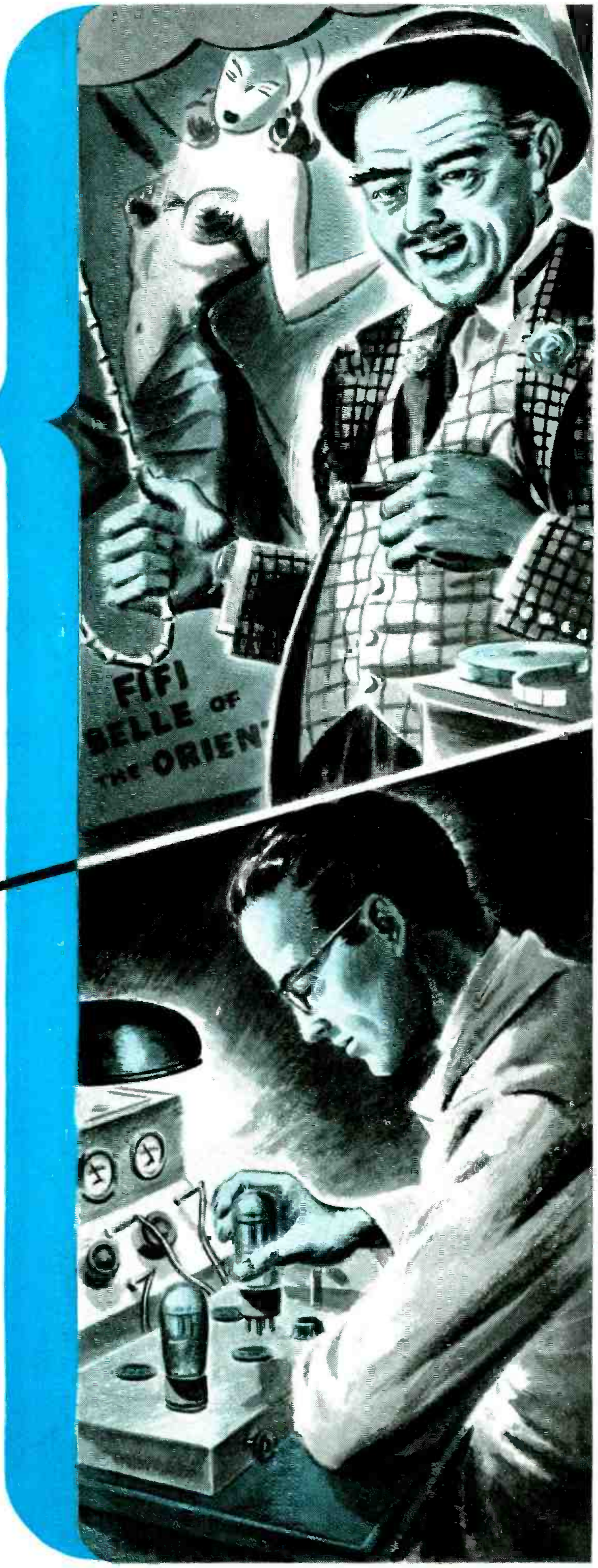
RAYTHEON proudly submits its 12,000 skilled workers as an important segment in this great American achievement. For nineteen years the RAYTHEON laboratories have concentrated on research and development. Scientific achievement has always been foremost in the Company's policy. The fact that today RAYTHEON employs over 12,000 tube experts — supplying the demand for critical electronic tubes — is the proof of the wisdom of this unselfish foresight.

RAYTHEON TUBES RADIO & TRANSMITTING

RAYTHEON PRODUCTION CORPORATION

Newton, Mass., Los Angeles, New York, Chicago, Atlanta

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



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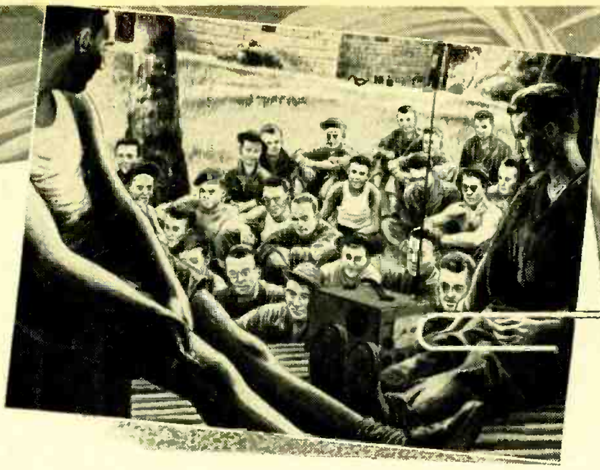


Australia
June 18, 1943

Hallicrafters
Chicago, Illinois
U.S.A.

Dear Sirs:

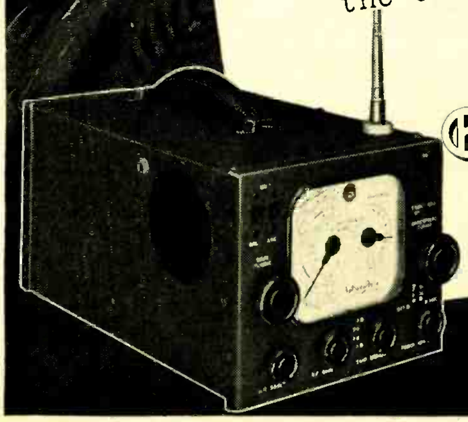
In the May issue of QST, appeared a picture of your Hallicrafters Model S-29 Radio...and a group of men and myself listening in on a program...in the New Guinea area.

The Radio which appears in this picture was purchased by myself in August, 1941. This same radio has been in continuous operation...and has caused no trouble.

This Hallicrafters Model S-29 was one piece of equipment which every man...was anxious to carry. It was carried at all times...through New Guinea jungles...in the midst of a jungle swamp ...where tropical rains fell heavily...in extreme damp heat, this radio never once faltered. It brought untold relief to every fighting man... caused tense nerves to become relaxed, bringing happy moments to dark surroundings. The part played by this instrument could never otherwise be duplicated. Every night...the fellows would listen to the news from home. Notes were taken ...and news was called to the troops on front line duty. Without this radio there would have been no contact with the outside world.

This same radio is operating perfectly and the only replacement needed was a new set of tubes.

Sincerely yours,
Glen V. Blakeslee
Glen V. Blakeslee



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the hallicrafters co.
CHICAGO, U.S.A.
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF SHORT WAVE RADIO COMMUNICATIONS EQUIPMENT

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FOR RADIO MEN IN THE SERVICE!

"WRITE A LETTER"

As you know, the Hallicrafters make a wide range of Radio Communications equipment, including the SCR-299 Mobile Communications unit. We are proud of our handiwork, proud of the job you men have been doing with them on every battlefront

RULES FOR THE CONTEST

We want letters telling of actual experiences with this equipment. We will give $100.00 for the best such letter received during each of the five months of November, December, January, February and March! (Deadline: Midnight, the last day of each month.)

We will send $1.00 for every serious letter received so even if you should not win a big prize your time will not be in vain.

Your letter will be our property, of course, and we have the right to reproduce it in a Hallicrafters advertisement.

Good luck and write as many letters as you wish. V-Mail letters will do.

W. J. Halligan

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MAKERS OF THE FAMOUS SCR-299 COMMUNICATIONS TRUCK

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RADIO

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NOTE: Because of wartime censorship restrictions, we must reserve the right to withhold from foreign subscribers any issue the regular domestic edition of which is not approved by the authorities for export without changes. In such cases subscriptions will be extended so that each subscriber will eventually receive the number of issues to which he is entitled.

◆

IF YOU MOVE, notify us in advance; we cannot replace copies sent to your old address. Notice must be received by the 20th of the month preceding the cover date of first issue to go to the new address.

OCTOBER 1943 No. 285

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COVER

Cabinet, styled by famed designer Henry Dreyfuss, housing rectifier unit of W71NY's 10-kw FM transmitter. Note base of vertical coaxial antenna which extends upwards through roof. (Photo courtesy Western Electric Co.)

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 132 West 43d Street, New York 18, 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 1943 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.

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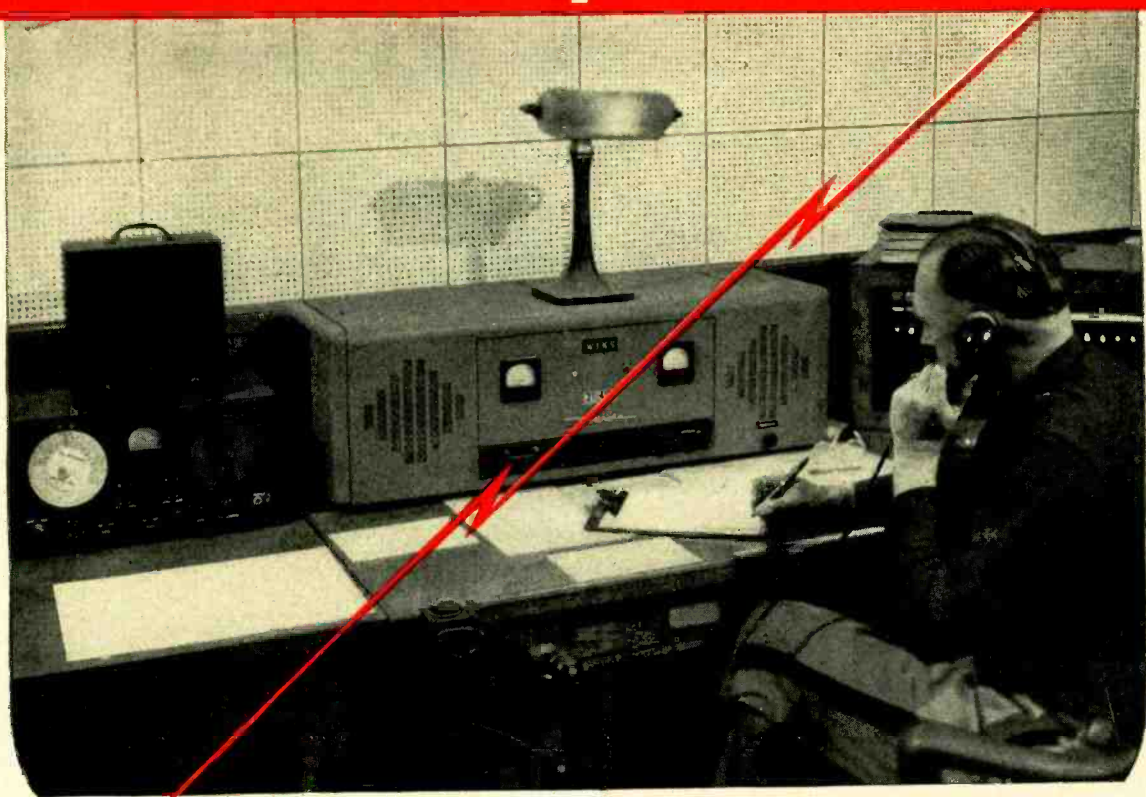
It's Easier To Cope With Crime



WITH A Motorola 2-WAY RADIOTELEPHONE SYSTEM

One police patrol car equipped with a 2-Way Radiotelephone set is worth three cars without radio. Thus the installation of 2-Way Radio provides you with an immediate extension of your police facilities.

With police officers leaving the force to join the military services nowadays, you more than ever need to conserve manpower. 2-Way Radio will help you do this—you will be able to make each patrol car do the work of three. And you save tires, gas and car repair as well.

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Communities which can show either a vital public need or a vital military need for a Police Radiotelephone System can obtain one by merely making application for allotment from the Government Pool. For full information on how to proceed, simply write or phone us. A Motorola field engineer will survey your requirements and get you started. No obligation.

For the development and production of Radio Communications Equipment for our armed forces, Motorola organization was awarded the Army-Navy "E" with added Star for continued excellence of performance. Motorola is proud of the part it has been privileged to play in the speeding of Victory.

Radio Communication Systems
Designed and Engineered to Fit Special Needs
GALVIN MFG. CORPORATION · CHICAGO

EDITORIAL

FRUITS OF TECHNOLOGY

★ As examples of the impact of technology on "life as she is lived," we offer the following brief news items, without comment:

With the institution by the A.T.&T. of direct telephone connection with Moscow, one may now phone a friend in this city and talk for 3 minutes for the small cost of $21.

The FCC denied the petition of the CIO to intervene, as a party to the proceeding, at the September 10 hearing on the proposed transfer of the Blue Network from RCA to American Broadcasting System, Inc. In denying the petition, the Commission took the position that the CIO is not entitled to intervene in the proposed transfer of Blue Network facilities as a matter of legal right.

Radio was the agency that saved the war-strained railroads of the nation approximately 5000 passenger round trips when, on September 25, the National Association of Foremen condensed the time and travel normally spent on its annual national gathering into a one-hour broadcast to delegates meeting locally throughout the nation.

James C. Petrillo, president of A.F.M., signs contract with Decca and World Broadcasting, calling for graduated royalties on records processed by these firms, said payments to be made into the union fund.

Representative Martin J. Kennedy proposes a constitutional amendment prohibiting abridging freedom of speech by radio or wire communication. Said Kennedy, "Regardless of who may be on the FCC there will be no question about the freedom of radio."

A radically new form of "lighthouse" radio relay station developed by RCA will make relaying of television programs a relatively simple matter after the war. Unattended relay stations located 20 to 50 miles apart will not only link television stations into national networks but will open up a new era in international communications, through development of trunk lines over such vast areas as Russia and China.

WAR PRODUCTION DRIVE

★ The American war worker is fighting the war not only with sweat, but with intelligence. Thousands of suggestions for increasing production from workers who want to do a better job, are recorded at War Production Drive Headquarters. Those which have been put into operation in America's mines, mills, factories and shipyards already have saved millions of dollars and hundreds of thousands of invaluable man-hours.

In recognition of the tremendous potential worth of practical ideas for improving the job from the men who do the job, the War Production Board, under the leadership of Donald Nelson, set up a system of national honors for the suggestions which in actual industrial usage prove to be of value in increasing production. Labor-Management Committees have been established in 2400 plants in which 5,000,000 war workers are fighting the "Battle of Production." Union representatives comprise the labor half of the committees in all plants where there is a recognized labor organization.

Throughout the country, Labor-Management Committees have been encouraging workers to write out their ideas, and drop them in suggestion boxes conveniently located in the plant. If a worker thinks that he is doing two operations where only one is necessary, or that a substitute raw material might be more effectively used, or that a mechanical adjustment in his machine would make his work more efficient, or if he has any other ideas for improving and increasing production he can make his contribution to the suggestion box in the knowledge that his proposal will receive careful consideration.

Both management and labor representatives on the Committees review suggestions for merit. If they are found to be useful, they are adopted in the plant. If the Committee considers the suggestion to be of enough value to have promise of broader application throughout industry, it is submitted to War Production Drive Headquarters, where it is reviewed by the Board for Individual Awards, composed of technicians and engineers in various industrial fields. Four grades of awards are given, proportionate to the breadth of application of the idea. Almost 1000 workingmen have already received recognition from the government. Of these, 14 have received the highest award—the Citation for Production Ideas, which is "a citation for a suggestion making an outstanding contribution to the war production program of the United States."

So that these building blocks in the country's War Production program may be available to every plant in every industry, War Production Drive Headquarters has a nation-wide exchange service. A pamphlet briefly describing the award winning suggestions is available on request, and war plants interested in specific items may write in for a fuller description, and blueprints if necessary.

The American worker likes this system. The Suggestion Box is for him a tie-line to the battlefield, and the number of Ideas for Victory submitted every day are an indication of the widespread interest the man on the production line has in meeting the country's war production quota.

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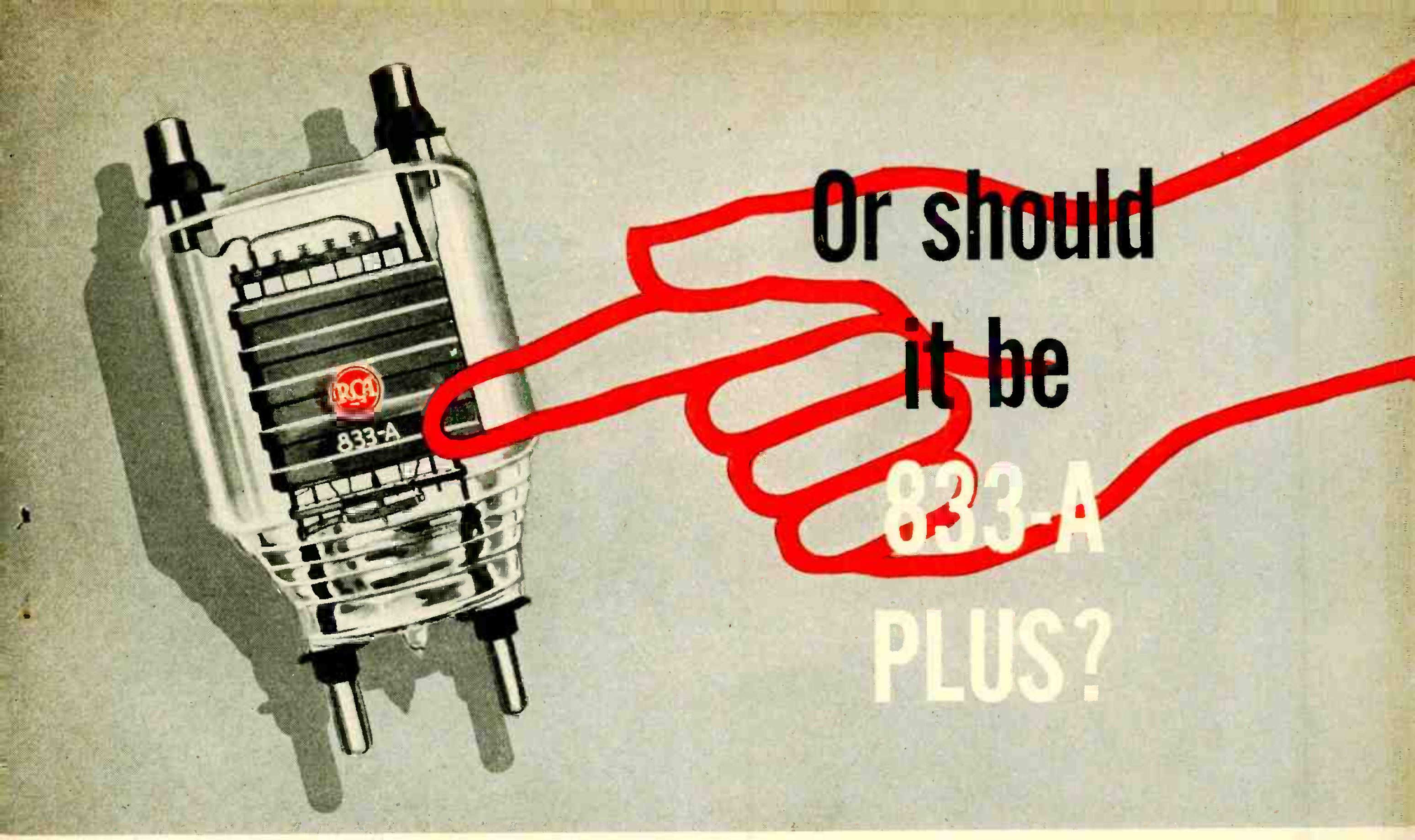

THE RCA 833 became the RCA 833-A long before Pearl Harbor—when important design changes made improved ratings possible.

Now the price is 10% lower—$76.50 instead of $85.00 because fine performance has meant wide acceptance, resulting in production economy.

ZIRCONIUM-COATED ANODE: This famous RCA anode gives the 833-A a 44% higher input rating and 33% higher plate dissipation. To a designer, that means wider application possibilities; to a user, it means the 833-A will give longer life than the 833 it replaced.

EMISSION RESERVE: The 100-watt thoriated tungsten filament of the 833-A has a tremendous reserve of emission. That means less chance of damage in case of unexpected overloads, plus longer filament life.

FILAMENT SHIELDING: The 833-A's plate is specially constructed to shield the filament, thus eliminating bulb bombardment by stray electrons.

FORCED AIR COOLING: Design refinements in the 833-A made it possible for RCA to announce increased ratings when forced-air cooling is used. That means you can increase power by the use of 833-A's instead of 833's—or, you can operate at the same power and run the 833-A's cooler.

TUNE IN "WHAT'S NEW?"

Radio Corporation of America's great new show Saturday nights, 7 to 8, E. W. T., Blue Network.

Operation with Forced-Air Cooling	Class B A-F CCS*	Class B A-F ICAS†	Class C 'Phone CCS*	Class C 'Phone ICAS†	Class C T'graph CCS*	Class C T'graph ICAS†
Typical Operation						
Plate Volts	4000	4000	3000	4000	4000	4000
Power output, watts	2400	2700	1000	1500	1440	1600
Driving power, watts	29	38	37	42	26	35
Max. frequency, Mc:						
at Full input	—	—	20	20	20	20
at 65% input	—	—	75	75	75	75

*Continuous Commercial Service.
†Intermittent Commercial and Amateur Service.

SEND FOR THIS BOOK!

For a wealth of information on RCA Transmitting Tubes and how to use them, send 35¢ for the 72-page "RCA Guide for Transmitting Tubes." Write to RCA Commercial Eng. Section, Radio Corp. of America, 506 South Fifth St., Harrison, New Jersey.

RCA ELECTRON TUBES

RCA Victor Division • RADIO CORPORATION OF AMERICA • Camden, N. J.

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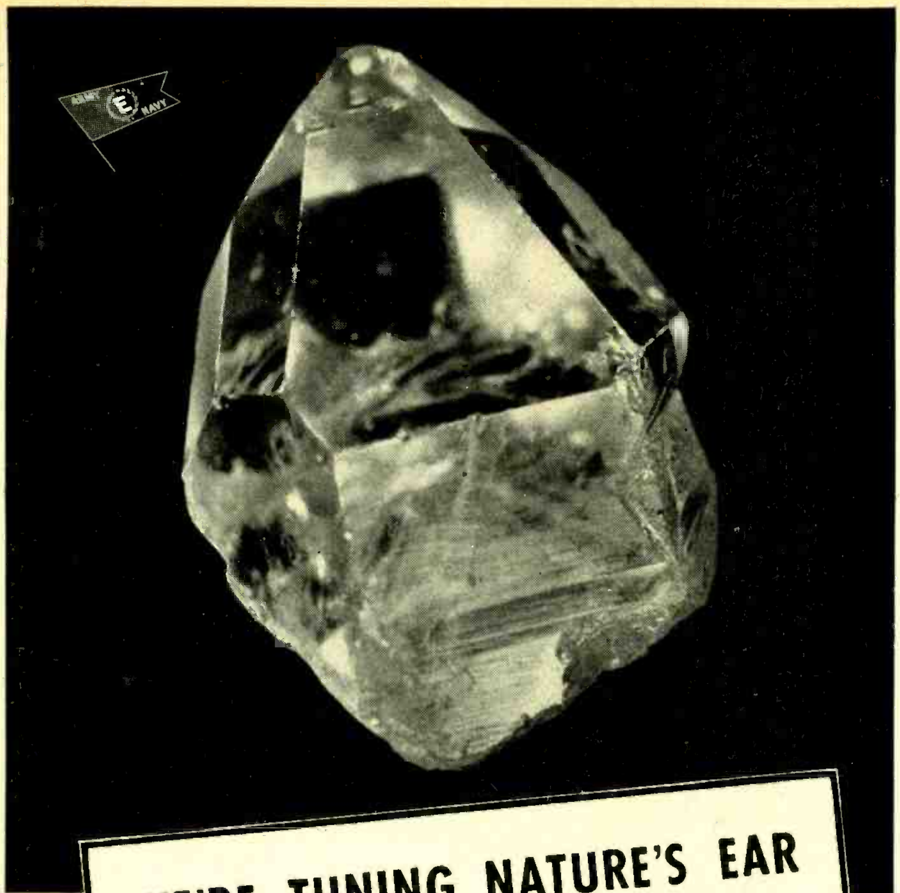

WE'RE TUNING NATURE'S EAR TO THE WAR EFFORT . . .

This piece of South American quartz crystal is remarkable for its piezo-electric properties. Ground so it responds to the proper frequency, it becomes a most important part of electronic devices used by our armed forces. ❖ ❖ ❖ This grinding is a very "touchy" operation. Our special equipment and specially trained personnel are doing a fine job, we believe. ❖ ❖ ❖ This is one of "Connecticut's" contributions to the war effort.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES INC.

MERIDEN, CONNECTICUT

● Our development engineers are glad to discuss electrical and electronic product ideas which might fit in with our postwar plans. Address Mr. W. R. Curtiss at the above address.

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TECHNICANA

"ASYMMETRICAL" CONTRAST EXPANSION

CONTRAST EXPANSION has been with us for some years now but has not found as much favor as it might. This is partly due to the feeling that it is accompanied by distortion and that the unavoidable delay in pickup at a sudden loud sound does not satisfy the hearer. At least a partial solution to the above objections is offered by D. T. N. Williamson in an article entitled "Contrast Expansion Unit", appearing in the September 1943 issue of *Wireless World*.

The customary system of contrast expansion employs a control voltage derived from the signal itself, by rectification, and applies it to an element of a variable-mu amplifier tube, so as to increase the amplification for louder signals. To prevent the gain from varying during the cycle it is necessary to employ a time delay circuit which limits the rate of change of gain so that it cannot follow the lowest frequency signal to be handled. In the usual design the time delay for rising and falling gain is equal, but in Williamson's design a practically instantaneous rise in gain is possible, but the fall in gain is limited by a circuit having a time constant of about one second. He thus introduces all the filtering on the fall of gain, and none or very little on the rise; hence the term "asymmetrical".

The argument is that, in practice, transients are present which do suddenly rise in volume; this sudden rise is not satisfactorily handled by the conventional expansion circuit. On the

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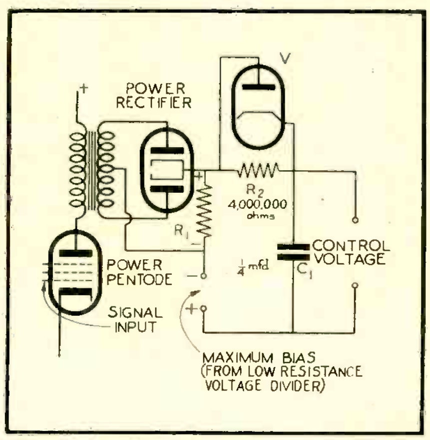

Fig. 1. Expansion control circuit

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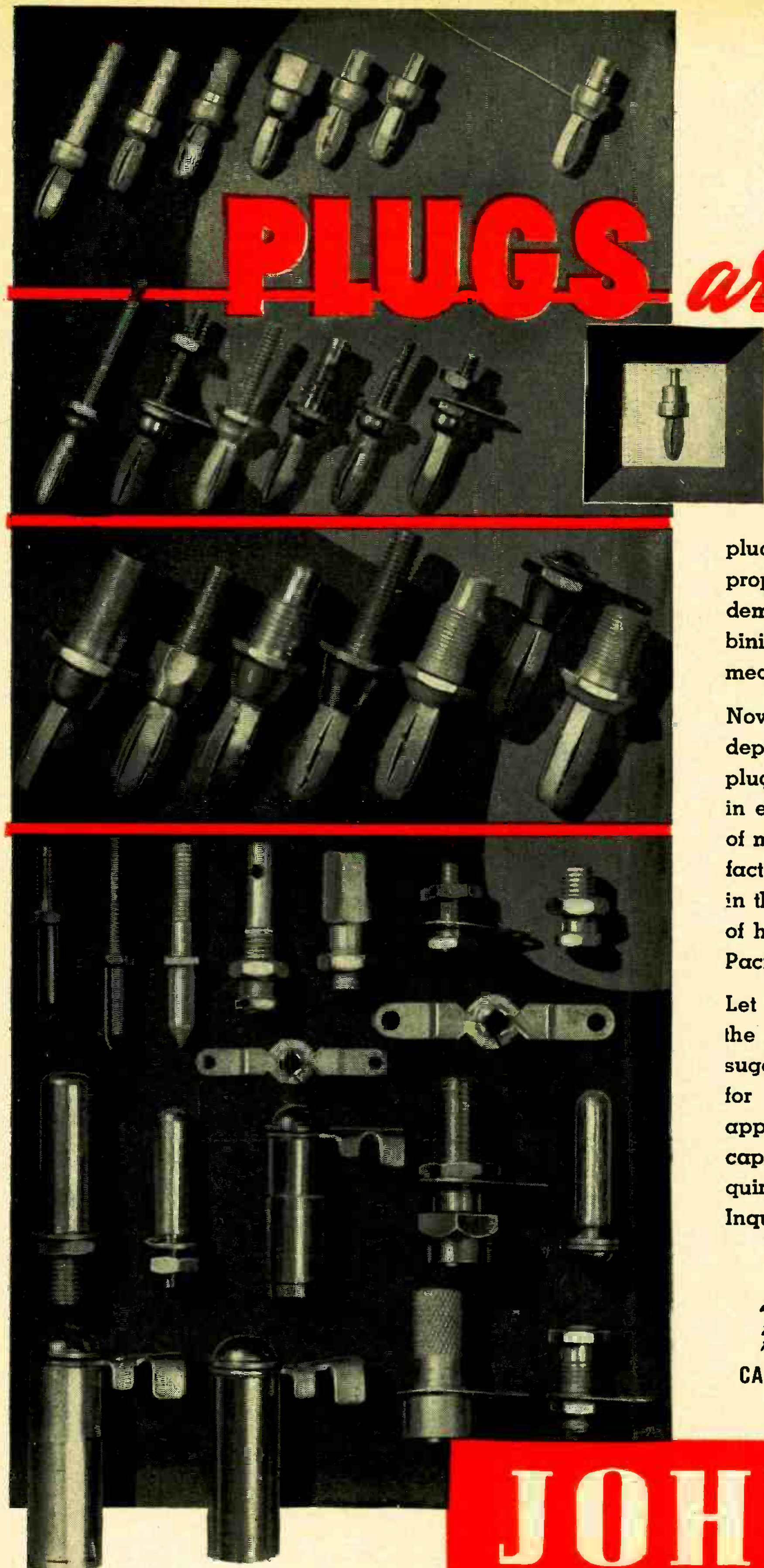
PLUGS are Vital



Where connections must be made and broken quickly and where these connections occur thousands of times in the life of the apparatus, only plugs are practical. In most cases, proper functioning of the apparatus demands a perfect connection, combining qualities of low resistance, mechanical stability and long life.

Now, the lives of our fighting men depend on such small things as plugs. There can be no compromise in engineering design, in the quality of materials, in the honesty of manufacture. A few cents per thousand in the cost of plugs can cost the lives of hundreds of men in Europe or the Pacific.

Let Johnson, one of the pioneers in the manufacture of plugs and jacks, suggest a plug and jack combination for YOUR requirements in YOUR apparatus. Johnson has production capacity and a type for every requirement. Samples are available. Inquire today.

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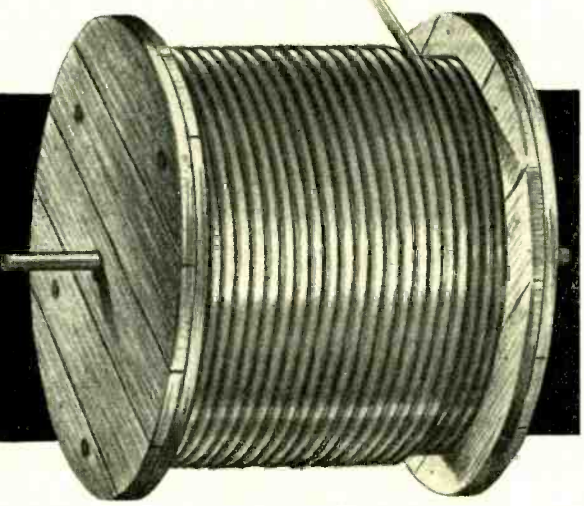
COAXIAL CABLE

1/2 YARD - OR 1/2 MILE

In One Piece !

The Andrew Company is now able to supply standard 70 ohm 7/8" soft temper coaxial cable in continuous lengths up to 4,000 feet! The cable is electrically identical to rigid cables of equal size, but has these extra advantages: the cable may be uncoiled and bent by hand, thus greatly simplifying installation; no connectors, junction boxes or expansion fittings are necessary, thus effecting a big saving in installation time and labor. To insure that all splices are pressure tight and that all foreign matter is excluded in shipment, the cable may be fitted at the factory and shipped to you under pressure.

The Andrew glass insulated terminal, an uniquely successful development, may be used with this flexible cable to provide a gas tight system.



ANDREW

The Andrew Company is a pioneer in the manufacture of coaxial cables and accessories. The entire facilities of the Engineering Department are at the service of users of radio transmission equipment. Catalog of complete line free on request.

ANDREW CO.

COAXIAL CABLES
ANTENNA EQUIPMENT

363 EAST 75th STREET—CHICAGO 19, ILLINOIS

TECHNICANA

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other hand, if a loud sound were to be abruptly stopped and be followed by a period of silence, it is of no consequence at what rate the gain of the amplifier is falling. If the loud sound is followed by a decaying sound, due to reverberation, it is undesirable to have the level of the reverberation unduly attenuated. This can be avoided by decreasing the rate of fall of gain and holding the gain near its maximum for the duration of the echo. A time of decay of gain of about one second proves very satisfactory in all respects and gives the advantage that "flutter" does not occur due to large fluctuations of gain when reproducing music consisting of loud chords separated by short intervals of silence.

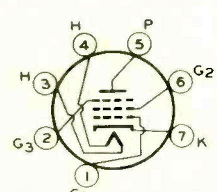
The rapid increase of gain at the beginning of a transient will cause some waveform distortion, but this will occur over so short a period as to be unappreciable.

The control circuit for this type of expansion is shown in *Fig. 1.* The time constant for the fall of gain is determined by the combination *R2* and *C1*, and is about one second. For the rise of gain, the rectifier *V* shunts the resistor *R2*, and under these circumstances the time constant is about one millisecond. Since a sudden change in gain in a variable-mu pentode is accompanied by a sudden change in plate current, this will create a transient by itself which must be eliminated by controlling two such tubes in push-pull. And they must be transformer coupled to the next stage if cancellation of the transient is to be obtained.

NEW TUBES

RCA IS MAKING available to equipment manufacturers the following three new electron tubes for use in connection with WPB rated orders.

The *6AK6* is a miniature type of power amplifier pentode for use either singly or in push-pull in the output



7BK

stage of compact, lightweight equipment. In Class A service, a single 6AK6 can handle a maximum-signal

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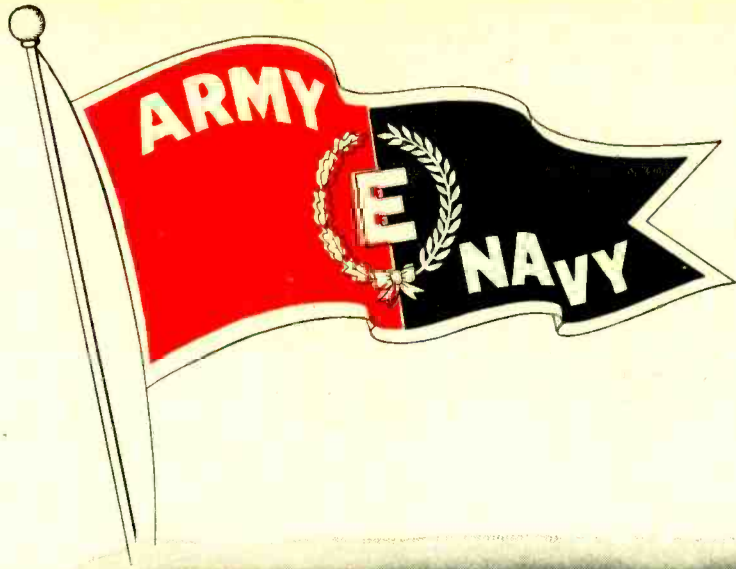

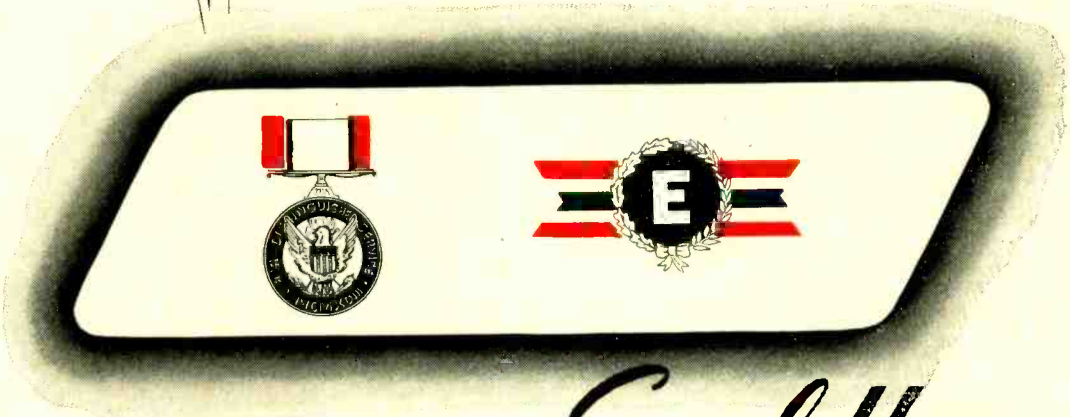

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Awarded for distinguished service . . . to employees of

SCIENTIFIC RADIO PRODUCTS COMPANY

The fighting man with the Distinguished Service Medal on his breast is proud. For it denotes exceptional bravery beyond the call of duty—a personal EXTRA contribution toward Victory.

Our workers can be proud that their exceptional contribution too has been recognized. For the "E" pins they now wear signifies distinguished service, individual excellence on the production front. To them, not we, must be given credit for outstanding service to the nation.

SCIENTIFIC RADIO PRODUCTS COMPANY ★

738 West Broadway — Council Bluffs, Iowa

MANUFACTURERS OF PIEZO ELECTRIC CRYSTALS AND ASSOCIATED EQUIPMENT

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• It Does the Job of Several Mikes • You Can Hold It
• You Can Hang It • You Can Mount It on Standard Stands

A truly multi-purpose microphone, which can do the job of two or more units. It fits the hand snugly; is equipped with a suspension hook for hanging mike applications, stage work and call systems; it can be mounted on any standard floor or desk stand. Especially engineered for maximum voice response and smooth, natural response to music pick-ups. Gunmetal or chrome type finish.
The Turner Han-D is equipped with a contact slide switch, for easy on-off operation.

9X Crystal has level of —48 DB, range of 60-7,000 cycles.

9D Dynamic, especially recommended for use under bad climatic conditions, intense heat and rough handling. Level —50 DB Range 60-7,000 cycles. With 7 ft removable cable set, available in 200-250 ohms, 500 ohms or hi-impedance.

TURNER THIRD HAND WITH L-40 MIKE

Leaves Both Hands Free for Other Jobs
For every spot where both hands are needed on the job, Turner 3-H-L40 is the lightweight unit to use. Defense plants use it for call systems. Police cars need it for better communications. The "Third Hand" holds the mike close to the mouth, giving tremendous volume without feedback.

Equipped with Turner L-40 microphone which has exceptionally high signal level. Gives more intelligible speech reproduction and minimizes feedback. Chest sounds are damped out. Gunmetal or chrome type finish. Level —48 DB.

The Turner Third Hand, 3-H, slips over the neck in a jiffy. Goose neck adjusts mike to any position. Can be used with long lines as traveling mike. Window demonstrators find 3-H indispensable. Can be ordered with mike switch at extra cost.

All Crystals Licensed Under Patents of the Brush Development Co.

Free New Turner Microphone Catalog, showing all available models. Write for yours today.

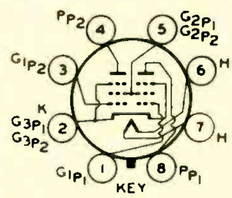
THE TURNER CO.
CEDAR RAPIDS, IOWA

TECHNICANA

[*Continued from page 12*]

power output of 1.1 watts with 10 per cent distortion. Its electrical characteristics are essentially the same as those of the octal-glass type 6G6-G.

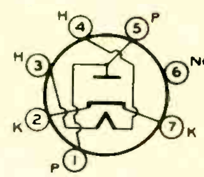
The *12L8-GT* is a twin-pentode power amplifier having GT-construction. It is useful in the output stage of compact, light-weight equipment where



8BU

moderate power is desired. In such service the units, each of which can handle a power output of 1 watt to 10 per cent distortion in Class A service, may be connected in push-pull or in parallel depending on the requirements.

The *9006* is a heater-cathode type of midget diode suitable for uhf use as



6BH

a rectifier, detector, or measuring device. It has a peak inverse plate voltage of 750 volts, and a peak plate current rating of 15 milliamperes. The resonant frequency of the 9006 is approximately 700 megacycles.

QUARTZ CRYSTALS

THE JANUARY AND JULY 1943 issues of the *Bell System Technical Journal* contain several articles on quartz crystals and their applications. The first article, in the January issue is entitled "The Mathematics of the Physical Properties of Crystals" by W. L. Bond. This article provides a treatment of matrix algebra which is clearer than many other texts.

Other articles on crystals, which are found in the July issue are: "A Mineral Survey for Piezo-Electric Materials" by W. L. Bond; "The Fundamental Equations of Electron Motion (Dynamics of High Speed Particles)" by L. A. MacColl; "Quartz Crystal Applications" by W. P. Mason, and "Methods for Specifying Quartz Crystal Orientation and Their Determination by Optical Means" by W. L. Bond.

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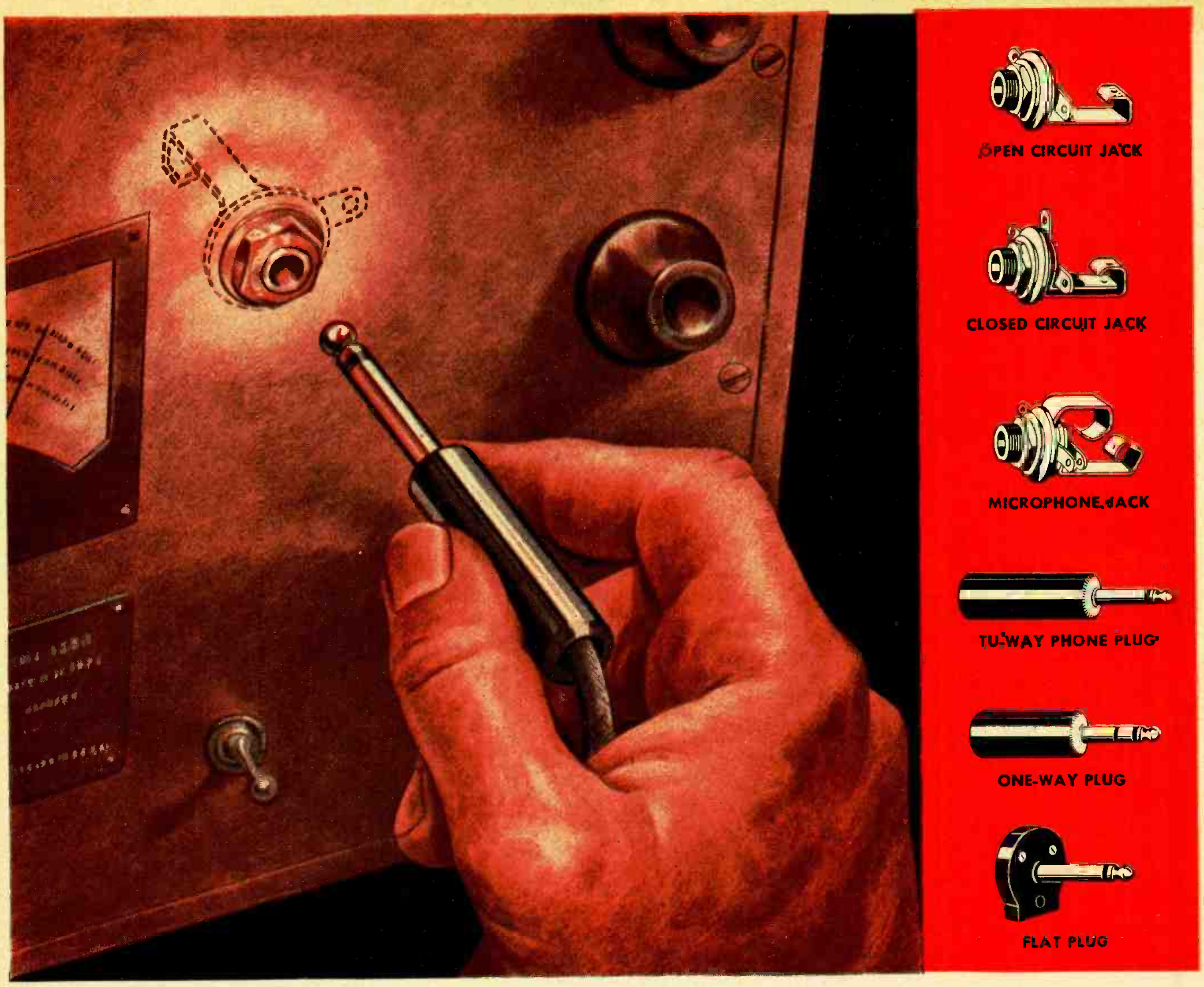

utah CAN HELP YOU MAKE THE RIGHT "CONTACTS"...

THE right "contacts" are always important. In electrical and electronic applications a poor contact can mean costly losses. By using Utah Jacks and Plugs you can be sure that your equipment will not fail from the want of proper contact. They have been tested in the laboratory and in actual use thousands of times, answering every test successfully—under all types of conditions.

UTAH PHONE JACKS are everything that selected materials and human ingenuity can make them. They are available in Imp, Short and Long frame types to fit the standard phone plugs. Special Jacks are also made to meet Navy and Signal Corps Specifications.

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TECHNICANA

[*Continued from page 14*]

COUPLING COEFFICIENTS

IN AN ARTICLE appearing in *Wireless World* for September 1943, S. W. Amos derives an equation for the coupling coefficient k in terms of the dimensions of two coils and their separation. This article refers specifically to the usual i.f. coil, as in *Fig. 2*. Assuming that both coils are equal and that the separation, b, between them is more than four times the length, a, of the coil, the value of k is:

$$k = \frac{1+\frac{2.3a}{D}}{\left(1+\frac{2.3b}{D}\right)^3}$$

Solving for the dimension b when k and a are known:

$$b = 0.4375D\left(\sqrt[3]{\frac{1+\frac{2.3a}{D}}{k}}-1\right)$$

The error due to a simplification of the formula is not more than 4 percent so long as b is more than four times a. The full equation for k, without simplification, is:

$$k = \frac{1+\frac{2.3a}{D}}{\left(1+\frac{2.3b}{D}\right)\left(1+\frac{2.3c}{D}\right)\left(1+\frac{2.3e}{D}\right)}$$

where $c = b - a \qquad e = b + a$

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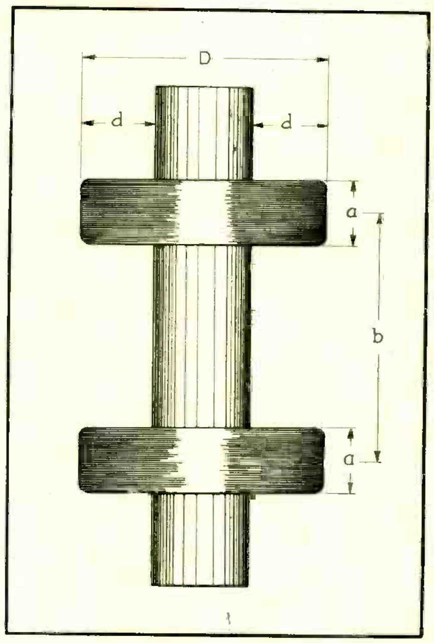

Fig. 2. Coil coupling factors.

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The Inspection Of Quartz...

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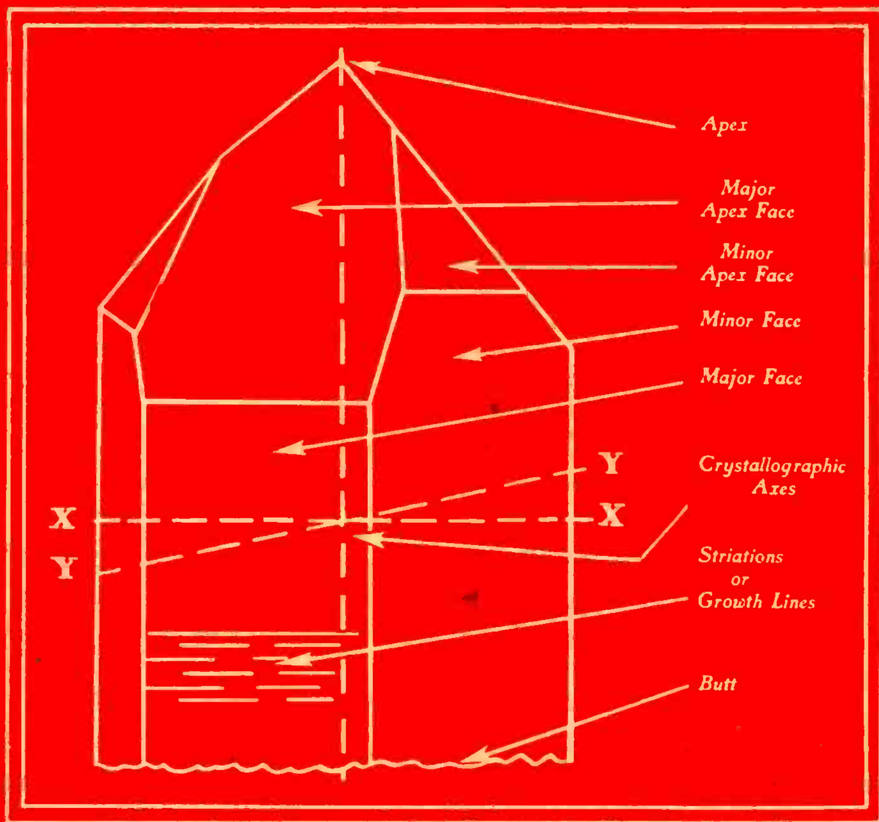

Quartz with the better piezo-electric properties are imported. The mineral is usually classified according to size with pieces ranging from 100 to 300 grams.

A shipment of quartz nearly always represents a cross section of the quartz supply . . . some crystals will have good faces and apexes, others only few faces and no apexes, and still others no faces or apexes at all. It is therefore necessary that they be expertly sorted, usually into three groups, each one to be treated in a different method before cutting.

Next, in order, comes the study of impurities in the different kinds of crystals. The impurities can be seen with the naked eye, by having a beam of light pass through the crystal. This shows up such impurities as fractures or cracks, foreign particles included within the crystal, bubbles, needles, veils, color and ghosts or phantoms. The latter are cases where the crystal contains internal colored bands or planes parallel to the faces of the crystal. These really represent stages of growth of the crystal and it appears to the eye as if one crystal has grown within another. Crystals with excessive amounts of impurities are, of course, rejected.

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TECHNICANA

[*Continued from page 16*]

IRON-CORE COILS

IN AN ARTICLE titled, "Powdered Iron Cores" by A. Crossley, in the *Journal of Applied Physics* for September 1943, the author reviews the history of iron cores for high-frequency coils, discusses the type of material employed for the cores and winds up with an application promised for the future. "This device provides means for varying coupling from zero to a desired maximum value and in addition the phase relationship of the inductive coupling can be adjusted to be aiding or opposing the electrostatic coupling inherent in the system being coupled."

Fig. 3-A shows the customary i.-f. coupling system, wherein the bandwidth is increased by moving the two coils closer together. "Increasing the coupling beyond critical coupling introduces complications, because the mutual inductance starts increasing both primary and secondary inductance and both circuits are thereby tuned to a lower frequency."

Fig. 3-B shows how this can be overcome by means of variable iron cores. As the three cores are moved downwards simultaneously, they increase the mutual inductance, and at the same time decrease the small compensating inductances *A* and *B*, so as to keep the system tuned to the same carrier.

"*Fig. 3-C* is an improvement electrically and economically over the arrangement shown in *Fig. 3-B*. In this

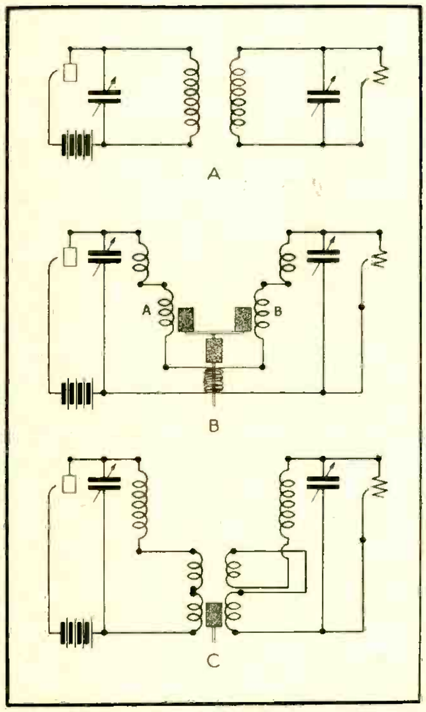

Fig. 3. Iron-core coupled circuits.

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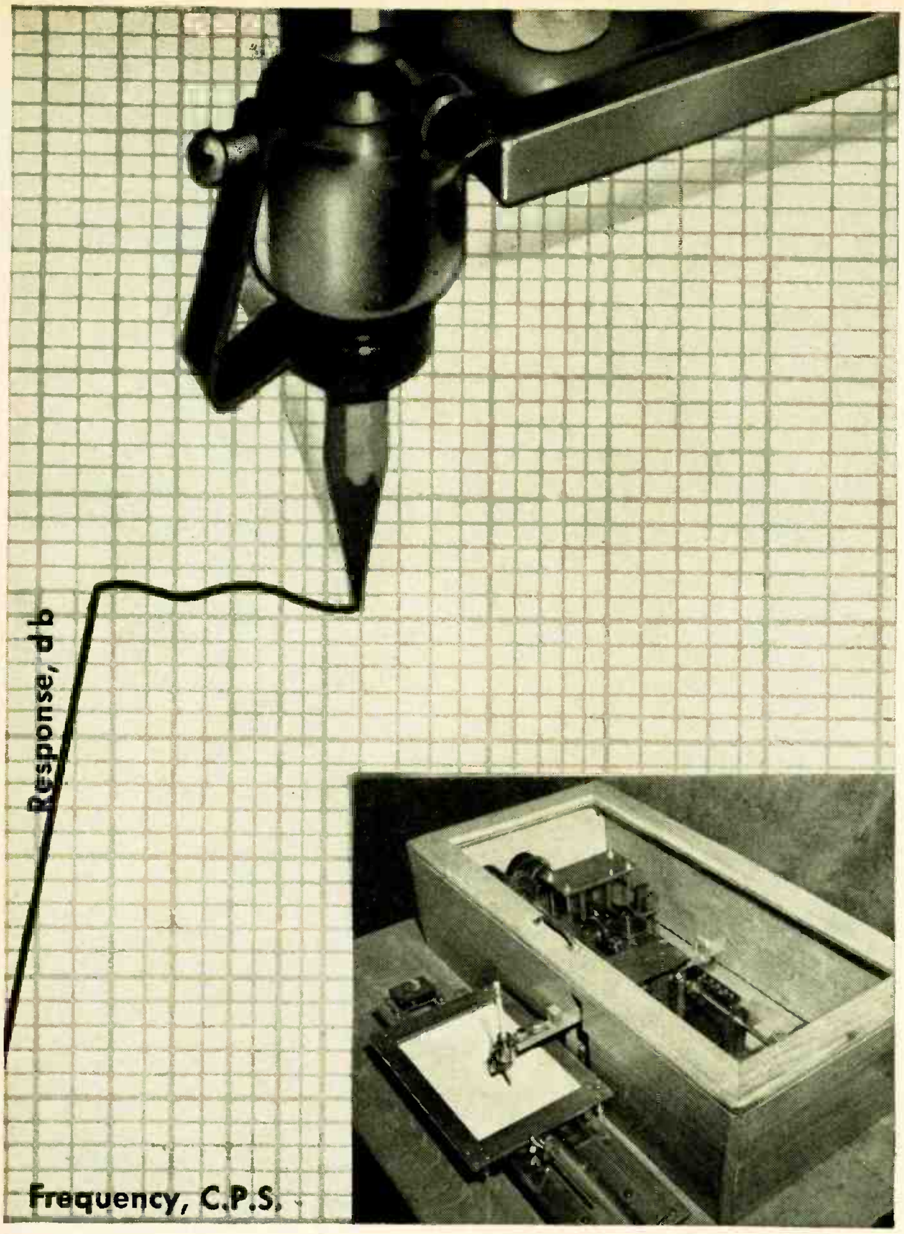

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Designers and Manufacturers of Microphones and Acoustic Devices

TECHNICANA

[*Continued from page 19*]

figure one coupling coil system and one iron core do the work of the three previously used. The coil consists of a bakelite tube upon which is wound bifilarly four coils and inside of the tube is a powdered iron core having an adjusting rod. The winding connections of one of the four coils are reversed thereby providing the novel condition whereby the movement of the iron core can produce any desired degree of coupling from zero to maximum with the additional feature of phase changing.

"Zero coupling is obtained by moving the core to the center of the tube whereby the negative mutual obtained with the reversed primary coil is counterbalanced by the positive mutual of the lower coil system. Moving the core upwards produces an increase in coupling until maximum is obtained when the core is completely enclosed by the upper coil system. Moving the core downwards also increases the coupling but this coupling is 180 degrees out of phase to the previously mentioned coupling.

"Thoroughout the entire movement of the core for any degree of coupling the inductance of both the primary and secondary remains constant."

This coupling system can also be applied to oscillators for the control of feedback, or for filter systems where a variable coupling is desired.

MEASURING WAVELENGTH OF SOUND

THE CATHODE-RAY oscillograph is a useful instrument for the measurement of the wavelength of sound by a method described by G. N. Patchett in the *Proceedings of the Physical Society* for July 1943.

The method consists in measuring the phase difference between the sound

[*Continued on page 22*]

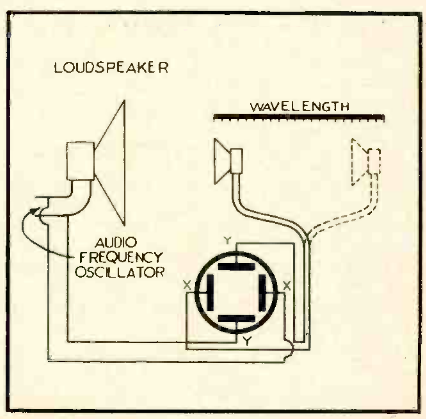

Fig. 4. Sound-measuring set-up.

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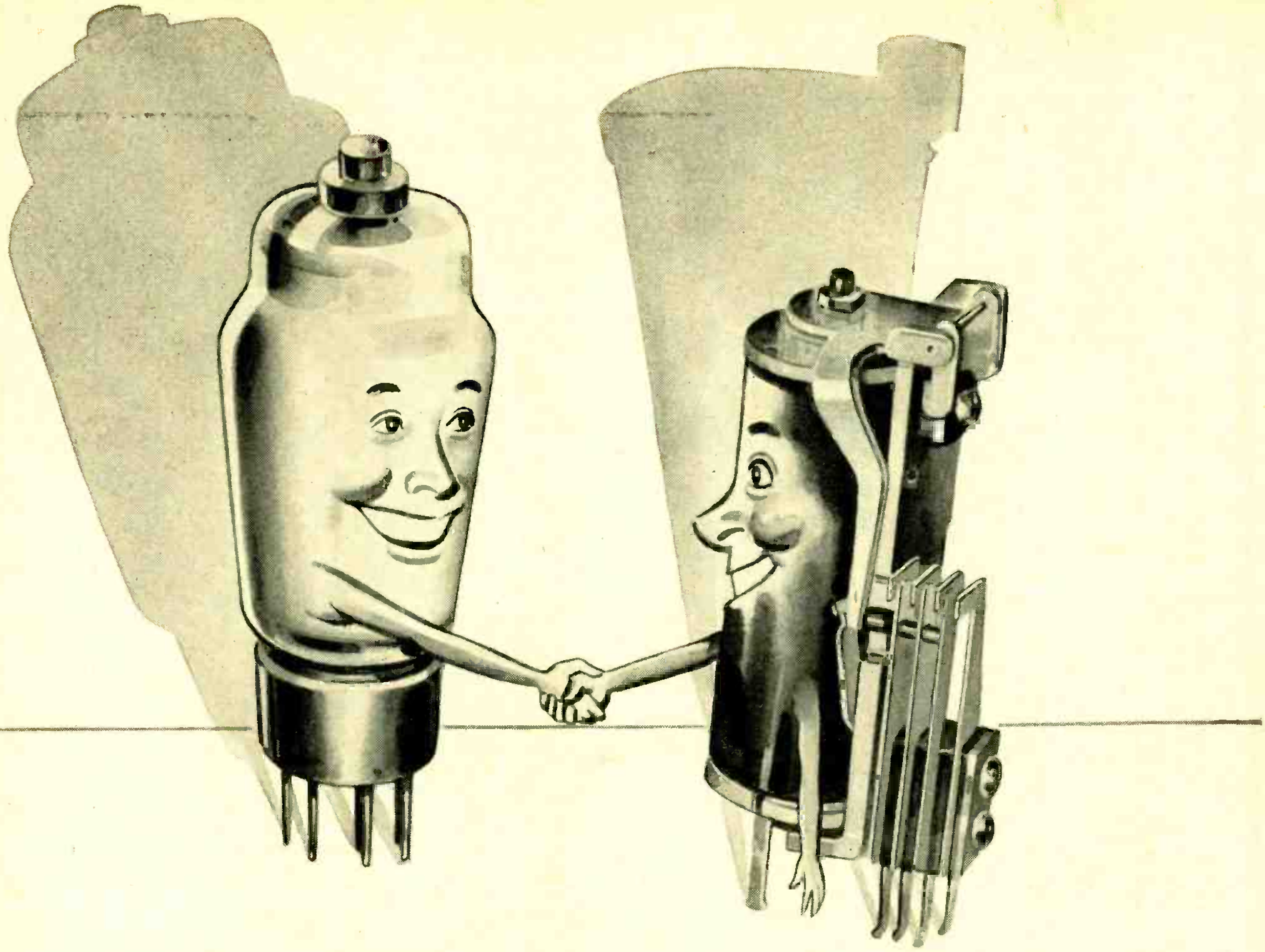

LET'S POOL OUR KNOWLEDGE

WORKING with electronic engineers in scores of industries has taught us a lot about electronic science—what it is doing to increase the effectiveness of our tools of war—how it is speeding up war production—about the miracles it promises for our postwar world.

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TECHNICANA

[*Continued from page 20*]

emitted at a loudspeaker and that received by a microphone, then moving the microphone away from or towards the loudspeaker until the phase difference is the same again. The distance over which the microphone is moved, equals the wavelength.

Referring to *Fig. 4*, a loudspeaker is energized by means of an audio oscillator, and the voltage at the terminals of the loudspeaker is also applied to the X plates of a cathode-ray oscillograph. The voltage obtained from a pressure microphone directly in front of the loudspeaker is applied to the Y plates of the oscillograph with or without an amplifier. The trace on the screen will form the customary ellipse, circle or straight line. It is suggested that the microphone be placed so that the trace is a straight line, then moved away from the loudspeaker or towards it until it has gone through all phases and the straight line, sloping in the same direction, returns. To avoid undesirable effects due to reflection, the loudspeaker and microphone should be reasonably near each other in a large room.

VIBRATION AND OSCILLATION

THERE IS A FUNDAMENTAL difference between vibration and oscillation says P. C. Jones in an article on Multivibrators appearing in the *Bell Laboratories Record* for September, 1943. Vibration is derived from the Latin *vibrare*, meaning to shake or brandish, while oscillation comes from the Latin *oscillare*, meaning to swing: the motion of the pendulum. These two are not the same.

"A pendulum—if the arc of motion is short—always completes each full swing in the same time and this time—or period—is determined by the length of the pendulum. Mathematically, this type of motion results because the accelerating force, which is due to gravity, is proportional, but opposite in sign, to the displacement from the vertical position of the pendulum.

"In electrical circuits containing inductance and capacitance, there may be a relationship between the voltage and time similar to that between distance and time with the pendulum. The voltage increases in one direction, returns to zero, and then increases and decreases in the other direction exactly analogous to the motion of the pendulum. For this reason such an electric circuit is called an oscillator.

[*Continued on page 61*]

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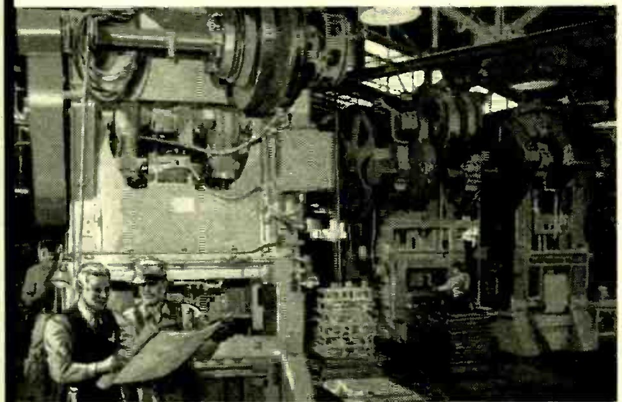

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MAXWELL'S EQUATIONS IN MICROWAVE REFLECTIONS

V. J. YOUNG
Sperry Gyroscope Co., Inc.

★ It is possible to solve even the simplest electrical problems by the application of a very general sort of electromagnetic theory. In the same way problems of physical optics, which physicists have approached so successfully with Maxwell's equations, must be subject to solution in terms of quantum electrodynamics which is even now in the process of development.

Procession

Thus, all branches of science seem to grow. As phenomena are studied, rules and laws concerning their action are formulated. With electricity there were first experiments with lode stones, amber rubbed with cloth, static machines, Leyden jars, etc., and by the time of Michael Farady (1791-1867) much could already be said about what would happen in many electric and magnetic circuits. In fact, the so-called quasi-stationary state with which these principles deal is all that is used even now in much of our engineering practice.

When J. Clerk Maxwell (1831-1879), working from the experimental results of Faraday and others, found that the quasi-stationary state solutions were not enough to describe all known results, his problem was not merely to explain away the new difficulties, but rather to formulate a theory which would also include as a part of itself the many already useful and well-established laws. In the same way, in the twentieth century, we have found that our ideas of electromagnetic theory are not good enough when we deal with atoms smashed by our cyclotrons and other machines designed to examine the inner core of the atom. Modern physicists do not take this to mean that Maxwell's equations are any less valid than they were at the turn of the century, when practically all known data were so well explained; rather, they say that a more general and quantized theory must be worked out that will be valid not only for the macroscopic world but also for the submicroscopic atom.

Luckily, in the study of microwaves, there is no such fundamental difficulty to be overcome. Because we use wave guides and pay even more attention to the path traveled by the actual radiation than we do with ordinary radio wavelengths; because we are so often dealing with circuit elements that are difficult to designate as combinations of L, C, and R, even over limited ranges of frequency, voltage and current; and because it is difficult to always trace out the path over which the charge moves; for these reasons ordinary circuit theory is at times insufficient for our purpose. It may still be a useful guide and analogy, but for a straightforward solution of a problem we must often turn to Maxwell's equations and their accompanying theory. In doing so we will not find results inconsistent with calculations at longer wavelengths, where the usual circuit theory is sufficient for practically everything, but rather a more general statement of the laws of nature which govern electromagnetism.

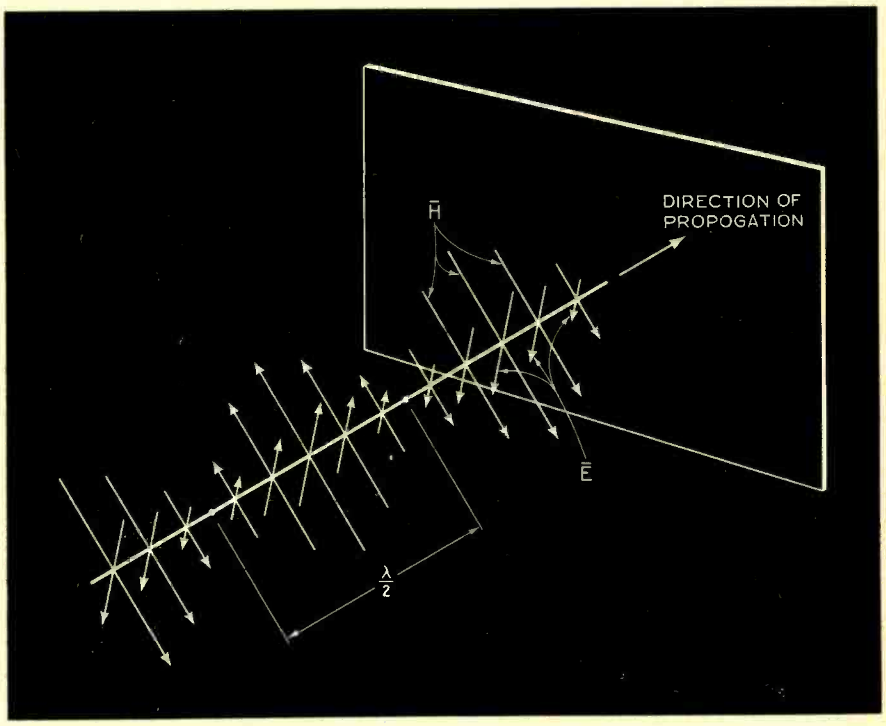

Fig. 1. A "snapshot" of the vector values of E and H as an electromagnetic wave approaches a surface but before any reflection occurs. The whole pattern moves forward in the direction of propagation with a speed which in general equals that of light.

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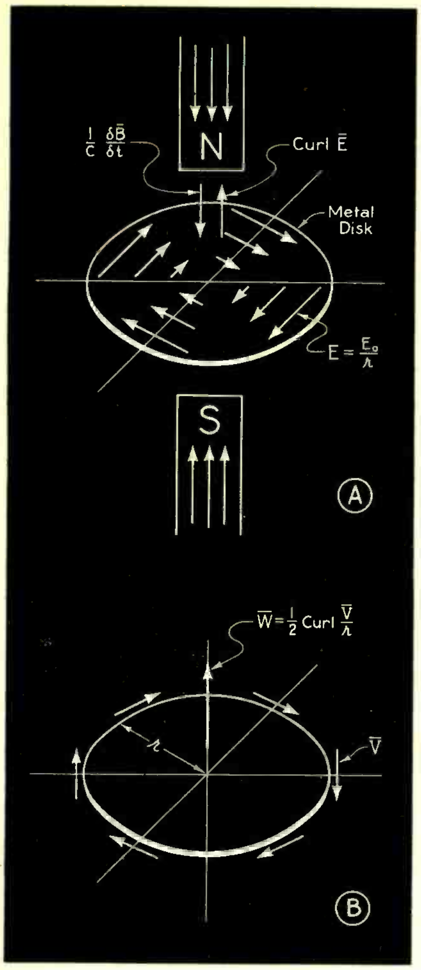

Fig. 2. In (A) is indicated magnetic poles approaching a metallic disk along a line perpendicular to the plane of the disk. If the magnetic field therefore increases at the disk with a rate (1/C) $\delta B/\delta t$, then an electric field will exist at every point in the disk and will be so tangentially directed as to urge charge to move around the disk. In (B) the Curl vector relation is shown for a perfectly general vector W without attaching any physical significance to it.

The Seven Relations

It is our purpose here to illustrate how a physical picture of the reflection of radio waves may be formed directly in terms of field quantities as defined in a more general electromagnetic theory. In doing this, even in an essentially non-mathematical manner, we must be sure of our interpretation of the underlying rules.

Seven relations must be specified to describe the basic principles. Four of these are known as Maxwell's equations and owe their rigorous completeness to him. The other three are statements which have to do with the properties of materials; that is they define electrical resistance, magnetic permeability, and the dielectric constant. These are often called the constitutive equations.

Today, as we write all these relations, it is much easier to see their physical meanings than it was at the time of Maxwell's death. This is because of the general use which is now made of vector algebra. To write the same expressions out in a given set of three-dimensional coördinates would mean the use of three times as many equations. What is still more important is, that actually all these relations are quite independent of the coördinate system. Said this way, the statement certainly sounds true at once. If an ampere of current flowing along a wire gives rise to a gauss of magnetic field encircling the wire, the same thing is meant whether we choose a set of Cartesian coördinates, in which the current is along the z axis and the magnetic field is measured at a point (x, y, z), or formulate the representation in cylindrical coördinates and make the measurement at a point (r, θ, z).

This, translated into mathematical terminology, says that all the vector symbols used in writing down Maxwell's equations are invariant as to coördinate system. As we shall write them, no coördinate is in evidence at all. Each symbol has a perfectly definite physical meaning quite apart from how we may wish to tag various points of that part of space in which we are interested. When we wish to actually use the relation in a problem, we have to substitute expressions for the symbols and what we substitute does depend on the coördinates we use. The final result, however, is interpreted the same in any event. Coördinate systems are chosen only for convenience. Any problem solvable by our theory can, in principle, be solved in any coördinate system.

The seven equations are*:

$$\text{Curl } H = \frac{1}{C}\frac{\delta D}{\delta t} + \frac{4\pi u}{C} \qquad (1)$$

$$\text{Curl } E = -\frac{1}{C}\frac{\delta B}{\delta t} \qquad (2)$$

$$\text{Div } B = 0 \qquad (3)$$

$$\text{Div } D = 4\pi\rho \qquad (4)$$

$$B = \mu H \qquad (5)$$

$$D = \epsilon E \qquad (6)$$

$$u = \sigma E \qquad (7)$$

where H and B are measured in oersteds or gauss; E and D are in electrostatic volts per cm; u is in electrostatic amperes per square cm; μ is permeability and therefore a measure of the magnetic condition of a material and its characteristics; ϵ is the dielectric constant telling how the medium is subject to polarization; and σ is the conductivity of the substance in electrostatic amperes per electrostatic volt of potential applied between opposite faces of a cubic cm of material.

Since these relations are an all inclusive description of the action of macroscopic electricity, we can ask any question about any circuit, and to the extent we can surmount the mathematical difficulties we will find the answer in the equations. Practically, we may have real difficulty in formulating the question since it too must be expressed in terms of our mathematical symbolism. As a mathematician would say it, the asking of a question consists of specifying the initial and boundary conditions of the problem.

Reflection Problem

To see how this works and better understand what the equations mean, let us go immediately to the reflection problem. We ask what happens when an electromagnetic wave which is traveling through space meets a conducting surface. In *Fig. 1* the initial condition of the problem is illustrated. As it is shown, the wave approaching the reflector would be said to be plane polarized since the E and H vectors are pointing in a perfectly definite direction. With unpolarized radiation their direction in the plane of the E and H vectors shown would be a ran-

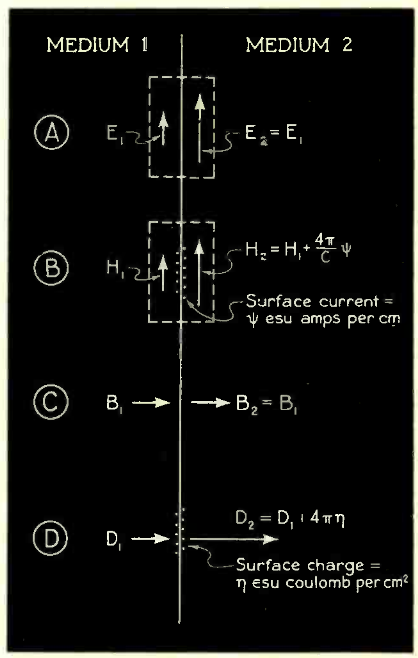

Fig. 3. The four fundamental continuity relations of the electromagnetic field quantities are illustrated as they are obtained in the limit.

*The vector quantities here, and throughout the remainder of the article, are indicated by italics.

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dom function of time and space. The thing that is always necessary in isotropic mediums is that E, H, and the direction of propagation be all mutually perpendicular.

The requirement of perpendicularity can itself be immediately seen in Maxwell's equations. Because in equation 5, B and H differ only by a factor of μ which in an isotropic medium is independent of direction, B and H in general are in the same direction. Equation 2 tells us about the vector relation and hence the perpendicularity of E and B. This equation 2 is the rule of transformers and generators. B is that measurement of magnetic field called magnetic induction. As the amount of magnetic induction through a circuit changes (this is $\delta B/\delta t$), a potential (and hence E which is potential per cm) is found in the windings. Evidently then the operator curl is one which reconciles the direction of B along the axis of a circle and that of E around the circle and perpendicular to that axis. This geometrical interpretation of the curl of a vector is illustrated in *Fig. 2* both as a specific example of this Maxwell equation and as a mathematical operation quite apart from physical interpretation. It will be noticed specifically in *Fig. 2-B* that a factor of ½ comes in. In the electrical case this is taken care of by the units chosen. It also is noticed that if a vector is said to be the curl of another vector, then the second vector is defined throughout space with a changing amplitude. This too is in agreement with our ideas about induced voltages.

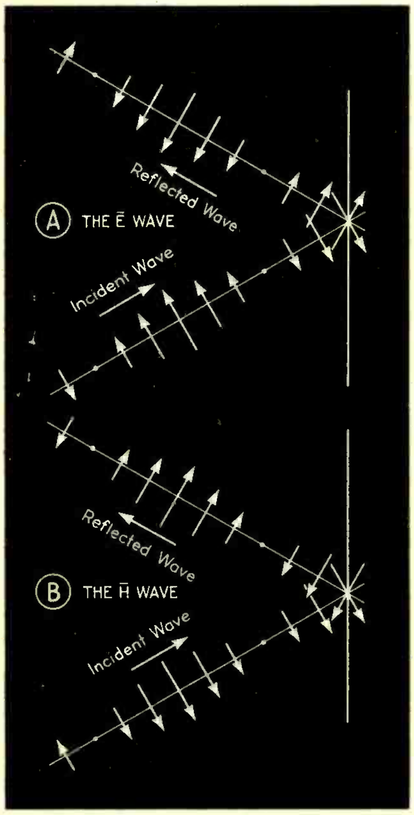

Fig. 5. The E wave in (A) is reflected with change of phase at a perfect conductor so as to have a net zero tangential component at the surface but a normal component equal to the surface charge. The H wave in (B) is reflected without phase change giving a zero normal component but a tangential part arising from surface current.

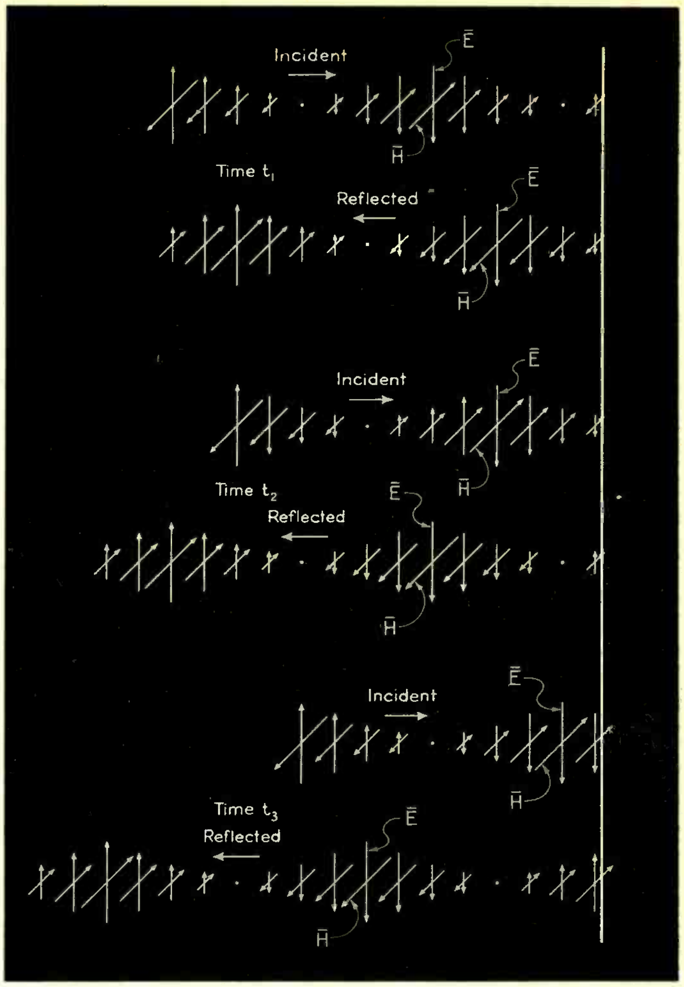

Fig. 4. These diagrams represent the way in which a radio wave is reflected from a large perfectly conducting surface. The E vector is reversed in phase at the surface and the H vector is not.

Thus, in *Fig. 1*, if we agree that energy propagation is given by Poynting's vector[1] which is perpendicular to both E and H, we have only to say that the first medium is air or vacuum and half of our job of question-asking is done. We have stated the initial conditions by visualizing the electromagnetic wave as it approaches the surface. We must next ask about the boundary conditions, about the relation of E and H which must exist at the surface. When we have done that the answer to the question of what happens after the wave reaches the surface becomes comparatively easy.

[1] "Poynting's Vector in Wave Guide and Radiation Phenomena," *Radio*, August 1943.

The Four Conditions

Without restricting ourselves as to media we can see from Maxwell's equations that four conditions must hold at any surface of discontinuity. They are:

I The tangential component of E is continuous
II The normal component of B is continuous
III The discontinuity in the tangential component of H is $4\pi/C$ times the surface current
IV The discontinuity in the normal component of D is 4π times the surface charge density.

Fig. 3 is helpful in understanding why these relations must be true. In *Fig. 3-A*, an impossible case is shown which violates I. E_t is imagined to be larger at an infinitesimal distance into medium 2 than in medium 1. According to our interpretation of the operator curl, this means that in the dotted region, vectors exist which are perpendicular to the plane of the paper and which may be identified as curl E. By our equation 2, this is equivalent to $-1/C(\delta B/\delta t)$, which is certainly a finite vector repre-

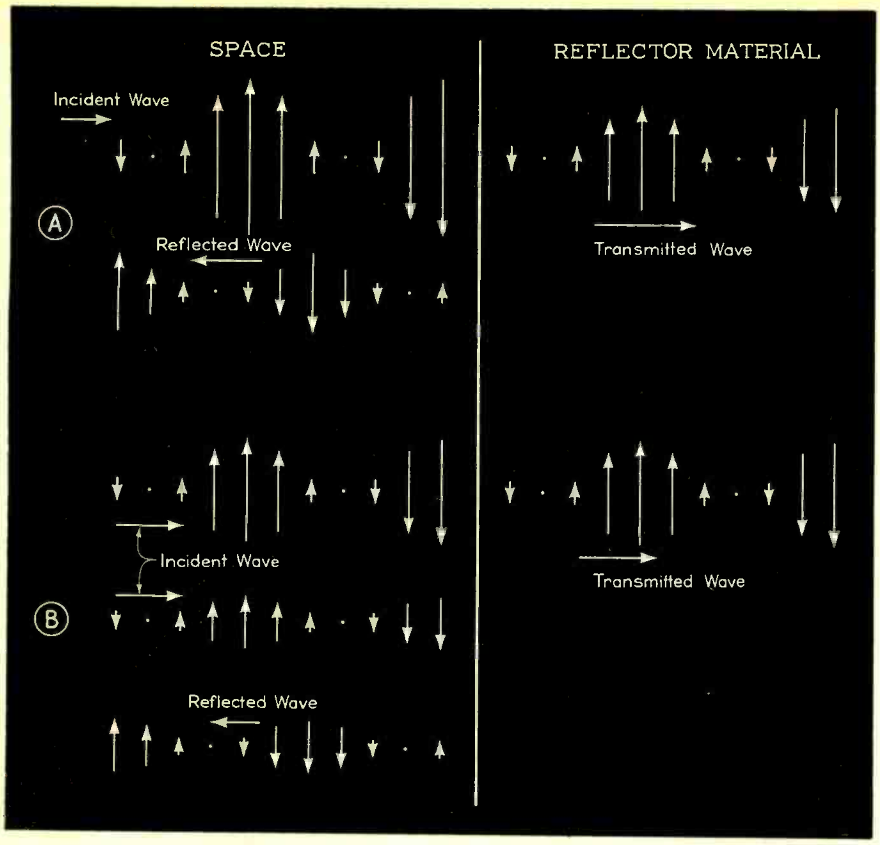

Fig. 6. An E radio wave approaching a reflector is partially transmitted and partially reflected. In (B) the incident wave is drawn in two parts to more easily show how the boundary condition is satisfied.

senting the time rate of change of magnetic induction in the dotted area. Thus, if we imagine the dotted area to become thinner and approach simply a double line drawn at the boundary, the number of vectors, $-1/C(\delta B/\delta t)$, which may be erected in the area certainly must approach zero. This is possible in the limit only if E_1 and E_2 are equal so they contribute equal but opposite amounts to the curl vectors. Their contributions will be opposite all right since the curl vector is thought of as existing between them. They represent tangents to rotations in opposite directions around such a vector as an axis.

In *Fig. 3-C* a sketch is shown upon which we may base a similar argument for condition III. This time the vectors perpendicular to the paper are curl H or by equation 1, $(1/C)(\delta D/\delta t) + 4\pi u/C$. As the dotted area is made thinner, this expression need not approach zero, as did a similar quantity in the curl E case, but rather will approach $4\pi/C$ times the surface current.

To see that II as illustrated in *Fig. 3-B* is true we need only to understand the meaning of the operator div (divergence) as used in equation 3. This equation is simply a mathematical statement of the fact that magnetism arises from magnetic poles which never occur separately but always as a combination of a north and a south pole. A bar magnet six inches long may be said to have a north pole at one end and a south pole at the other. If this magnet is cut into small pieces no matter how tiny, both poles are still found on each piece. Div $B = 0$ tells us just this. Magnetic induction arises from magnetic poles which, however, are never more than infinitesimally separated from opposite poles. Thus, lines of B are always continuous. Mathematically divergence tells us the amount of increase of a vector as it flows through an infinitesimal volume. The statement that Div $B = 0$ is merely a more general way of saying what we have in II.

In a similar way we can justify IV by equation 4. Here the electric field D is one that arises from the presence of charge. Unlike magnetic poles, however, charge can exist on the surface. Thus D instead of being continuous at the boundary, will change its magnitude in accordance with whatever surface charge is present.

In *Fig. 4* is illustrated the case of a radio wave approaching a large metallic surface at a right angle. We make the approximation that the metal is a perfect conductor. Then no electric field can exist inside the conductor since with $\sigma = \infty$, equation 7 would otherwise require an infinite current which is certainly impossible. Moreover, it is clear from Maxwell's equations that if E is everywhere zero at all times, then D, H, and B must also be zero or at least constant. Thus the boundary conditions of *Fig. 4* are very simple. Normal components of B and D do not exist, and since E is zero inside the conductor, it must be zero at the boundary. H must also be zero at the boundary except for whatever surface current may flow. These conditions can be satisfied at all times only by postulating a reflected wave of the same amplitude as the incident wave. The surface current generated by E is just enough to double the value of H at the boundary. This means that E is reflected without change of phase and H with a phase reversal. This is necessary in order that Poynting's vector shall change and show energy flow away from the boundary for the reflected wave. By showing both the E and H waves at three times, t_1, t_2, and t_3, *Fig. 4* shows how the existence of the boundary conditions call for such a wave and are satisfied by it. A radio wave approaching a large perfectly conducting surface is reflected without loss.

If the wave approaches at some other angle, the situation is only a little more complicated. *Fig. 5* illustrates this case. Each vector then has a normal as well as a tangential component. The boundary conditions are satisfied only if the reflected wave makes an equal angle with the surface but in such a phase and at such a position as to satisfy both the normal and tangential conditions. This is so called specular reflection just as is obtained with ordinary light at mirror surfaces.

Fresnel's Equations

As we know from experience, it is by no means necessary to have a perfectly conducting surface in order to get a reasonable amount of reflected energy. We might well guess immediately that with a surface such as wood or a similar material, the reflection efficiency is reduced. E, H, B, and D may now exist within the material so all the wave is not reflected. Some is transmitted into the reflector material and either dissipated there or carried on through to a third medium. The situation at the surface necessary to satisfy our boundary conditions and still allow for partial transmission and reflection is illustrated in *Fig. 6*. As shown in *Fig. 6-A* it looks rather complicated but in *Fig. 6-B* the original incident wave has been split into two waves and one thought of as suffering complete transmission and the other complete re-

[*Continued on page 59*]

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MODERN THEORY OF ELECTRONS

PAUL R. HEYL, Ph.D.

PART 2

★ Here we are in for another mental jolt, for the next turn taken by theory was to suggest that an electron might be in part or in whole a little bunch of waves. This is the fundamental idea of the theory of wave mechanics, initiated by de Broglie(12), and later amplified and developed by Schrödinger (13).

It appears as though de Broglie, on looking over the array of new concepts in physics produced by the twentieth century, had become curious to see what would happen if one mixed them, much as a beginner in chemistry ventures with more or less trepidation to mix the contents of several bottles from the laboratory shelves. So de Broglie seems to have asked himself: "What if we applied the theory of relativity to the quantum theory, or to the doctrine of the equivalence of mass and energy?" He tried the experiment. The smoke arising from the reaction obscured his vision for some time, but when it cleared away he saw that which he, and Schrödinger after him, have elaborated into the theory of wave mechanics.

Wave Mechanics

De Broglie's hypothesis was that every mass particle was enveloped and surrounded by a group of waves (never mind of what, for the present) traveling with the particle as a sort of bodyguard. Though the group as a whole keeps pace with the particle, the individual waves constituting the group travel more rapidly, dying out a little distance ahead of the particle, and new ones coming into existence a little way behind. Just so successive generations of men pass rapidly across the stage of time, while human progress moves onward more slowly. This concept of "group and wave speed" was not new to physicists.

But further study showed that de Broglie's hypothesis was unable to continue its early promise, becoming involved in logical difficulties. However, this suggestion, coming under the thoughtful notice of Schrödinger, was the starting point for the more fruitful theory known as wave mechanics.

Schrödinger said to himself: "If such a group of waves always keeps pace with the particle, why the particle at all? Let us see what may be expected to happen if we suppose the group of waves itself to be what we call the mass particle."

★ This, the second and concluding installment of Dr. Heyl's article, leads up to the modern conception of the electron as a "dual personality." As he points out, upon this dual wave-particle aspect of the electron has been based the important invention of the electron microscope. It is the charged particle aspect of the electrons which causes them to be brought to a focus by the magnetic lens, and it is the very short-wave aspect of the electrons which gives to the microscope its high resolving power. Thus do we have at least one instance where the work of the pure scientist has contributed to the advancement of technology.—**Editor.**

As the first thing, Schrödinger saw that it would be necessary to establish for this proposed "wave atom" a satisfactory and acceptable pedigree. He took down from the shelves of science, where it had been resting for years, a principle originally formulated by Hamilton, the inventor of quaternions. Of this principle it has been said by Professor Edwin B. Wilson that it is "the most fundamental and important single theorem in mathematical physics." From it, it would seem that the whole of ordinary mechanics is derivable, and from it Schrödinger deduced an equation representing much the same thing as de Broglie's group of waves. By reason of this pedigree and the mathematical relationships involved in it he was able to determine just how such a group of waves would behave under different conditions; and among other things he found that the motion of what may be called the "center of gravity" of such a group of waves would, according to the laws of wave propagation, follow exactly the same path as would a mass particle under the laws of ordinary mechanics. Such a wave group passing near a mass particle would be deflected just as though the law of gravitation acted on it. And in following these laws the wave group turned out to be more consistent than a mass particle would be; for it is a remarkable thing, of which we have become fully aware only within the present century, that the laws of ordinary mechanics are not always applicable to systems of atomic dimensions(14); yet even in problems of this character wave mechanics proved itself useful, and showed, perhaps, its most interesting application in the structure of the atom.

Schrödinger Atom

The Schrödinger atom is electrical in its nature. It may be visualized as a nebula of disembodied electrical charge, everywhere of the same sign, continuously distributed throughout a spherical region, the distribution being subject to slight fluctuations in the intensity of the charge, which constitute the vibrations of the atom.

Schrödinger's equations show that the electric density in the atom falls off rapidly with increasing distance from the center of the sphere. For all practical purposes, therefore, the Schrödinger atom has a definite boundary; but strictly speaking, the intensity of the charge falls off asymptotically to zero, and in consequence two such

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atoms, however far apart, are connected by an infinitesimally tenuous bond of the same nature as their own substance.

Here we have a curious and interesting state of affairs, suggesting a compromise between the continuous and the atomic theories of matter. This modern adaptation of an ancient idea, this bridging of the centuries, calls to mind the well-known quatrain of Omar Khayyam:

Myself when young did eagerly frequent
Doctor and Saint, and heard great argument
About it and about; but evermore
Came out by the same door where in I went.

The test of the acceptability of any theory is not its conventionality nor its grotesqueness, its simple or abstract nature, but what it will do. Nothing in all modern science has appeared at first sight more fantastic and unreal than the theory of relativity, yet it made its way into general acceptance because it was able to do things a little better than its predecessors.

The same is true of the wave atom. Its immediate predecessor, the Bohr "solar system" atom, while successful in explaining many things, failed completely to explain three important features of atomic behavior; and of these three the wave atom gave simple and unforced explanations. In addition, for such happenings as "collisions of electrons with atoms," and "emission of electrons" the wave atom furnished a ready mental picture. An emitted electron, according to this theory, would be a little bunch of waves thrown off from a larger vibrating sphere, something like a wisp of flame thrown up from a wood fire, except that the electron lasts indefinitely. Perhaps it meets another vibrating sphere and coalesces with it, adding its energy to existing vibrations or contributing a new frequency to the atom.

The wave atom is still the most successful atomic model that has ever been proposed; but like all theories it has its weak points, two of which we shall mention.

The group of waves which is fundamental in this theory is assumed to be made up of trains of waves of different wave length and correspondingly different speeds of travel. They must therefore be carried by a dispersive medium. Now the ether which transmits light waves, X-rays and radio waves, whatever it is, is not a dispersive medium; for all these waves, which differ enormously in extreme wave lengths, travel with the same velocity.

There are two ways out of this difficulty. One is to suppose that the Schrödinger waves are different in kind from all other waves that we know anything about; and that empty space, while permitting all the known kinds of waves to travel with the same speed, exercises a dispersive effect upon the Schrödinger waves. The other alternative is to suppose that the Schrödinger waves are carried by a secondary ether, existing side by side with the old-fashioned ether, somewhat as sound and light may be carried by different media through the same space; but this rather crowds things.

Weakness of Theory

Another weakness of wave mechanics is that its whole development is based upon negative electricity. There is no place in the Schrödinger wave atom for positive electricity. This may be a little more understandable when we recall that in 1926, when this theory was developed, positive electrons were as yet unknown, and negative electrons occupied the foreground of the perspective in the picture of sub-atomic particles. The proton and the alpha particle were indeed known, but these were of atomic magnitude, and were regarded as in a different class from the sub-atomic negative electron. In the scientific literature of those days we find statements like these(15):

"At present it appears that positive electricity never leaves the atom, whereas (negative) electrons allow themselves to be taken away from or added to the atom with relative ease."

"A negative charge means too many electrons; a positive charge too few."

This last quotation carries us back to the days of Franklin. In fact, for some years before wave mechanics was developed, negative electrons and their behavior so occupied attention that the general attitude of mind may perhaps be described as a "negative one-fluid theory" of electricity. When positive electricity was mentioned at all it was with a vague hope that perhaps a similar set of equations might be developed to account for it.

But why, then, should we spend time in describing a theory that has such serious weaknesses? The reason is that in spite of its defects this theory has furnished the best atomic model that anyone has been able to devise up to date; and, in addition, there is experimental evidence that this theory contains an important kernel of truth. This evidence was discovered by Davisson and Germer(16) in 1927, at the Bell Telephone Laboratories, closely followed by G. P. Thomson(17) in Scotland, in 1928. These experiments lead inevitably to the conclusion that an electron is as much like a little bunch of waves as it is like a particle, and that neither of these aspects can be ignored.

It is interesting to note that the first of these discoveries came about by accident, which reminds me of something which Dr. W. R. Whitney, of the General Electric Research Laboratories, said on one occasion: "Interesting and important things sometimes happen unexpectedly, and our object here is to have the right man on the spot when this happens."

Davisson and Germer were investigating the distribution-in-angle of electrons scattered by reflection from a target of nickel in a vacuum tube. During this work a liquid air bottle exploded near by the tube, at a time when the target was at a high temperature from the electronic bombardment. The tube was broken, and the target heavily oxidized by the inrushing air. In repairing the damage, the same target, with the oxide removed by prolonged heating in hydrogen, was used in a new tube. When the experiments were resumed it was found that the distribution pattern of the reflected electrons had completely changed. This was traced to a recrystallization of the nickel that had occurred during the prolonged heating necessary to reduce the oxide. The target originally had the usual structure of nickel—a closely packed aggregate of very small crystals; but the prolonged heating brought about the formation of a few very large crystals, and the reflection from a single crystalline face was of a different pattern. Regular reflection may occur from such a face, after laws similar to those that govern the behavior of X-rays under similar conditions. If, however, the stream of electrons is reflected from a surface of ordinary nickel, made up of many small crystals instead of one large one, no regular scattering is ever observed. In this also the behavior of the electrons resembles that of X-rays.

Dual Theory

Now regarding the electron as a particle, no regular scattering is to be expected under any conditions. Crystals, large or small, are made up of atoms, and an electron is many thousands of times smaller than an atom. The impact of a stream of electronic particles against a surface of atoms is compared by Davisson to a load of bird shot fired against a pyramid of cannon balls. Such a target would be much too coarse grained to serve as a regular reflector for such small impinging particles. An electron must, therefore, be something like a bunch of waves.

But the reflected electrons can be deflected by a magnetic field, which would have no effect on electric waves; the

[*Continued on page 58*]

RADIO-ELECTRONIC PRODUCTION SPEED-UPS

Foreword

★ The data presented on this page constitute suggestions for speeding up production which have been certified to War Production Drive Headquarters of the War Production Board by Labor-Management Production Committees enlisted in the War Production Drive. These are not untried suggestions. They are practical ideas which have been tested in the shop or laboratory and have been adopted as standard practice in the plant where they originated. They have been further reviewed at the War Production Board by the Board of Individual Awards, composed of technicians and engineers in various industrial fields. This Awards Board has accorded appropriate recognition to the originators. For details of drive, see editorial page.—**Editor.**

SALVAGING ANODES

By E. G. MAYER
RCA Manufacturing Co., Harrison Plant

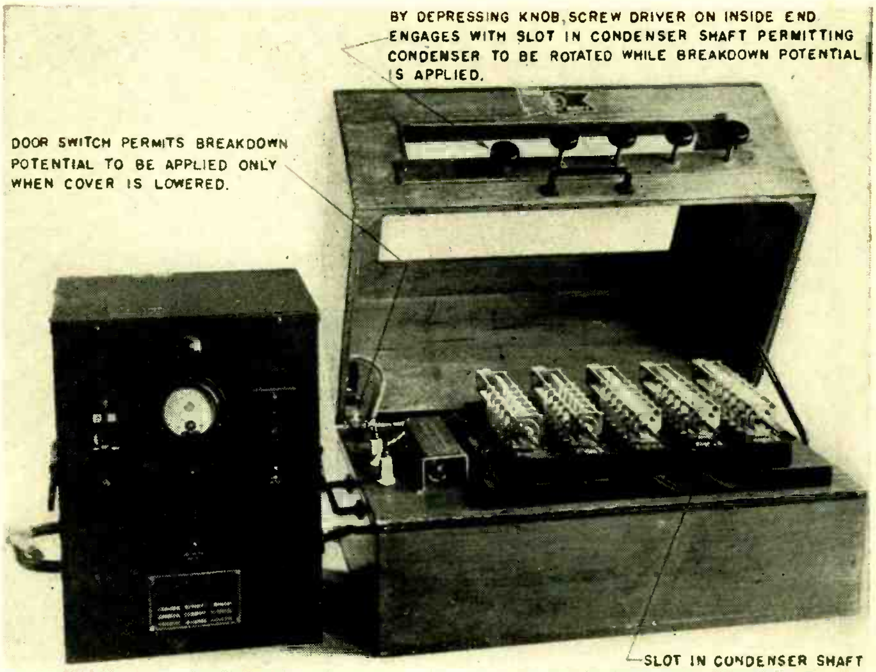
★ Previously, no attempt was made to salvage an expensive anode (FP 330-1A) for a special type of power tube. These anodes were merely discarded for scrap copper. Now 25 per cent of shrinkage anodes are saved by cutting out the filament and grid mounts and splicing a short length of glass to each end of the glassed anode. From this point the anode is retubulated, annealed, cleaned and re-used.

On a gross production of 65,000 at 25 per cent shrinkage the material saved vs. cost of salvage will be $2800.

★

CONDENSER TESTING JIG

By E. M. BECVARIK,
Western Electric Co., Hawthorne Station



Details of 1000-volt breakdown condenser-testing jig.

★ On the 1000-volt breakdown test on condensers now requiring two men, one man can be spared by means of a jig, shown in the accompanying photo. One man at present is required to turn the condenser shaft, while the other applies the 1000 volts. The motor will now turn the shaft.

To insure that variable condensers will not break down under service conditions, 1000 volts is applied between plates, which is considerably more than service application. The use of two men on this operation was instituted in order to locate breakdown points with greater ease than is generally possible under power drive. By compromising on this suggestion, a manually-operated jig was provided, which eliminated the extra man and retained the desirable feature of manual operation. As this is a continuous production job, the effect of this suggestion has been to release many man-hours for use on other work.

The condenser testing jig has reduced the time required for testing 1000 condensers from 170 man-hours to 30 man-hours, or 140 man-hours net savings. This jig has been used on 19,000 condensers and will be used on 34,000 on the "present contract."

★

RECEIVING-TUBE IMPROVEMENT

By W. J. CARLIN and H. SCHAEPE
RCA Manufacturing Co., Harrison Plant

★ The wing micas as shown in the accompanying sketch were originally designed to position the mount in the glass bulb. These micas were also the means of reducing vibration on this tube type under consideration. However, after a series of tests it was decided that positioning of mount and vibration limits could be successfully met by using the top mica as the positioner and vibration cushion. Standardization for this change has been placed.

Top mica in receiving tube used as positioner and vibration cushion

This suggestion eliminates the necessity of side, wing, or positioning micas on two types of receiving tubes which have a yearly production of approximately 855,000. The direct labor saving is 1330 hrs./yr. The direct material saving is $1440 a year.

★

SILVER PLATING CRYSTALS

By S. SHEPPARD
Radio Corp. of America, Camden Plant

Suggestion: That silver solution be prepared in a more alkaline phase in order to obtain a more substantial silver plate on crystals.

Note: Expansion in communications equipment needs for the war has caused a corresponding demand for somewhat scarce quartz crystals. A great majority of instruments require that the crystals be silver plated, an operation enabling a fixed set of frequencies to function in greatly varied temperatures and locations. Having expanded crystal facilities several thousand per cent, a means of increasing production or improving quality is of special value.

Result: A heavier and more uniform plate, thus virtually eliminating rejects due to pure plating and improving quality.

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"BIMORPH" ROCHELLE SALT CRYSTALS AND THEIR APPLICATIONS

ROY S. SAWDEY, Jr.
Engineering Department, The Brush Development Co.

PART 2

Earphones

★ Crystal earphones have enjoyed wide acceptance in amateur and commercial radio communication. They have also found use in group hearing-aid installations and for general testing purposes. High-fidelity types (See *Fig. 5*) responding to frequencies up to 12,000 cycles have been employed for sound measurements, audiometry and monitoring.

Their wide acceptance has been due primarily to the following desirable features:

(*1*) Exceptionally high impedance, thus causing a minimum of disturbance in critical electrical circuits. (*2*) Wide-range response with more uni-

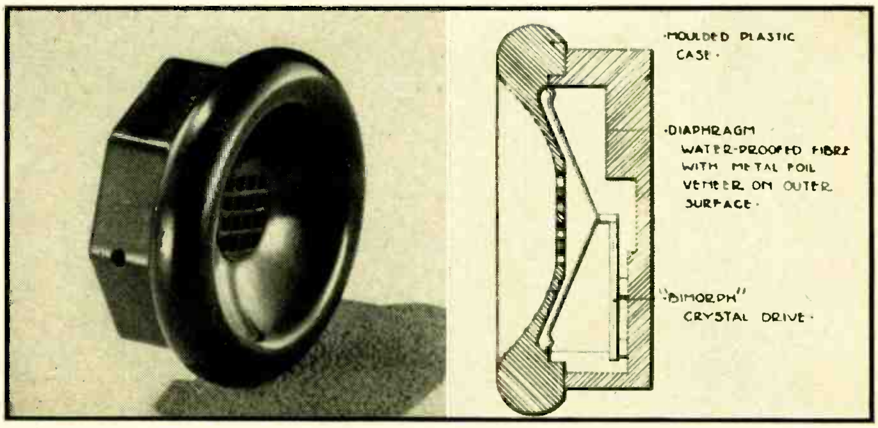

Fig. 5. Type A crystal earphone, with cross-section at right.

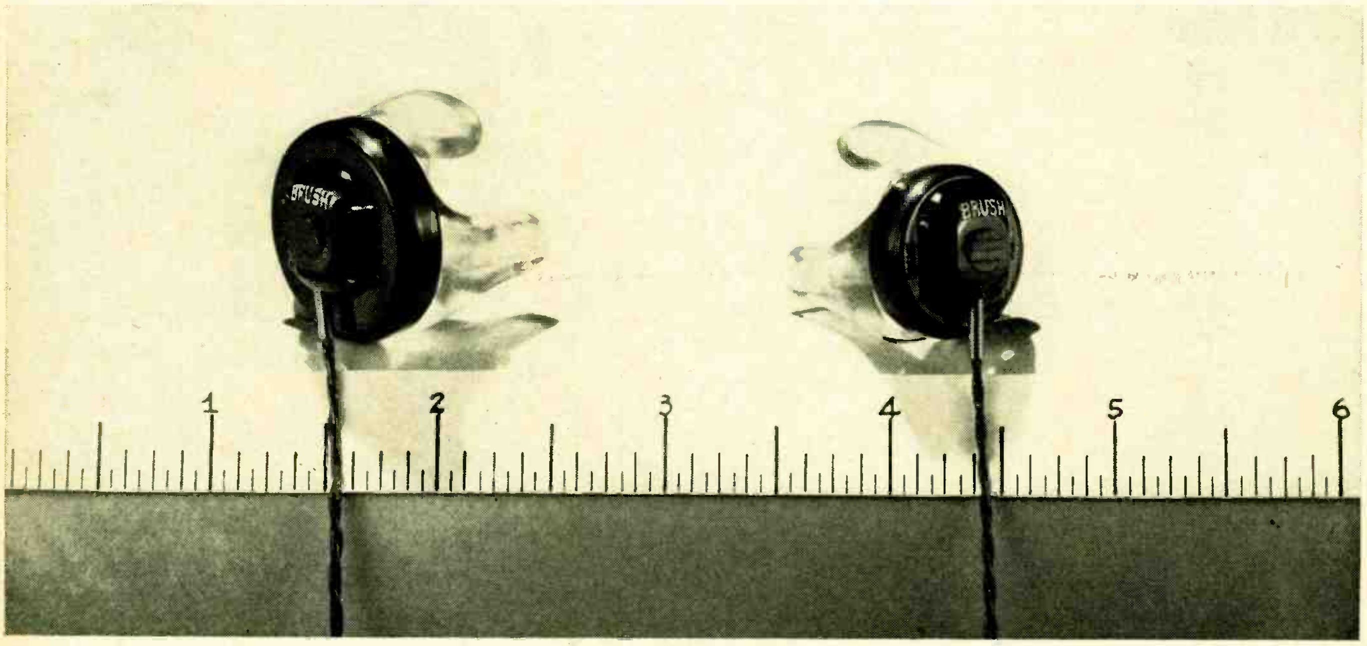

Fig. 6. Two sizes of miniature crystal earphones used for wearable hearing aids.

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form output. (*3*) Non-magnetic, permitting their use in close proximity to delicate electrical instruments normally effected by external magnetic fields. (*4*) Designed to give better ear seal, improving low-frequency response. (*5*) Light weight and durable construction.

Also available are miniature crystal insert earphones (See *Fig. 6*) which are being widely used today for wearable type hearing aids and which are also applicable to pocket-type radios.

Microphones

A large number of the microphones employed today for radio broadcasting, communications, sound recording and public address, employ Rochelle salt crystal elements. Microphones are available possessing different characteristics depending on their specific application. Where high-fidelity is paramount and output level is secondary, crystal microphones having uniform frequency response up to 10,000 to 15,000 cycles can be had. With frequency-modulation transmitters and for precision sound measurements the latter types are of particular importance. For other specialized work, crystal microphones have been made extending into ultra-sonic frequencies.

On open circuit most crystal microphones will respond to 1 c.p.s. as well as 1000 c.p.s. When worked into recommended load impedance, the low-end response usually is uniform down to the lowest audio frequencies encountered.

Crystal microphones may be placed into two general categories, i.e., diaphragm and "sound cell". In the former the sound pressure acts on a diaphragm which actuates the crystal element and is more sensitive than the latter in which the sound pressure acts on the crystal elements directly (See *Figs. 7* & *8*). Some microphones employ two diaphragms to operate the crystal element in push-pull fashion. High-fidelity response with exceptionally high output is obtained by this arrangement. Metal diaphragms are generally utilized in microphones thus providing a complete seal for the crystal element against humidity and moisture. In one particular design, all viscous materials are eliminated which greatly reduces response dependance on temperature. The response in this design changes less than 1 db over a temperature range of from 30 to 120 degrees F.

One type of crystal microphone offers a three-way directional pick-up: unidirectional, providing a wide angle, front side pick-up with reduction of sound pick-up from rear; bi-directional, providing front and back pick-up with dead sides; and non-directional, full 360-degree pick-up for group presentation, etc.

Contact microphones used in conjunction with crime detection work and musical instrument reproduction also employ Rochelle salt crystals.

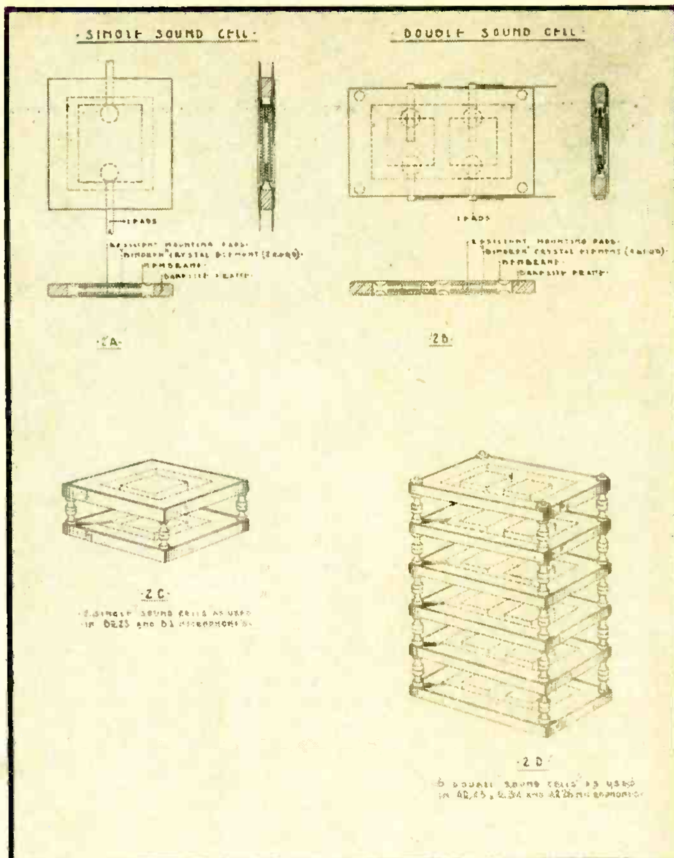

Fig. 7. Construction of "sound cell." Note multiplicity of "bimorph" crystal elements.

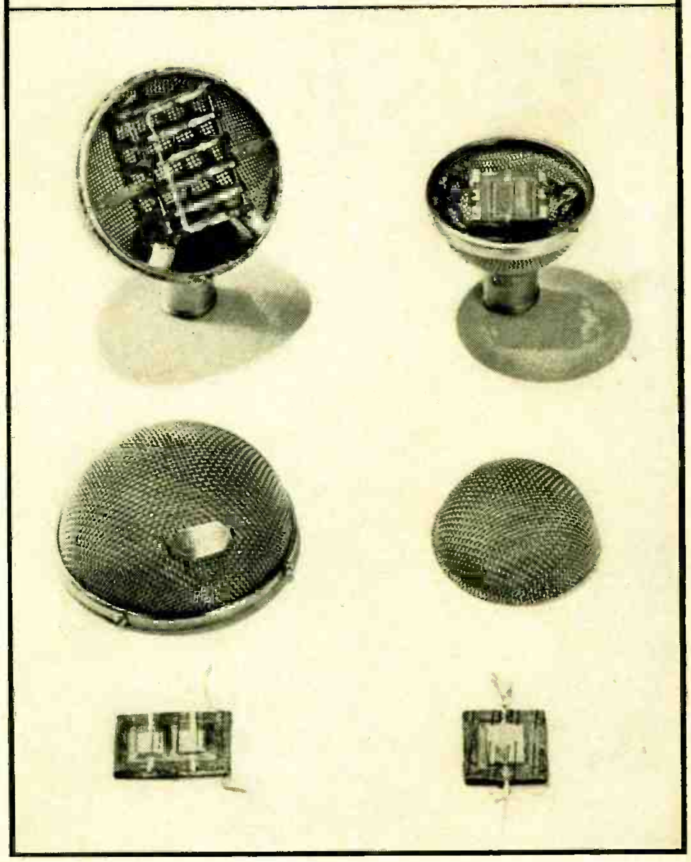

Fig. 8. Microphones employing (left) double type, (right) single type "sound cells".

Phonograph Pickups

During the past few years, the major portion of radio-phonograph combinations have employed phonograph pickups of the crystal element type.

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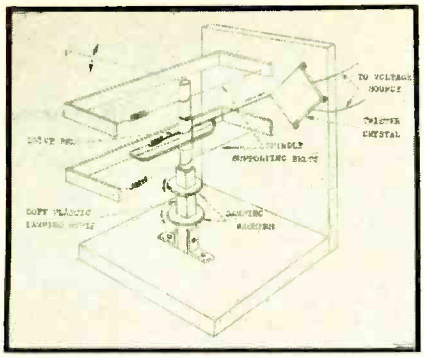

Fig. 9. Crystal drive and multiplier employed in the direct inking oscillograph.

The past four years has witnessed an increasing use of a new type of crystal phonograph pickup. This pickup is characterized by a vibratory system of low inertia and polished sapphire stylus which usually forms an integral part of the unit. Uniform response over a wide range of frequencies (up to 10,000 c. p. s.) is thus made possible with practically no distortion. When accompanied with low stylus force (usually one ounce) these features insure longer record life, and a considerable reduction in acoustic and background noise.

Disc Recorders

Many of the disc-type records made today in the home, studio, school and government monitoring stations are produced with crystal recorders. These recorders fall into two general classifications, the cutter and the embosser. In the former a stylus having a sharp chisel shaped point is actuated by the crystals and removes material from the record surface, forming a groove. Where high-fidelity results are important, this type of recorder is used because it permits a somewhat wider range in frequencies to be engraved in the record.

In embossing, a blunt stylus is actuated by the crystal and material is pushed aside rather than removed to form the groove in the record. Recording of long-playing records at constant low linear speeds, especially when wide frequency range is not essential, has made this process very popular.

Temperature variations between 72 and 95 degrees F. cause the sensitivity of crystal cutters to vary only from 4 to 6 db. In cases where the sensitivity of the crystal and characteristic of the damping material must remain constant, as in the case of electrical transcriptions, temperature-controlled crystal cutters may be supplied. These cutters are provided with thermostatically controlled heaters which maintain the crystal at a temperature of approximately 95 degrees F.

Direct-Inking Oscillograph

An instrument which has found widespread application in the field of industry is the direct-inking oscillograph, designed for making instantaneous and permanent ink-on-paper records of low-frequency electrical alternations, transient phenomena, surges, relay timing, etc. Low-frequency noises and vibrations found in electrical motors, generators, airplane and automobile engines can be recorded by this instrument when working from vibration pickups. The direct-inking oscillograph may also be employed for recording pulsating gas or liquid pressures in pipe lines, etc., when working from pressure pickups. This instrument when working from crystals mounted against surfaces under varying or vibrating stresses may be used for measuring and recording the stresses. Examples of this application are the recording of pressures exerted at the electrodes of welding machines as well as strains in airplane propellers and wings.

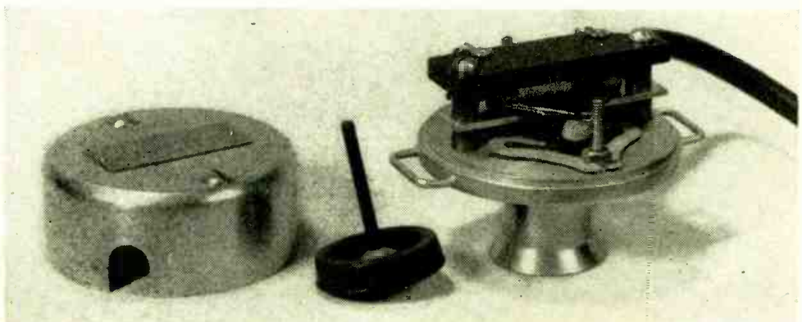

Fig. 12. Displacement type vibration pickup —recommended for low frequency vibrations.

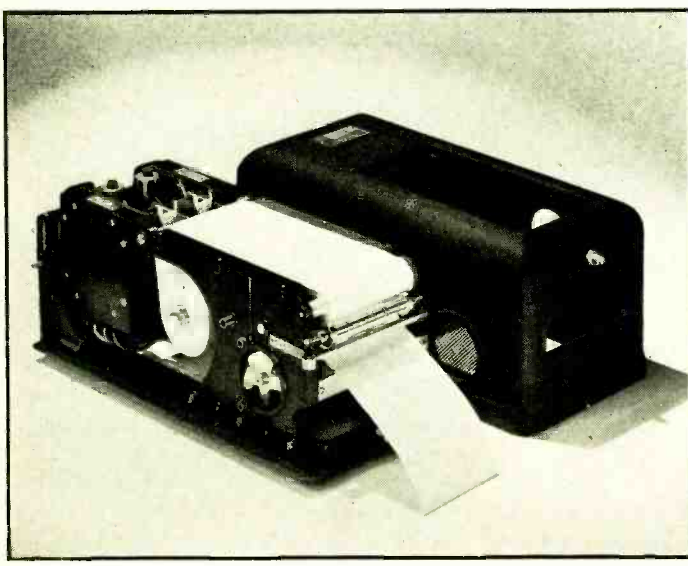

Fig. 10. Two 120-cycle pen motors mounted on single direct inking oscillograph frame.

Fig. 11. A complete surface analyzer consisting of a direct inking oscillograph, drive head on surface plate, and a calibrating amplifier.

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This instrument is also employed for recording smoothness of finished surfaces in an instrument known as the Surface Analyzer, and in the medical field for recording of heart beats and brain waves (electrocardiographic and electroencephalographic studies).

Briefly the direct-inking oscillograph employs a pen of high stiffness and low inertia (See *Fig. 9*) which traces an inked record on a moving chart when actuated by a crystal element to which it is attached. The deflections of the pen are directly proportional to the electrical potentials applied across the crystal element.

An amplification of 200 is obtained between pen point and crystal motion by employing a 3″ pen and a .015″ step on the pen spindle around which is wrapped the crystal drive belt, as shown in *Fig. 9*. Stabilization is provided by a thermostatically controlled heater which keeps the crystal element at practically a constant temperature.

Two types of pens are normally available: one responding to frequencies up to 60 cycles per second, the other up to 120 cycles per second. *Fig. 10* shows two 120-cycle pen motors mounted on the same oscillograph for simultaneously recording two voltage phenomena.

Surface Analyzer

The surface analyzer* is designed for recording instantly and permanently on a moving chart irregularities in finished surfaces such as metals, plastics, glass, motion picture film paper, etc., in microinches (millionths of an inch). In traversing the surface under test, a diamond stylus actuates a crystal element to generate a potential which is magnified by an amplifier and then recorded on the moving chart of the direct-inking oscillograph. *Fig. 11* shows a complete Surface Analyzer.

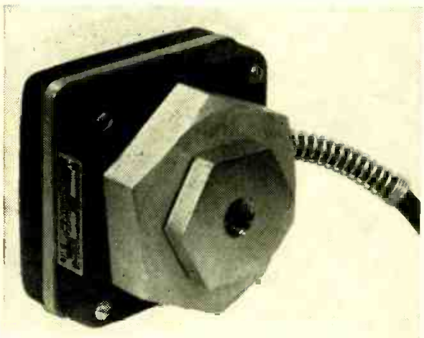

Fig. 14. Pressure pickup used for the study of pulsating pressures.

* For detailed description, see "Piezo-Electric Surface Analyzer," by Roy S. Sawdey, Jr., *Radio,* March 1943.

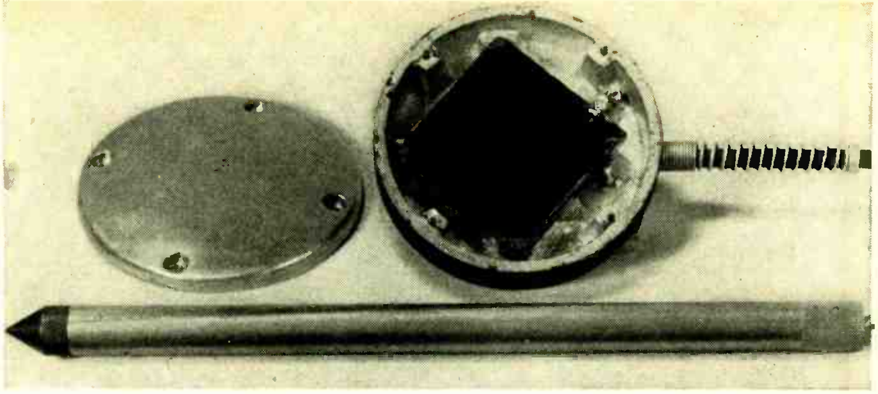

Fig. 13. Inertia type vibration pickup—for high frequency vibrations.

Pickups

A variety of crystal pickups have seen service in the industrial and medical fields. Some have taken the form of vibration pickups, pressure pickups, watch timing pickups, water leak detectors, heart-beat pickups, etc.

The vibration pickups fall into two general classifications, i.e., displacement and inertia. The displacement type (See *Fig. 12*) delivers a voltage directly proportional to the amplitude of motion of the vibrating body, and is independent of frequency over a relatively wide frequency range. Consequently, the frequency and harmonic content of the generated voltage is identical to the observed vibrations. To achieve this type of response, the crystal element is actuated directly by a suitable drive pin which bears against the vibrating body. The displacement pickup is preferred for low-frequency work because of its type of response and its greater sensitivity at these frequencies.

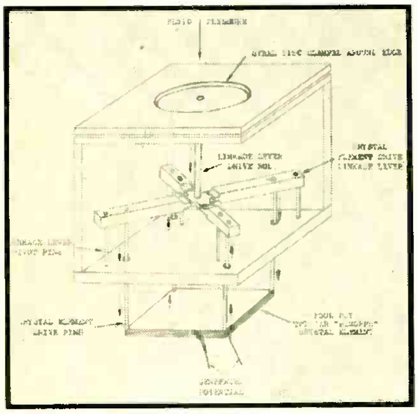

Fig. 15. Basic construction and operation of pressure pickup.

The output of the inertia type pickup, for any given amplitude of vibration increases greatly as the frequency of vibration increases, making this type of pickup especially useful for measuring high-frequency vibrations when low-frequency vibrations also exist, as it automatically discriminates against these low-frequencies. *Fig. 13* shows this type of vibration pickup with crystal element exposed.

Pressure pickups have been found useful for converting pulsating gas or liquid pressures into corresponding electrical potentials. The type shown in *Fig. 14* employs a stiff stainless steel diaphragm which actuates a crystal element, the output of which may be used in the operation of relays or measuring equipment. The pickup is designed to measure pressures up to 1000 pounds per square inch over a frequency range of from approximately 5 to 2000 cycles per second. The sensitivity is sufficient to measure pressures as low as 0.1 pound per square inch. *Fig. 15* illustrates the internal construction of the pressure pickup shown in the preceding figure.

Watch-timing pickups (ordinarily incorporated as part of watch timing recorders) have been used for accurately adjusting watches and clocks, etc.

Water-leak detectors employing crystal elements find application in detecting underground leaks in water mains. Earphones are usually used in conjunction with the detector for exploration of the affected area. Noise created by the escaping water can easily be detected with little practice.

Electrical stethoscopes (sometimes called heart-beat pickups) employing crystal elements are used for listening to or recording heart pulsations. Graphic records can be obtained when this instrument is used with the direct-inking oscillograph.

Galvanometers

Crystal reflecting type galvanometers have been employed for vibration recording and analysis, geophysical studies, electrocardiographic recording, and sound-on-film recording. A small mirror which is actuated by a crystal element reflects a light beam on a sensitized film.

Conclusion

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GEOMETRIC SOLUTIONS FOR RESONANT IMPEDANCE TRANSFORMING NETWORKS

ROBERT C. PAINE

★ A tuned circuit is a well-known device for transforming a given impedance or resistance load into any desired effective resistance at a given frequency. Such a change is frequently desired for matching the load to the power supply, usually at radio frequencies. The values necessary for such a change can be determined mathematically, but it is often convenient to use a geometric construction.

Simple Example

The simplest case is that of a pure resistance load to be changed to an effective resistance of different value. A network is shown in *Fig. 1-A* in which the resistance load, R' is to be transformed to an effective value, R. The inductance X_L, and capacitor X_C in parallel with resistance R' are equivalent to the series circuit *Fig. 1-C*, in which the reactive elements resonate and the effective value is the equivalent series resistance R'_S equal to R.

A geometric construction for determining the required values of X_L and X_C is shown in *Fig. 1-B*. Lay out the line OR' on a suitable scale equal to the given resistance R' and OR equal to the desired resistance R. Draw a semicircle on OR' as a diameter and erect a perpendicular RZ at R. The intersection of the line RZ and the semicircle at Z gives the required equivalent series impedance OZ. A line from R' through Z, intersecting a perpendicular through O at X_C gives the value of the capacitance X_C. The required inductance is represented by the line OX_L drawn equal to RZ which is the value of the equivalent series capacitance X_{CS}.

Proof of Fig. 1-B: The line OZ in the series impedance triangle ORZ is the equivalent series impedance of the parallel combination of the resistance OR' and a capacitance OX_C in the parallel impedance triangle OX_CR'. An explanation of this method of finding the equivalent impedance of a parallel circuit is shown later. The semicircle is the locus of the point Z for the combination of all capacitances such as OX_C with OR'. The line RZ is the locus of equivalent series impedances, such as OZ, with a resistive component equal to OR. The intersection of these two loci give the required value of OZ. The capacitive component of OZ is RZ so the series inductance X_L equal to RZ will resonate the circuit, leaving only the effective resistance R'_S equal to R, the required value.

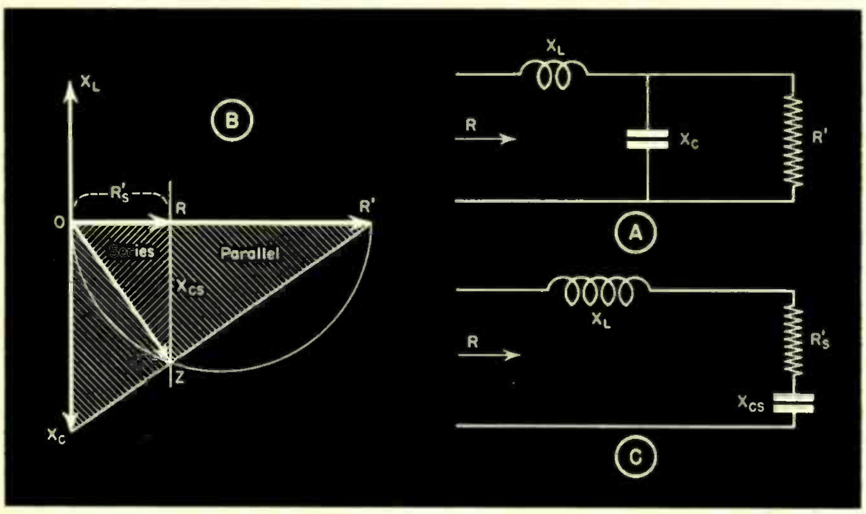

Fig. 1. (A) Tuned circuit used to change resistance R′ into a lower effective value R. (C) Series resonant circuit equivalent to (A). (B) Geometric construction for determining values required for (A).

Mathematical Solution

The mathematical solution follows simply from the geometric construction. Line $OX_L = RZ = \sqrt{OR(OR'-OR)}$, since RZ is the mean proportional between the segments of the hypotenuse of the right triangle OZR'. Also $OX_C/OR' = OR/RZ$ (by similar right triangles) or $OX_C = OR'(OR)/RZ$. Expressed in formulae these equations become $X_L = \sqrt{R(R'-R)}$ and $X_C = RR'/\sqrt{R(R'-R)}$. In *Fig. 1-B*, which has been drawn to scale $R'=3$, $R=1$, and the values of X_L and X_C are found by these formulae to be 1.4 and 2.1 respectively.

In the example given above, a given resistance is transformed into a lower value. To transform a given resistance to a higher value the circuit of *Fig. 2-A* is used. This circuit changes the given resistance R to the desired equivalent parallel resistance $R_P = R'$ as shown in *Fig. 2-C*. The construction is shown in *Fig. 2-B*. In this case the semicircle is the locus of the point Z of the equivalent parallel impedance

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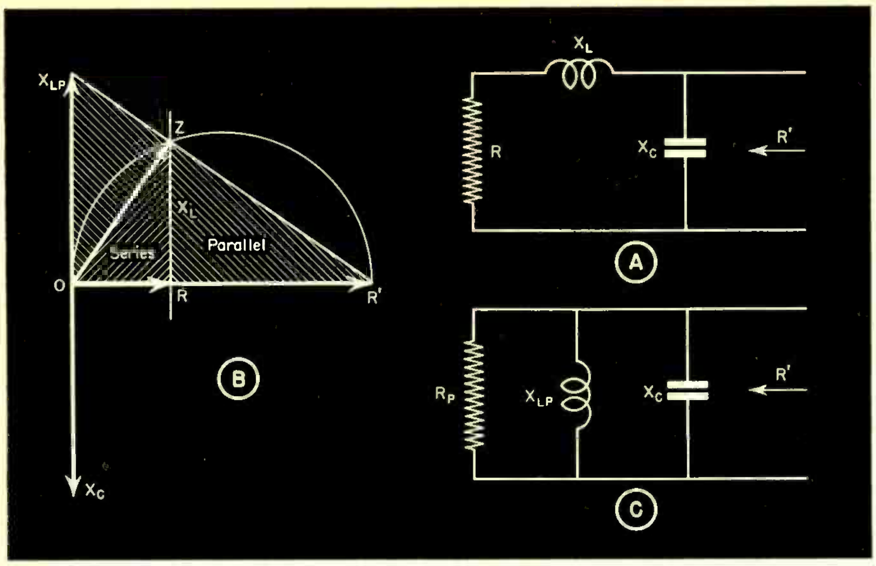

Fig. 2. (A) Tuned circuit used to change resistance R into a higher effective value R'. (C) Parallel resonant circuit equivalent to (A). (B) Geometric construction for determining values required for (A).

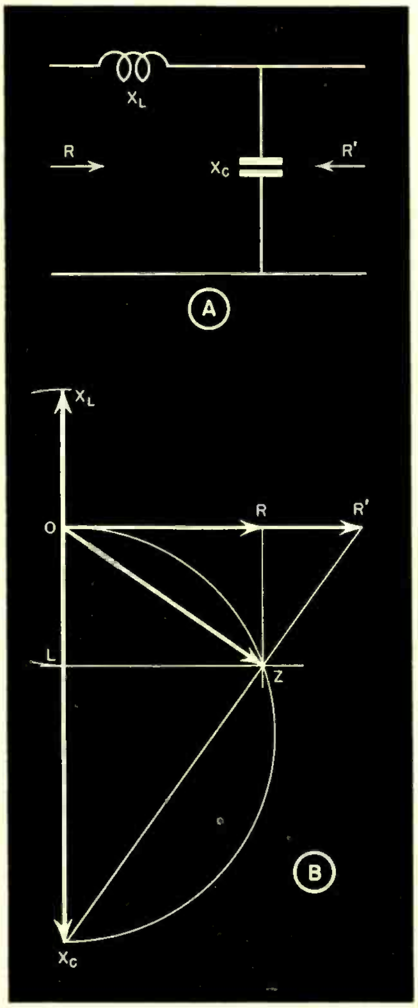

Fig. 3. (A) Tuned circuit of which the image resistances R and R' are to be determined. (B) Geometric construction for determining the image resistances of (A).

triangle $OX_{LP}R'$, one side of which, OR', represents the desired resistance R' and the other side a variable inductance OX_{LP}. Then OX_{LP} is the parallel equivalent of the actual series inductance X_L. The perpendicular RZ is the locus of Z for the series triangle OZR formed by a given resistance, R, represented by the line OR and any inductance. The intersection of these two loci give the required impedance OZ. Then RZ equals X_L the required inductance and OX_C, drawn equal to OX_{LP} is the value of the parallel capacitance to resonate the circuit.

The same values of R and R' have been used in both *Fig. 1-B* and *Fig. 2-B* and it will be seen that the lines of one figure are the reverse of those of the other, so that the reactances which have been thus determined are the same for both figures. The resistances R and R' correspond to a pair of image resistances either of which can be transformed by the given reactances into the other.

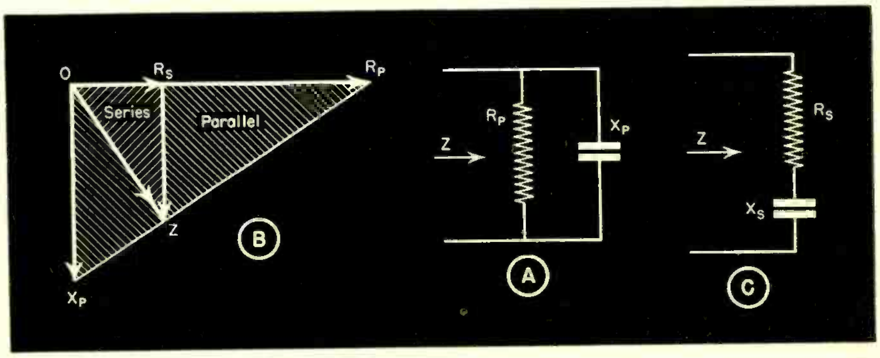

Fig. 4. (A) Parallel circuit and, (C), the equivalent series circuit. (B) Geometric construction for finding the equivalent series circuit of (C) when the parallel circuit of (A) is given.

Image Resistances

Given two reactances as in *Fig. 3-A*, the image resistances can be determined by the construction of *Fig. 3-B*. In this figure the lines OX_L and OX_C represent the given reactances X_L and X_C. The semicircle on OX_C as a diameter is the locus of the point Z of the equivalent series impedance, represented by the line OZ, of any resistance such as OR' in parallel with the given reactance OX_C. The line OL is taken equal to OX_L and the line LZ at right angles to OL is the locus of the equivalent series capacitance which can be resonated by the given inductance X_L. The intersection of these two loci gives the required impedance OZ. The line through X_C and Z determines the resistance R' equals OR', and a perpendicular dropped from Z to the line OR' determines the value of the other resistance R, represented by the line OR. Then R and R' are the required image resistances.

The mathematical solution of the image resistances follows from the geometric construction of *Fig. 3-B*. From this figure, by similar right triangles, we obtain the proportion $OZ/OX_C = OL/OZ$, then $OZ^2 = OL(OX_C) = OX_L(OX_C)$. Also $OR = \sqrt{OZ^2 - RZ^2} = \sqrt{OX_L(OX_C) - OX_L^2}$. By similar triangles $OR'/OZ = OZ/OR$, or $OR' = OZ^2/OR = OX_L(OX_C)/\sqrt{OX_L(OX_C) - OX_L^2}$

Expressed in formulae these equations are: $R = \sqrt{X_LX_C - X_L^2}$ and $R' = X_LX_C/\sqrt{X_LX_C - X_L^2}$. In *Fig. 3-B*, which has been drawn to scale, $X_L = 1.41$ and $X_C = 4.23$, and the value of R and R' is found to be 2 and 3 respectively.

Circuit Conversion

The geometric method used to convert a parallel circuit into its equiva-

[*Continued on page 59*]

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SOME SUGGESTIONS FOR STANDARDS OF GOOD OPERATING PRACTICE IN BROADCASTING

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PART 3

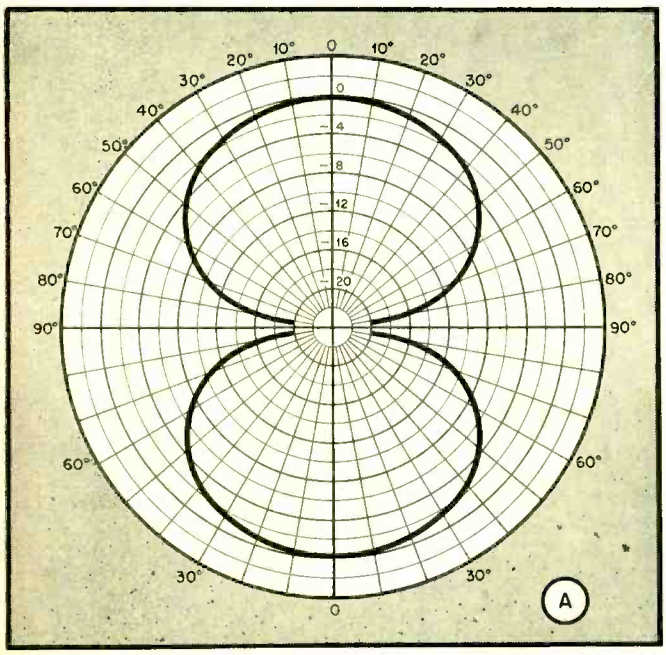
★ The operator in the control room is called upon many times to set up complex musical and dramatic shows, especially in smaller stations that have no production man. The responsibility of set-ups of studio shows is not a simple one. Many years of research and a lot of thought have gone into production, and a knowledge of at least the fundamentals of the art as they affect the technical aspect, will help the control technician over many difficult situations that are bound to arise in the course of his work.

Microphone Patterns

In determining the proper use and placement of microphones for any given set-up, it is important that the operator becomes familiar with pick-up patterns of the microphones used. These patterns tell the complete story of the function as to amplitude and frequency response for varying degrees of placement about the face of the microphone. *Fig. 8-A* shows the pattern of the RCA 44-BX velocity microphone, and *Fig. 8-B* is the pattern of an RCA 77-B combination ribbon and pressure-type instrument. There are several important points of interest relating to these patterns which reveal great differences in characteristics aside from the most apparent one, that of bi-directional and uni-directional pick-up.

An analysis of the patterns reveals a much wider range of amplitude response for the combination pressure-gradient (ribbon) and pressure-type microphone, than for the ribbon type alone. See *Fig. 9*.

Take for example the 1000-cycle curve for the 44-BX velocity microphone. It is noted that at an angle of 70°, the amplitude response is down about 10 db in respect to its response at 0° (assuming same distance from microphone is maintained.) Now note the 1000-cycle response curve of the 77-B combination type. Here it is noted that the amplitude response at 70° is down only approximately 4 db from 0° reference. It is obvious that these patterns are useful for determining the set-ups necessary for discriminating against unwanted sources of sound, and for obtaining a particular relation between sounds of different sources. It



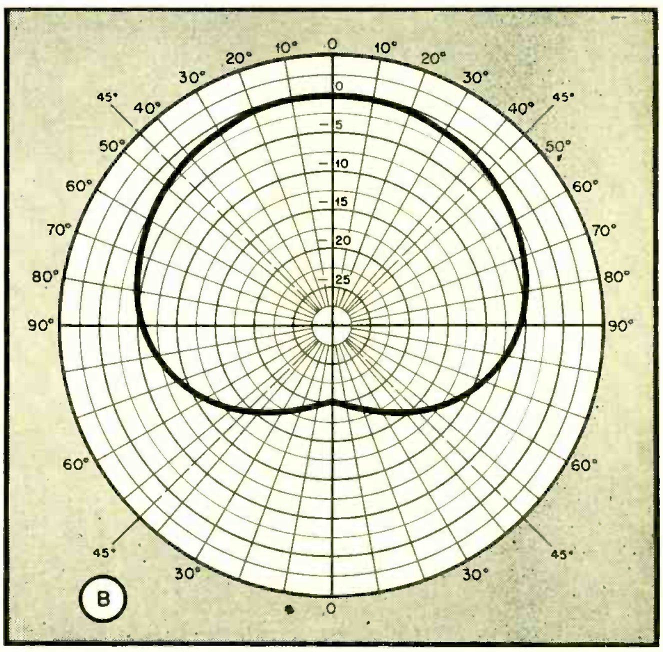


Fig. 8. A—The 1000-cycle response curve of RCA 44-BX microphone. B—The 1000-cycle response curve of RCA 77-B microphone.

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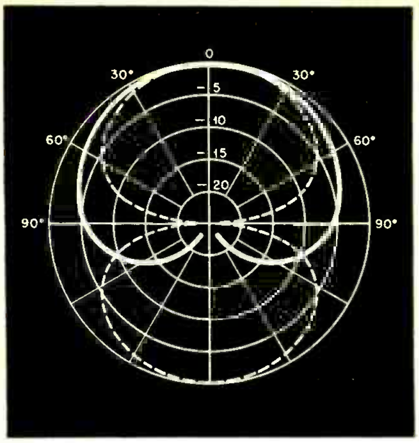

Fig. 9. Dotted lines show bi-directional characteristic of ribbon-type microphone; and the solid line the directional characteristic resulting from annulling one loop of ribbon output with that of a pressure type.

is also obvious that as a performer is moved around the microphone, loss of sensitivity may be compensated for by moving closer to the instrument.

Using Patterns

Fig. 10 is presented as a basic principle in using patterns of a uni-directional microphone, of the combination ribbon-pressure type. It is a well-known

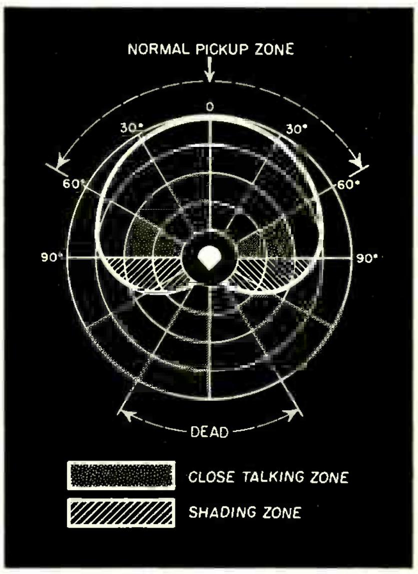

Fig. 10. Data on use of combination ribbon-pressure type microphone set-up. Dotted area is close-talking zone; shaded area the shading zone.

fact that due to the pressure gradient characteristic of the ribbon type microphone, this instrument will favor the lower frequencies under close talking conditions. For this reason, announcers working from such microphones must be more than two feet from the instrument regarless of the degrees off center. When close talking becomes necessary, the combination type instrument may be utilized by the technician, who can then safely instruct the announcer to approach at an angle of 90° with the face of the microphone as shown in *Fig. 10,* and work as close as desired. In this position the ribbon element will contribute practically no energy to the output, leaving the pick-up to the pressure element which is not affected by the spherical character of close-talking sound waves.

It may be seen that the "fading zone" where sensitivity falls off rapidly with increasing angles is just as useful as the regular pick-up zone, since the quality is just as good, and a fine degree of shading may be realized by understanding its proper use.

So far as is practically possible, only one microphone should be used for a given pick-up. When two or more instruments are used, serious frequency and delay distortion is likely to result, since each microphone will be a different distance from an initial sound source. It is obvious that sound waves would not reach the instruments at the same time, and their combined outputs will result in partial reinforcement or cancellation, depending on the phase relationships.

When it is absolutely necessary to use two microphones very close together, they may be poled so that their outputs are additive rather than subtractive, either by rotating a bi-directional microphone through 180°, or by reversing the connections on a uni-directional instrument. This may be accomplished by means of a patch-cord between any two terminations on the jack panel of the circuit in question. The proper phasing of the two microphones is accomplished by watching the VU indicator when the two inputs are switched to first one, then both together, and observing whether the combined outputs are additive or subtractive. Usually one connection will simply give greater additive effect than the other connection, and this effect sometimes changes with a change of frequency, thus making it apparent that the best is only a compromise.

Fig. 11 presents the basic idea in proper placement of microphones when two instruments are necessary for good pick-up of two separate sound sources.

Microphone Placement

As a rule the most common error of newcomers to control rooms is the placement of the microphone too close to the sound source. As has been discussed previously, the loudness sensation for a given meter reading depends largely on the harmonic content of the waveform. Placement of the microphone extremely close to the musical instrument results in peaks in the VU indicator that are practically inaudible

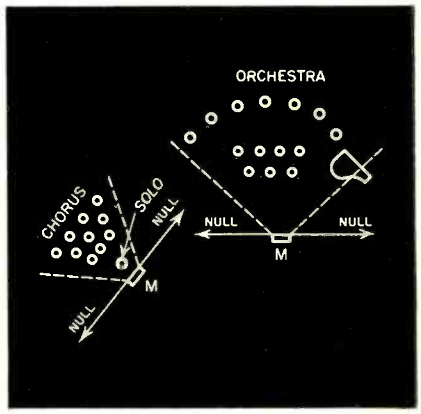

Fig. 11. Proper placement of microphones when two instruments are necessary for good pick-up of two separate sound sources.

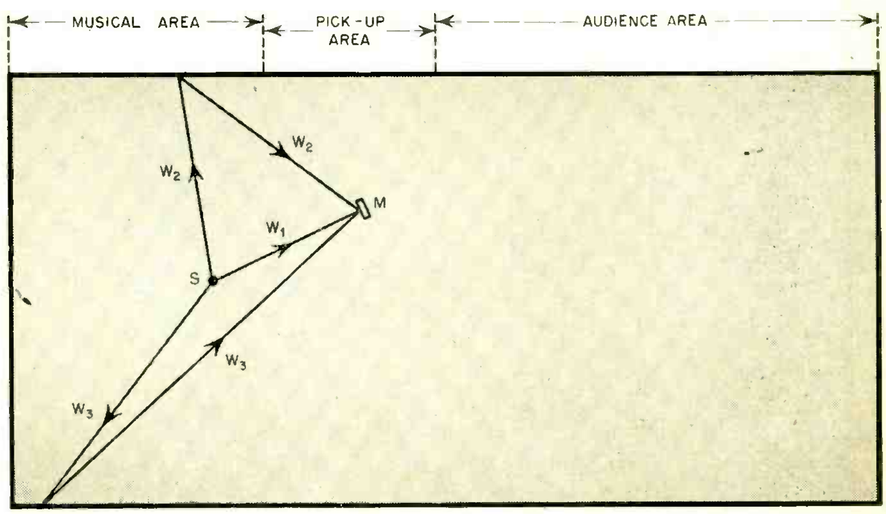

Fig. 12. Basic theory of wave-train travel from source to microphone.

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Solo Instrument	Studios of Optimum Reverberation Time	Studios of 25% Optimum Reverberation Time
BASS VIOL	6 FT.	4 FT.
BASS SAXOPHONE	6 FT.	4-5 FT.
TROMBONE	7 FT.	5 FT.
TRUMPET	10 FT.	6 FT.
FRENCH HORN	8 FT.	5-6 FT.
CLARINET	8 FT.	5 FT.
FLUTE	6 FT.	3-4 FT.
VIOLIN	5 FT.	3 FT.
PIANO	15 FT.	10 FT.
ELECTRIC ORGAN	15-20 FT.	6-8 FT.
PIPE ORGAN	25 FT.	10 FT.

TABLE 3—Approximate distance of microphone placement from source of representative instruments for good pick-up. This does not imply that these should be considered a rigid set of rules. It is intended to be an idea of the minimum distance to be considered from which to start experimenting on the rehearsal set-up. Any change should be toward greater distance rather than less.

to the listener, and since the intensity of these peaks must be kept below 0 vu, the resultant music is completely down in the mud and lacking in brilliance. Smooth control is impossible and harmonic content is very low.

For pick-up of piano music, a distance of at least 15 feet between microphone and piano should be observed, in studios of optimal reverberation time. More intimate pick-ups are necessary in dead studios, since no reinforcement of the sound waves takes place. Too great a distance in such studios results in a thin sound, lacking in body.

For the purpose of presenting a basic rule for distance in microphone placement for given instrumental solos, Table 3 is compiled. It is imperative of course that the operator experiment with microphone placement in his own studios to get maximum results for the particular acoustical characteristics present.

Phase Shift

The effect of phase shift in studios on the quality of musical sounds has been somewhat ignored to date, since the human ear is not essentially a "form analyzer," but rather a "frequency analyzer." Phase shift, nevertheless, causes trouble in both live and dead studios. "Dead spots" nearly always exist in studios due to cancellation of large amounts of the complex wave frequencies caused by phase shift.

Fig. 12 illustrates the basic theory of wave-train travel from its source to the microphone spot. The energy at M is the energy of the initial direct wave-train W_1, plus the energy of the reflected wave-trains W_2 and W_3. The amount of energy of the reflected waves is governed by the characteristics of the reflecting surface, which in turn determines the reverberation time of the studio.

It may be observed here how phase shift due to the different distances traveled by the wave-trains could cause reinforcement or cancellation of certain frequencies at the microphone spot. Complete dead spots are more likely to occur in live studios, since reflection from a perfectly hard surface causes no change of phase of the individual frequencies that make up the complex tone, creating a condition in which complete cancellation of the entire spectrum at a particular spot in the studio might occur. In dead studios, absorption of the higher frequencies is greater than at lower frequencies, thus making complete cancellation of the complex tone unlikely.

If this phenomenon is fully understood, it will be seen that microphone placement is much more critical in dead studios than in live ones, since dead spots are easily avoided in live-end studios where reinforcement of the musical tones is smooth and even over the entire spectrum of frequencies for a given pick-up spot; whereas the placement is only a compromise of the greatest possible frequency range for a given pick-up spot in dead studios. The contribution of the reflected waves in a live-end studio to the loudness intensity, resulting in the reinforcement and sustaining of the overtones of the musical instruments, more than compensates for any slight amount of distortion resulting therefrom.

In Conclusion

It has been the aim of this article to provide the broadcast technician with a brief reference or a basic guidance, depending on his period of acquaintance with broadcasting. If he be a veteran, here is a record to review; if a newcomer, here are a few of the lessons he should learn. The field is large, the horizon unlimited. The comments as published here in Radio have touched only lightly the basic problems as they present themselves to the average technician. It is hoped, however, that as a treatise this article will be both helpful and inspiring to those interested in the progress of broadcasting.

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SOLDERING TECHNIQUE

TODAY'S SOLDER decidedly differs from pre-war solder, and so should soldering technique. Previously solder was composed of tin and lead in about 50-50 ratio; today, except for certain applications, solder contains not more than 20 per cent tin, with perhaps small amounts of silver, bismuth, antimony or tin. Today's soldering technique calls for a hotter soldering iron, and attention to certain details. How to make better soldered joints has been explained in a communication issued by the metallurgy committee of the General Electric Company, which says:

1. Keep your work clean. Guard carefully against varnish, grease, oil, dirt, rust, or corrosion products. They prevent the flux from acting and the solder from alloying with the parent metal.

2. Keep in mind that the purpose of the soldering iron or torch is not to melt the solder but to heat the work until the solder will flow when applied to the work.

3. Keep the soldering iron clean and, to have the quickest possible heat transfer from the iron to the work, have the tip designed actually to fit against the work.

4. Investigate different methods available for doing the work—hotter

[*Continued on page 62*]

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Echophone Model EC-1

(Illustrated) a compact communications receiver with every necessary feature for good reception. Covers from 550 kc. to 30 mc. on three bands. Electrical bandspread on all bands. Beat frequency oscillator. Six tubes. Self-contained speaker. Operates on 115-125 volts AC or DC.

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RADIO DESIGN WORKSHEET

No. 18—TIME CONSTANT; SIDEBAND POWER; ANTENNA VOLTAGE

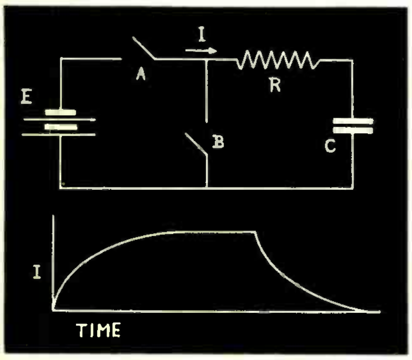
TIME CONSTANT

Problem: *Derive the relation for the transient current when a capacitor is suddenly connected across a source of constant voltage through a resistor, and for the discharge of the charged capacitor through the resistor.*

Solution: Let switch A be closed and switch B open. Then:

$$E = RI + \frac{Q}{C} = R\frac{dQ}{dt} + \frac{Q}{C}$$

Since I is a function of time and de-



creases in magnitude as the capacitor charges:

$$\frac{dQ}{dt} + \frac{Q}{CR} = \frac{E}{R}$$

$$Qe^{t/RC} = \int e^{t/RC}\frac{E}{R}\,dt + K =$$

$$(E/R \times RC \times e^{t/RC}) + K = ECe^{t/RC} + K$$

$$Q = EC + Ke^{-t/RC} = Q_M + Ke^{-t/RC}$$

at $t = 0$, $Q = 0$, and $K = -Q$

whence: $Q = Q_M(1 - e^{-t/RC})$

$$I = \frac{dQ}{dt} = \frac{Q}{RC}e^{-t/RC}$$

$$Q_M = EC$$

And: $I = \frac{E}{R}e^{-t/RC}$ which is the relation desired.

Now assume switch A is opened and switch B closed. Obviously the resulting current will be:

$$I = -\frac{E}{R}e^{-t/RC}$$

The quantity RC is known as the time constant of the circuit. It is important in many modern circuits. It is the time required for the capacitor to charge to 63% of its maximum or to fall to 37% of its maximum.

SIDEBAND POWER

Problem: *Assuming a completely amplitude-modulated wave, determine the relative power in the carrier and the two sidebands.*

Solution: In Radio Design Worksheet No. 11 (page 29, March RADIO) the expression for an amplitude-modulated wave was derived. The expression is:

$$I = A\cos\omega t\,(1 + K\cos pt) = A\cos\omega t + AK/2\cos(\omega + p)t + AK/2\cos(\omega - p)t$$

where K is percentage modulation. At complete modulation $K = 1$, whence the amplitude of each sideband is half that of the carrier.

The root mean square current is:

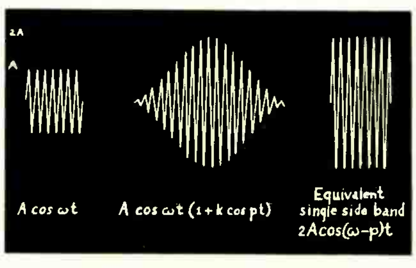
$$I_1 = \sqrt{A^2 + A^2/4 + A^2/4} = \sqrt{6A^2/4} = \sqrt{3A^2/2}$$

The power in the modulated wave is proportional to $I_1{}^2$ or $\frac{3}{2}A^2$.

The power in the unmodulated carrier alone is proportional to A^2, and the ratio of power in unmodulated to modulated wave is:

$$1.5A^2/A^2 = 1.5/1$$

Whence the power capability of the transmitter must be 50% greater than the radiated carrier power. The two sidebands, therefore, only carry one-



third of the radiated peak power. Now the ratio of antenna current for the two cases is obviously:

$$\sqrt{1.5} = 1.225$$

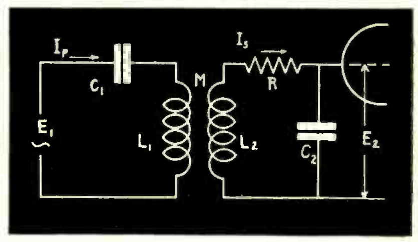
which means that the antenna current for complete modulation increases 22.5%.

One of the advantages of single sideband, carrier suppressed type of transmission is that 2/3 of the radiated power (carrier) does not bear intelligence and is therefore wasted. For the same transmitter power capability, therefore, a single sideband system could radiate four times as powerful a signal.

ANTENNA VOLTAGE STEP-UP

Problem: *Derive the expression for the voltage step-up from antenna to grid of first tube in a radio receiver.*

Solution: In connection with the accompanying circuit we have:



$$I_P = \frac{E_1}{\omega L_1 - \frac{1}{\omega C_1}}$$

$$I_s = \frac{\omega M\,I_P}{R}$$

$$E_2 = \frac{I_s}{\omega C_2} = \frac{\omega M\,I_P}{R\omega C_2} = \frac{\omega^2 M\,E_1 C_1}{R\omega C_2(\omega^2 L_1 C_1 - 1)}$$

But $Q = \frac{R}{\omega L_2} = R\omega C_2$

whence: $E_2 = \frac{\omega^2 M C_1 E_1 Q}{\omega^2 L_1 C_1 - 1}$

$$\frac{E_2}{E_1} = MQ\,\frac{\omega^2 C_1}{\omega^2 L_1 C_1 - 1}$$ which is the voltage step-up.

For low impedance primaries $\omega^2 L_1 C_1$ is small enough to be neglected. Obviously the step-up varies as the square of the frequency. This is one of the defects of low-impedance primaries. Often the antenna circuit resonates near the image frequency, thus materially reducing image rejection. The desirability of a large antenna (i. e., C_1 in accompanying circuit) is also obvious.

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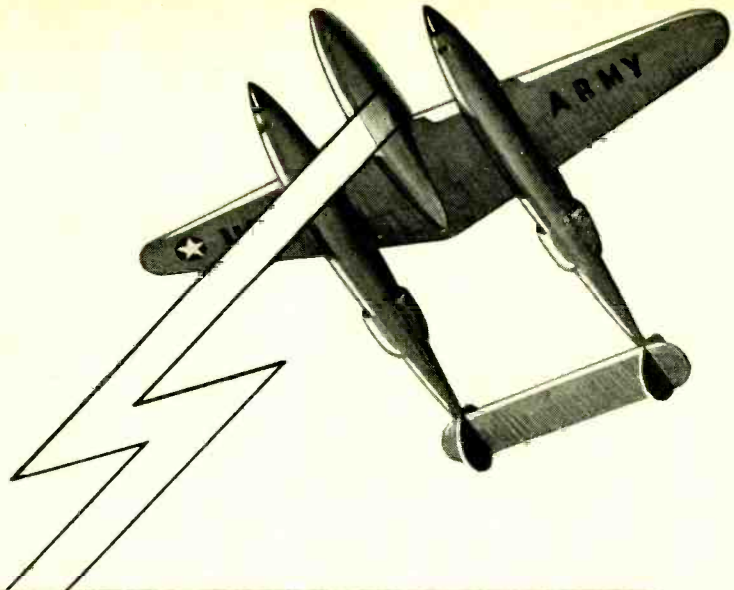
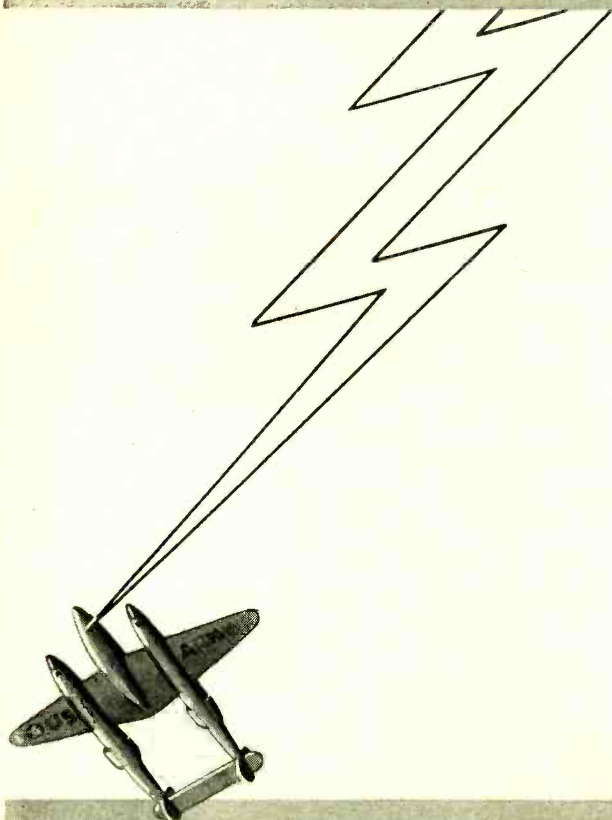


"ORANGE LEADER CALLING . . ." "**ROGER!**"



Pre-operational checking of transmitters helps make sure that messages will be received. Browning Frequency Meters (types S1 and S2) have for some years provided simple, comparatively inexpensive means for such checking. Type S2 is accurate to within .005%. They are easy to operate. They stand up under hard use. Full details are given in literature available upon request.

The balanced-capacitance Browning Signal System for plant protection without guard patrols is another product of Browning Laboratories research. A descriptive folder will be mailed when requested.

BROWNING

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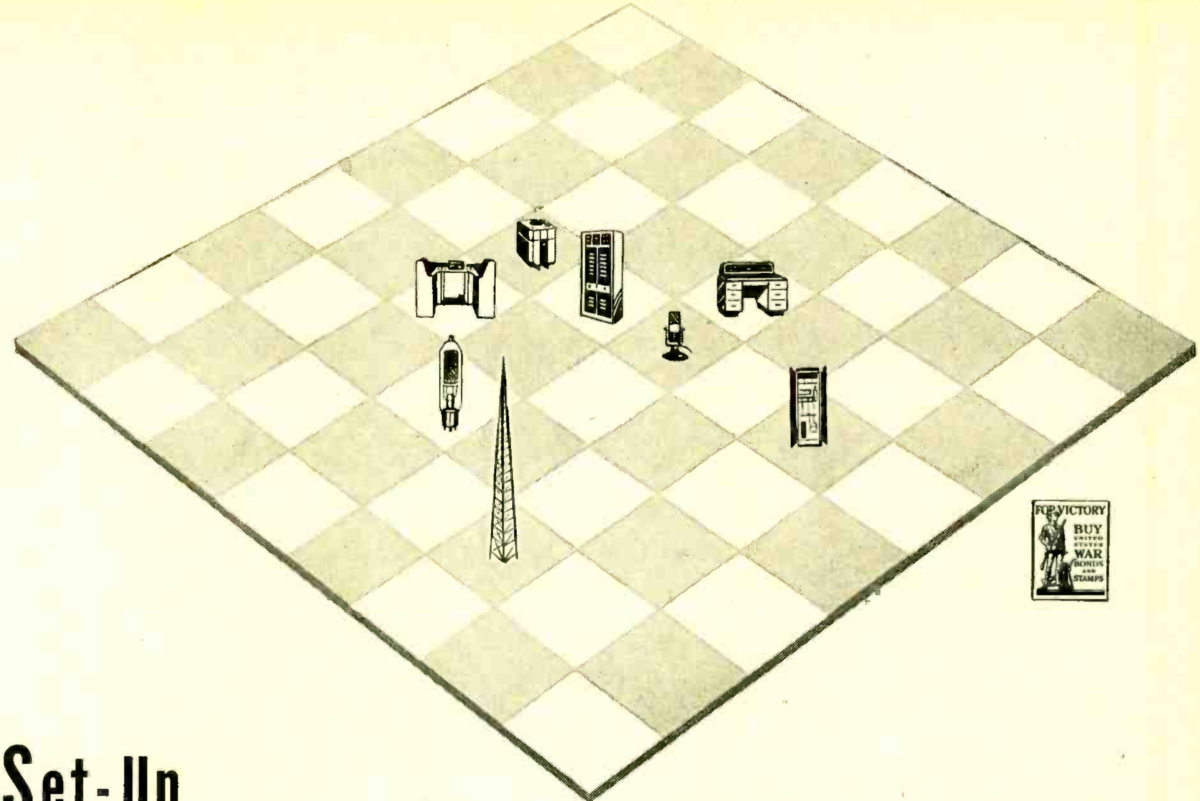

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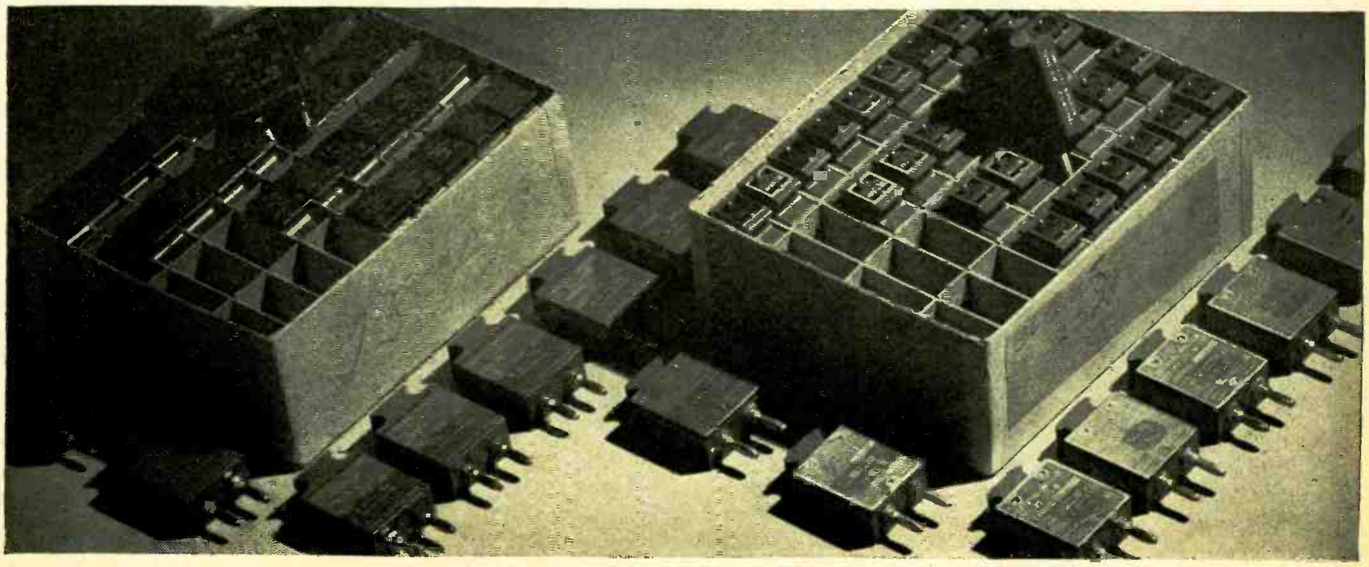

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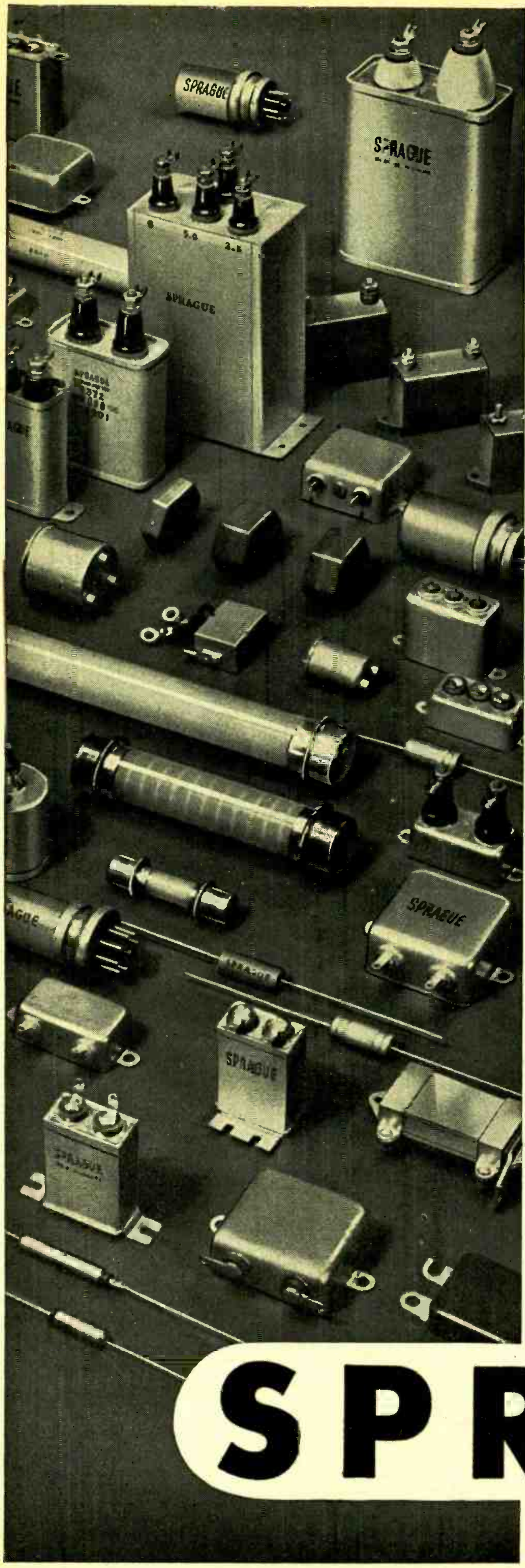

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Just as we do our best to make Sprague a good place from which to buy, so do we aim to make it a good place to which to sell. We are always open to suggestions, new ideas, and all the other helps that suppliers are often so well equipped to give. Although we buy carefully—just as we manufacture carefully—we aim to back this buying with the same courtesy, consideration, and loyalty we ourselves like to receive.

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(To be continued)

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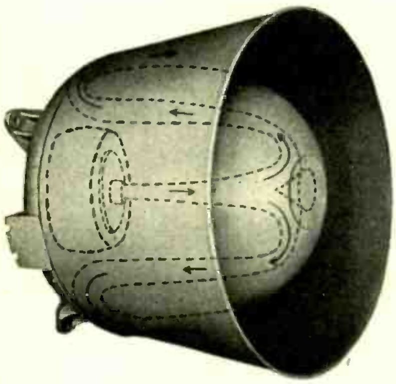
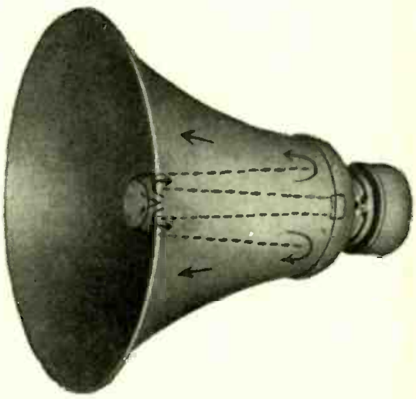
1 - - - United States War Bonds
2 - - - Racon Horns, Speakers and Trumpets

● Big drives are under way to speed up our war effort. Men fighting at the front, civilians buying War Bonds, industrial plants and military services using public address and sound installations — all contribute their share to a speedier, ultimate victory.

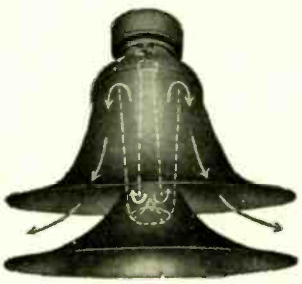
● Our military services, army and navy use RACON Speakers and Driving Units. So do shipyards and many war plants. RACONS are sound values, deliver more output per watt of input. They perform efficiently for the longest period of time. Units are available for every conceivable type of sound installation. Specify RACONS.





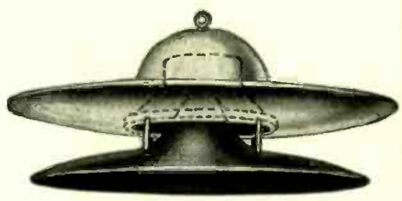
Left—MARINE SPEAKER; approved by the U. S. Coast Guard, for all emergency loudspeaker systems on ships. Re-entrant type horn. Models up to 50 watts. May be used as both speaker and microphone.

Right—RE-ENTRANT TRUMPET; available in 3½', 4½' and 6' sizes. Compact. Delivers highly concentrated sound with great efficiency over long distances.



Left—RADIAL HORN SPEAKER; a 3½' re-entrant type horn. Projects sound with even intensity over 360° area. Storm-proof. Made of RACON Acoustic Material to prevent resonant effects.

Right—AEROPLANE HORNS; super-powerful and efficient P.A. horns for extreme range projection. 9 and 4 unit Trumpets available.



Left—PAGING HORN; extremely efficient 2' trumpet speaker for use where highly concentrated sound is required to override high noise levels. Uses P.M. unit.

Right—RADIAL CONE SPEAKER; projects sound with even intensity over 360° area. Cone speaker driven. Will blend with ceiling architecture. RACON Acoustic Material prevents resonant effects.

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THIS MONTH

ACTION BY THE FCC

AERONAUTICAL FIXED FREQUENCIES

To provide an adequate allocation of aeronautical fixed frequencies to accommodate the apparent increase in communications traffic and extensions of Inter-American routes, the Commission has amended Section 9.73(h) of its Rules and Regulations Governing Aviation Service. The amendment will provide eight additional frequencies for this purpose.

The amended Section 9.73(h) reads as follows:

1. Inter-American Route. Available for aeronautical and aircraft stations:

3082.5	6583	8225(24)	17257
5405	6590	8233(24)	17274
5692.5	6597	11381	23301
6557(23)	8217(24)	11394	23324

Available for aeronautical fixed stations: A1 Emission only.

2648	9310(22)	10535(10)	16240
5370	9785	10640	16290(10)(36)
5375	10020	10847.5(37)	16310(36)
6680(35)	10440	10955	
8705(10)			
8910			

(10) These frequencies are assigned upon the express condition that no interference will be caused to any service or any station which in the discretion of the Commission may have priority on the frequency or frequencies with which interference results.

(22) For use on routes lying south of the United States only.

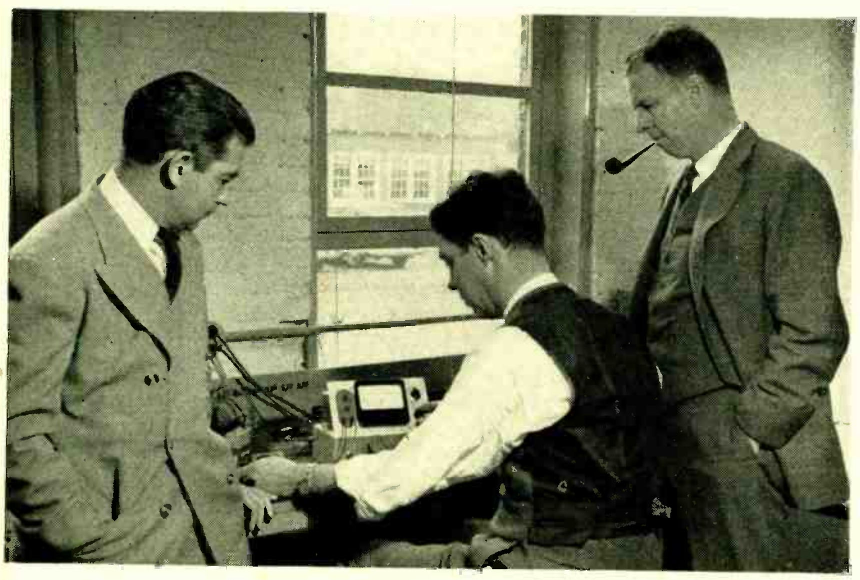
(23) Additional frequency to be used only in case of interference or when traffic conditions do not permit the use of the other frequencies assigned to this route. Not to be used in continental United States.

(35) This frequency is available only as long as the present unlimited national emergency exists, and it may be authorized only in the Miami, Florida, area.

(36) This frequency is available only as long as the present unlimited national emergency exists, and it may be authorized only in the Brownsville, Texas area.

(37) Available for assignment on the condition that no objectionable interference is caused to Domestic United States Blue and Green Chain operations on 10855 kilocycles.

Change Footnote (24) to read as follows: (24) Priority is recognized of the service existing outside the American continents as of January 28."



McMURDO SILVER HEADS RADIONICS DIVISION OF GRENBY MFG. CO.

Snapped a few days ago in the Radionics Laboratories of Grenby Manufacturing Company, Plainville, Connecticut, are left to right, Ralph H. Soby, Vice President, McMurdo Silver, Vice President in charge of radionics, and Carl A. Gray, President, and incidentally creator of the war-winning Connecticut Job-training program. It would appear that "Mac" is demonstrating to his associates the excellence of the final laboratory model of a new and badly needed piece of precision test equipment—a vacuum tube ac-dc-ohm-milliammeter—usable up to 300 megacycles.

This is one of the first pieces of Grenby precision equipment to be announced to the trade. And at Grenby precision means exactly that, for though new to radio users, Grenby is famous among war producers numbering among its best customers Norden, Sperry, Boeing, Wright, United Aircraft, etc.

LARGE SCREEN TELEVISION PROMISED

Perfected large screen television for motion picture theatres, homes, schools and churches, both in black-and-white and natural color, will be available commercially soon after hostilities cease as a result of basic patents issued by the Patent Office in Washington to Scophony Corporation of America, it was announced by Arthur Levey, President of SCA. The company is associated with Television Productions, Inc., a subsidiary of Paramount Pictures, and General Precision Equipment Corporation, which in turn is associated with Twentieth Century-Fox Film Corporation.

The basic U. S. Patents Nos. 2,330,171 and 2,330,172, were issued as part of the group of patents covering the Skiatron system, a new television projection apparatus expanding Scophony's basic television methods. It was described by Mr. Levey as having characteristic features in common with cinematography by which for the first time it will be possible to project a large-screen television picture up to full-sized theatre screens 20 feet in width or more, with brilliance equal to motion picture standards.

★

RMA INDUSTRY MEETINGS

Many problems in the stepped-up $4 billion military radio program and also postwar conversion were canvassed at the fall industry meetings of RMA held September 15-16 at the Roosevelt Hotel, New York City.

Coincident with formal organization of the Radio Technical Planning Board, which will develop postwar television, frequency modulation and other services, about 100 RMA members attended the New York meetings of the Association's Board of Directors, the Set and Parts Divisions and the initial session of the new RMA Postwar Planning Committee.

President Galvin presided at the RMA Directors' session which authorized immediate Association action on several problems of the increased military radio program and also approved several projects presented by Director R. C. Cosgrove, chairman of the Set Division and also of the Postwar Planning Committee.

The RMA board approved an increased annual budget for extension of Association work; authorized an RMA subscription of $25,000 to the "Back the Attack" war bond campaign and approved applications of fourteen new RMA members bringing the Association membership to its greatest strength since 1931.

War production and manpower problems were prominent in the RMA discussions together with those of future war contract terminations. Cooperation between prime and sub-contractors on contract cancellations was arranged by the Set and

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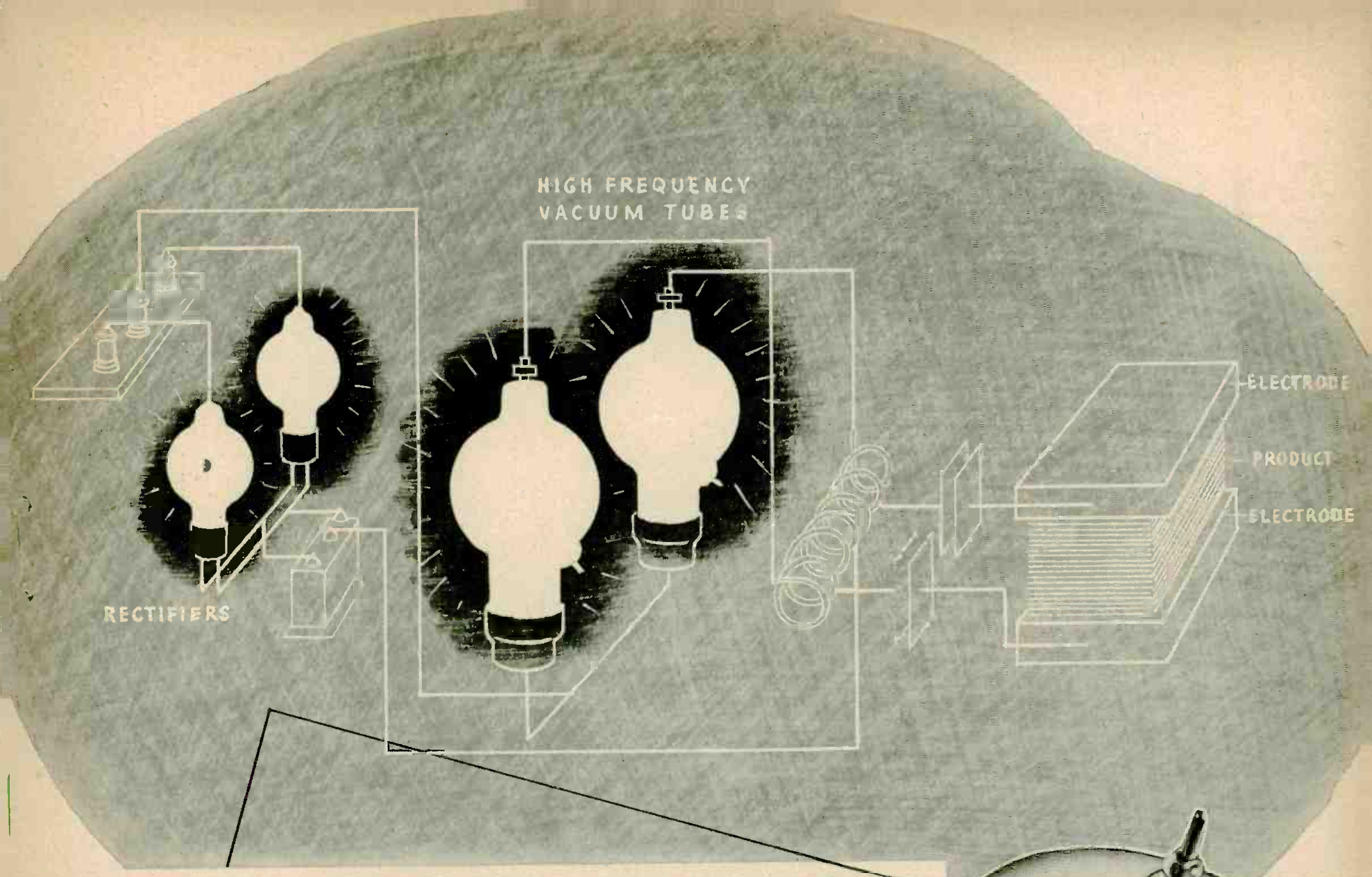
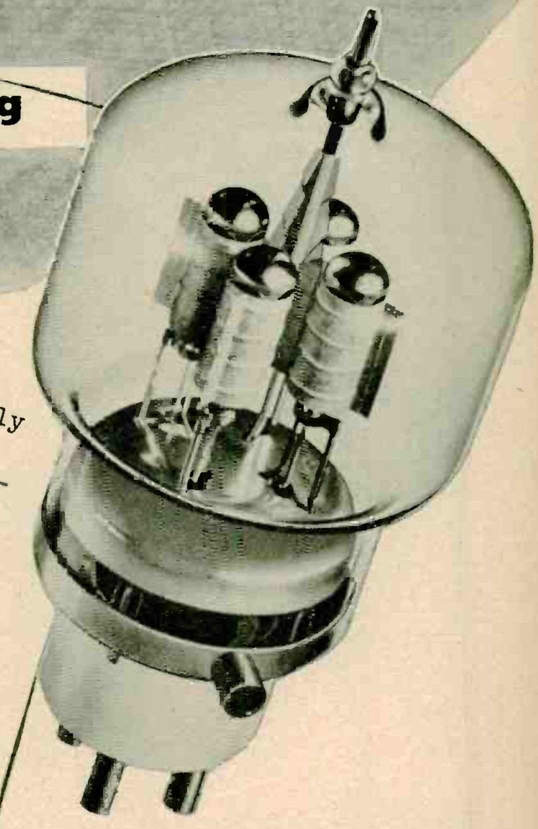


ELECTRONIC BRIEFS: Electrostatic Heating

High frequency electrostatic heating is simply the use of electricity to create friction between the molecules of a substance. The generation of heat in non-metallic substances by molecular friction is accomplished by the application of high frequency current, which is converted from a standard power supply. The equipment used employs the basic electronic circuit used in radio transmitters. The output of the power amplifier is connected direct to the material to be heated exactly as the output of a transmitter is connected to antenna and ground. The energy is sufficient to cause the molecules within the material to distort and rub against one another very rapidly. The friction thus caused creates heat within the material.

As with all things in the field of electronics, Electrostatic heating is wholly dependent upon the vacuum tubes employed. Eimac tubes are first choice of the world's leading engineers, first in the key sockets of the important new developments in electronics. You'll get long life, dependability and superior performance with Eimac tubes in the key sockets. Today Eimac tubes are proving their superiority in the most gruelling test — WAR.



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Parts Division, which held a joint conference on equitable procedure

Maintenance of the public's receiving sets, of which tube replacements are the major and growing shortage, also was discussed at the RMA Board meeting, with a report by Chairman Max F. Balcom of the RMA Tube Division. Arrangements for cooperation of set manufacturers were made. Tube Division members today were holding another meeting on the civilian replacement program with WPB Radio Division officials.

War contract termination problems were discussed separately and also jointly by the Set and Parts Divisions. Robert C. Sprague of North Adams, Mass., and Ernest Searing of Philadelphia, appointed as a committee by the Parts Division, conferred with the set manufacturers and arranged for cooperation and exchange of information on termination clauses for war contracts which would be more equitable for parts manufacturers. Plans also were made for prompt approval of claims and payment of parts manufacturers in the settlements of war contracts.

Preparation of a detailed industry program on postwar conversion was authorized by the special Postwar Planning Committee and later approved by the RMA Board of Directors. Sub-committees will be appointed by Chairman Cosgrove on the general program and also on such problems as reemployment, labor relations, disposition of government plants and inventories, distribution and financing problems, the latter including trade and consumer as well as manufacturers' financing.

Arrangements were made to re-establish the RMA Advertising Committee which was suspended when the industry was converted to war production. John S. Garceau of Fort Wayne, Indiana, former chairman, and the advertising committee are to be reappointed. Trade practices will be under the committee's jurisdiction and it also will act in the promotion of better understanding of the industry's contribution to War production. Another function in paving the way for future industry conversion to peace production, will be information to the public on the increased cost of labor and materials occurring during the gap between suspension and resumption of commercial production.

Compilation of industry statistics and market surveys also was planned by the RMA Set Division and Postwar Planning Committee, together with export trade promotion, the latter being detailed by Chairman W. A. Coogan of the RMA Export Committee.

Dr. W. E. Shoupp, of Westinghouse, demonstrating an electronic device to J. E. Zimmerman, a member of the Westinghouse Research Laboratories Graduate Study Course.

Patent and licensing problems also were discussed at the New York meetings, including legislation now pending in Congress and also future postwar patent problems. The RMA Legislative Committee, of which J. J. Nance is chairman, and the Association's executive committee were authorized to take proper action on all patent legislation.

Pursuant to the call of President Galvin of the RMA and President Wheeler of the IRE, the Radio Technical Planning Board held its first meeting September 29, at the Roosevelt Hotel, New York City. Representatives and alternates from the following industry and service groups were present:

American Institute of Electrical Engineers
American Radio Relay League
FM Broadcasters, Inc.
Institute of Radio Engineers
International Association of Chiefs of Police
National Association of Broadcasters
National Independent Broadcasters
Radio Manufacturers Association
Aeronautical Radio, Inc.

Dr. W. R. G. Baker, Vice President of the General Electric Company, was appointed as chairman of the new RTPB. for a term of one year, which action now makes possible the completion of further organizational details at meetings of the Board which will be held from time to time in the near future.

Copies of the plan of organization and procedure under which RTPB will function will be furnished to interested persons upon request to RMA headquarters. or the Institute of Radio Engineers, 330 West 42d Street, New York City.

★

RAYTHEON HOLDS POST WAR PLANNING MEETING

To plan the extensive post-war activities of Raytheon Production Corporation, manufacturers of Raytheon Radio and Electronic Tubes, E. S. Riedel, General Sales Manager, held a meeting in Chicago, September 16, attended by Raytheon's post war planning committee.

A. E. Akeroyd who has just returned to Raytheon's Newton, Massachusetts. plant on replacement tube sales activities. represented that division at the meeting Mr. Akeroyd was formerly on a special war assignment, at Raytheon's Waltham. Massachusetts, plant. F. E. Anderson. Fred Simmons and Russ Lund attended the meeting from the Raytheon, Newton, Massachusetts, plant.

★

HAZELTINE RECEIVES "E" AWARD

Hazeltine Electronics Corporation received the coveted Army-Navy "E" for high achievement in war production on Friday afternoon, September 24.

The ceremonies were held at the plant in Little Neck, Long Island, in the presence of officials of the company, 700 em-

[*Continued on page 66*]

Colonel E. M. Kirby, Chief of the Radio Branch of the Army's Bureau of Public Relations, demonstrating two models of General Electric's magnetic wire recorder at a recent meeting of the Associated Press Managing Editors Association in Chicago.

Centradite

A New CENTRALAB development in Ceramic material

Centradite has these outstanding characteristics:

LOW THERMAL EXPANSION • HIGH RESISTANCE TO HEAT SHOCK • LOW POROSITY • LOW LOSS FACTOR

These important characteristics are combined with excellent dielectric properties making it suitable for use in radio frequency circuits. (See Chart).

Centradite is particularly recommended for coil forms where thermal expansion must be low to prevent undue change in inductance.

Centradite is ideal where the application requires that the material withstand a rapid increase or decrease in operating temperature within a short period of time.

Centradite can be supplied in various shapes by extrusion or pressing.

Centradite, due to its resistance to heat shock, lends itself to a new process of soldering metal to ceramic, whereby the ceramic surface is metalized to permit soldering.

We invite inquiries regarding the further uses which may fit your applications.

Body No. 400	Description of Material
20-100 C° 1.9×10^{-6} 20-600 C° 3.1×10^{-6}	Thermal coefficient of expansion per degree Centigrade
13,000 lbs.	Modulus of rupture in lbs. per sq. in.
5.4	Dielectric constant
3.00 or less	Dielectric loss factor
Class "L3" or better	Grade per American Stand. C75.1-1943
Zero to .007%	Porosity or moisture absorption
White	Color of material

Centralab

Division of GLOBE-UNION INC., Milwaukee

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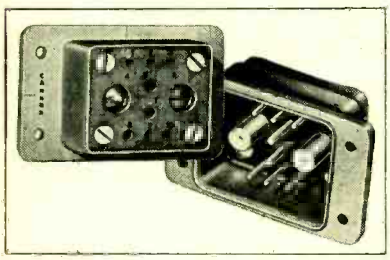
NEW PRODUCTS

CANNON TYPE DP-B CONNECTOR

The newest member of the Cannon DP line of electrical connectors is the DP-B10C2. This is classed as a rack type connector and is adapted by its design to radio rack assemblies, transmitters and any general applications where both plug and receptacle must be fixed permanently in their respective units of equipment.

Differing radically from the standard round or oval faced connectors, the DP-B is rectangular and is so designed to fit rack equipment. The shell is tapered to effect a close fit when engaged and the two units of the complete connector are self aligning but are dependent upon the accuracy of the equipment it connects.

The insert insulation is made of molded phenolic, having 8 standard contacts of brass, silver-plated, and 2 coaxial contacts of the same material and finish, with isolantite insulators. Two contacts are 30-amp. and 6 are 15-amp. Shell is die-cast aluminum alloy, with sand blast and clear lacquer finish. Four mounting holes have diameter of .144 countersunk for #8 flat



head machines screws. Weight of Receptacle .276 (lbs.) and plug .266 (lbs.).

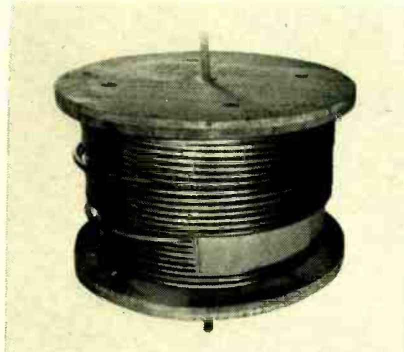
Write to Cannon Electric Development Co., 3209 Humboldt St., Los Angeles, California, for complete bulletin on the DP line.

★

½-MILE COAXIAL CABLE

Now, ⅞" soft temper copper coaxial cable may be obtained from the Andrew Company in continuous lengths up to several thousand feet.

The cable is wound on wooden reels and is electrically identical to rigid cables of the same size. Considerable time and labor is saved in installation because: 1—The cable is easily uncoiled and bent by hand to the desired contour; 2—Connectors, junction boxes and expansion fittings are not necessary, thus eliminating the hazards and defects which result from soldering in the field and eliminating the need of using skilled technicians in installation; and 3—To prove that all splices are pressure tight and to exclude foreign matter and moisture during shipment, the cable may be fitted at the factory with special Andrew glass-insulated terminals and shipped under pressure.



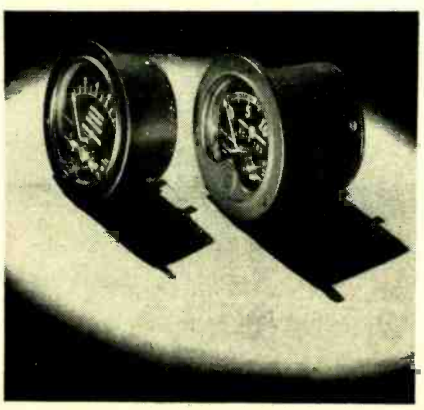
Further data may be obtained direct from The Andrew Co., 363 E. 75th St., Chicago 19, Ill.

★

G-E INTERNAL-PIVOT METERS

A new line of small, thin, d-c panel instruments featuring a revolutionary internal-pivot construction is announced by the General Electric Company for use in aircraft, and radio and communications equipment, and for application on various types of machinery. Available with either brass or molded Textolite dustproof and moisture-resisting cases in 2½ inch sizes, the line consists of d-c voltmeters, ammeters, milliammeters, microammeters, radio-frequency ammeters and milliammeters, and d-c volt-ammeters. The volt-ammeter, one of the group designed for naval aircraft, has a push-button-operated switch to change the reading from "amperes" to "volts."

In the new instruments, the pivots are solidly mounted on the inside of the armature shell instead of being secured to the outside of the armature winding in the conventional manner. One jewel bearing is mounted rigidly on top of the core-and-frame assembly, and the other is mounted in an adjustable sleeve fitted into the lower part of the soft-iron core. Thus the element assembly is a single, self-contained unit, all parts of which are supported by



a high-coercive cast magnet, and it can be removed easily for inspection or repair in the field.

This unique design enhances the sturdiness of the instruments and also renders them excellent for applications where vibration is present. In addition, the combination of high torque and a lightweight moving element results in a fast response, and good damping makes for ease and accuracy of reading. The instruments will operate satisfactorily in temperatures ranging from —50 C to 70 C, and are accurate to within the limits of ±2 per cent of full-scale value.

Two publications available on request to General Electric at Schenectady describe the new instruments in detail. Publication GEA-4117 covers the 2½-inch panel instruments designated Type DW-53 for Naval Aircraft. Publication GEA-4064 covers the 2½-inch diameter panel-type electric indicating instruments, designated Types DW-51 and DW-52.

★

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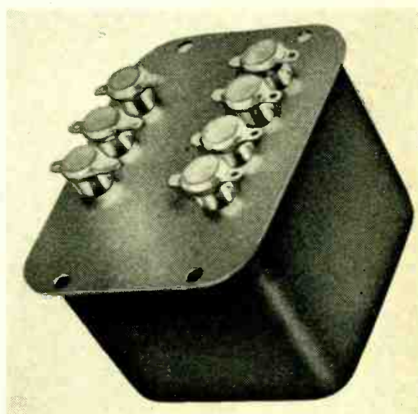
A new moisture and dust proof transformer that meets all Navy and other specifications for hermetic sealing is an-



nounced by Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Calif., manufacturer of transformers for aircraft, marine and ordnance installations.

Of particular value where dampness or dust protection is an important factor, the new transformers use glass or porcelain insulators with metal bands. These insulators are soldered into the transformer case which is of cold drawn copper-plated steel and thus become an integral part of the case. As in all Peerless transformers, their exclusive "Vac-sealing" impregnation process is used, insuring absolute impregnation without solvents or other deleterious material present inside the coil. This is accomplished through the use of a special type of impregnant that cures completely under heat.

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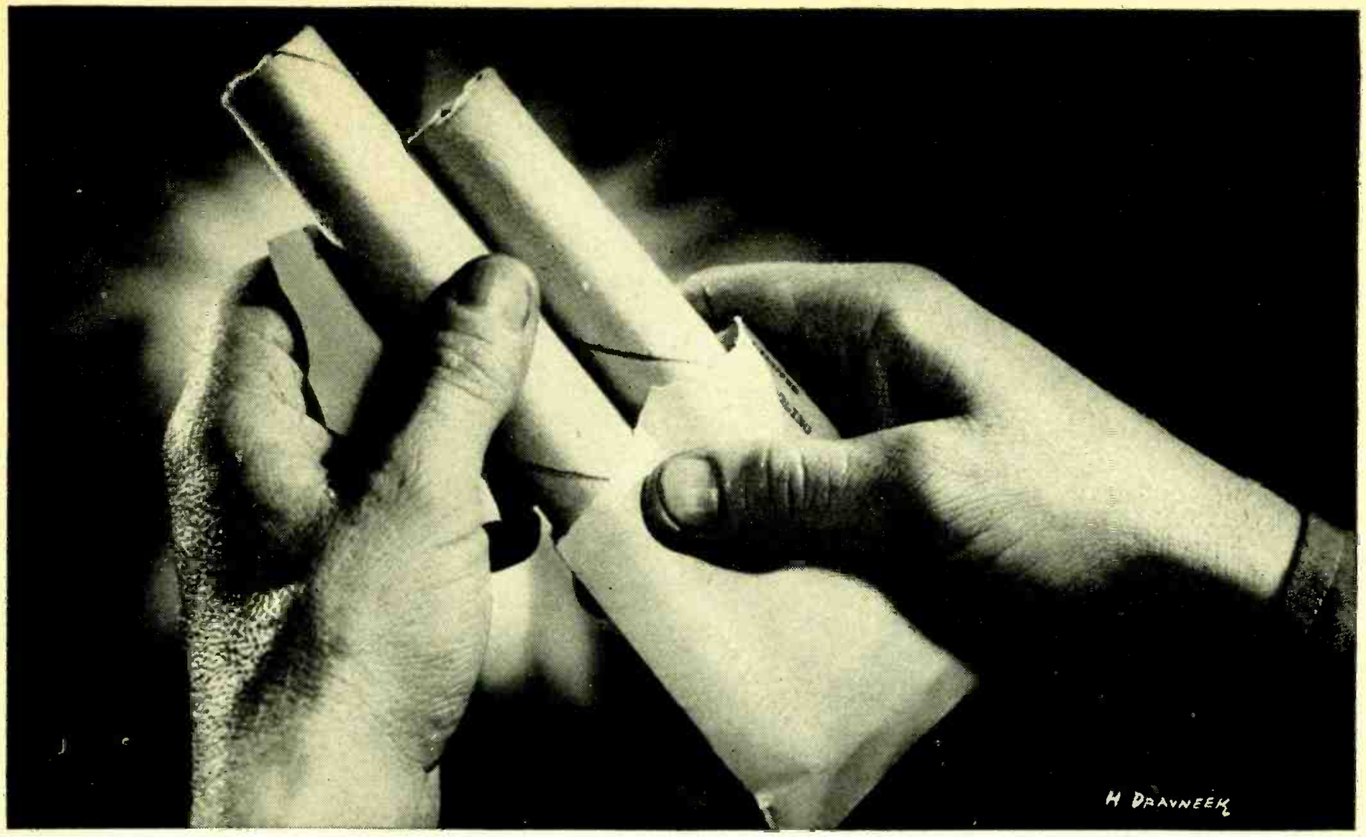

Mister—you're getting paid in DYNAMITE!

LET'S NOT KID OURSELVES about this. Our pay envelope today *is* dynamite.

If we handle it *wrong*, it can blow up in our face . . . lengthen the war . . . and maybe wreck *our* chances of having happiness and security *after* the war.

The wrong way to handle it . . . and why

The wrong way is for us to be good-time Charlies. To wink at prices that look too steep . . . telling ourselves we can afford to splurge.

We *can't* afford to—whether we're business men, farmers, or workers. And here's why:

Splurging will boost prices. First on one thing, then all along the line.

Then, wages will have to go up to meet higher prices. And higher wages will push prices up some more . . . faster and faster, like a runaway snowball.

The reason this can happen is that there is more money in pay envelopes today than there are things to buy with it. This year, we Americans will have *45 billion* dollars more income than there are goods and services to buy at present prices. *45 billion dollars extra money!*

That's the dynamite!

The right way to handle it . . . and why

Our Government is doing a lot of things to keep the cost of living from snow-balling.

Rationing helps. Price ceilings help. Wage-and-rent stabilization helps. Higher taxes help. They're *controls* on those dangerous excess dollars.

But the real control is in our hands. Yours. Mine.

It won't be fun. It will mean sacrifice and penny-pinching. But it's the only way we can win this war . . . pay for it . . . and keep America a going nation afterwards.

And, after all, the sacrifice of tightening our belts and doing without is a small sacrifice compared with giving your life or your blood in battle!

Here's what You must do

Buy only what you absolutely need. And this means absolutely. If you're tempted, think what a front-line soldier finds he can get along without.

Don't ask higher prices—for your own labor, your own services, or goods you sell. Resist pressure to force YOUR prices up.

Buy rationed goods only by exchanging stamps. Shun the Black Market as you would the plague.

Don't pay a cent above ceiling prices.

Take a grin-and-bear-it attitude on taxes. They must get heavier. But remember, these taxes help pay for Victory.

Pay off your debts. Don't make new ones. Getting yourself in the clear helps keep your Country in the clear.

Start a savings account. Buy and keep up adequate life insurance. This puts your dollars where they'll do you *good.*

Buy more War Bonds. Not just a "percent" that lets you feel patriotic, but enough so it *really* pinches your pocketbook.

If we do these things, we and our Government won't have to fight a post-war battle against collapsing prices and paralyzed business. It's *our* pay envelope. It's up to *us*.

KEEP PRICES DOWN!

Use it up • Wear it out
Make it do • Or do without

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ELECTRON THEORY

[*Continued from page 30*]

electron must, therefore, have a particle aspect.

The experimental work of G. P. Thomson dealt with the transmission of a beam of electrons through a very thin film of metal. He found that after passage through such a film the beam of electrons exhibited a diffraction interference pattern which could be recorded on a photographic plate. This pattern consisted of a series of concentric circular rings, like Newton's rings in optics. This whole interference pattern could be displaced by a magnet.

Now particles in motion in the same direction cannot interfere; it takes waves to do that; and ether waves cannot be deflected by a magnet as charged particles are. Thomson's experiments lead to the same conclusion as those of Davisson and Germer—that an electron has both wave and particle aspects; that neither can be neglected, and that neither is to be overemphasized at the expense of the other.

Thomson carried his experiments still farther. He used electrons of different velocities, measuring the velocity in the usual way, by electrostatic and magnetic deflection. He found that a change in the velocity of the electron altered the distance between the rings in the diffraction pattern, just as a change of wave length would do in the optical analogue. He found that a higher velocity of the electron corresponded to a shorter associated wave length. He was able to obtain a formula connecting these two quantities, which turned out to be the same as a formula suggested by de Broglie a few years earlier, on a purely theoretical basis.

Upon this dual wave-particle aspect of the electron has been based the important invention of the electron microscope. It may suffice to say at present that it is the charged particle aspect of the electrons which causes them to be brought to a focus by the magnetic lens, and it is the very short-wave aspect of the electrons which gives to the microscope its high resolving power.

Conclusion

It is evident from these experimental facts that in the electron we have to deal with something much broader and more general than any of our present attempts to grasp it. In this respect we are like the three blind men of the Hindu story, who went out to see the elephant. An obliging friend led them to the place where the elephant was, and said: "Now, there he is, just a few steps in front of you. Go and examine him." They advanced slowly with outstretched hands.

The first man happened to touch the elephant's trunk. He felt it up and down, and said: "How wonderful! An elephant is like a young tree with rough bark!" But the second, who felt the elephant's tail, said: "How can you say that? An elephant is much like a piece of rope." And the third, who had touched the animal's side, said: "You are both wrong; an elephant is like a great, broad, flat wall."

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RESONANT NETWORKS

[*Continued from page 37*]

lent series circuit is explained below.

It is shown in many text books that a resistance, R_P, in parallel with a reactance, X_P, gives an equivalent series impedance of $Z = R_PX_P/(R_P + X_P)$ vectorially, or an absolute value of $R_PX_P/\sqrt{R_P^2+X_P^2}$. To solve this problem geometrically, we draw *Fig. 4-B* in which OR_P is drawn to scale to represent the resistance, R_P, of *Fig. 4-A*, and OX_P to represent the reactance X_P. Connect X_P to R_P and drop a perpendicular, OZ from O to this line. Then in the similar triangles OX_PR_P and OZR_P, $OZ/OR_P=OX_P/X_PR_P$, but the hypotenuse $X_PR_P=$

$$\sqrt{(OR_P)^2+(OX_P)^2};$$

therefore $OZ=OR_P(OX_P)/\sqrt{(OR)^2+(OX)^2}=R_PX_P/\sqrt{R_P^2+X_P^2Z}$ as shown above. This shows that OZ represents the absolute value of Z. It can be shown that the vector OZ is also at the correct phase angle.

To divide OZ into its resistive and reactive components, drop a perpendicular from Z to meet OR_P at R_S. These components OR_S and ZR_S will then represent the equivalent series resistance, R_S, and the equivalent series capacitance, X_S, of the parallel circuit as shown in *Fig. 4-C*.

This is a very convenient method of converting a parallel circuit into its series equivalent. It will be readily seen that this construction can be used in the opposite manner to convert a series circuit into its equivalent parallel circuit.

MAXWELL'S EQUATIONS

[*Continued from page 28*]

flection. With no residual surface charge or current, it then becomes easy to see that the boundary conditions I through IV have been satisfied.

We would like now, however, to obtain a method which would tell us what fraction of the incident energy is reflected and transmitted. This will presumably depend upon physical properties of the reflecting medium. The equations which state this relation for a plane wave approaching the boundary at an arbitrary angle of incidence are known as Fresnel's equations. It turns out that the reflection coefficient (reflected amplitude divided by incident amplitude) depends not only on the angle of incidence but also on the polarization. Looking back at *Fig. 1*, it is clear that some such dependence might be anticipated. Tilting the wave-train relative to the plate in one direction would give only tangential com-

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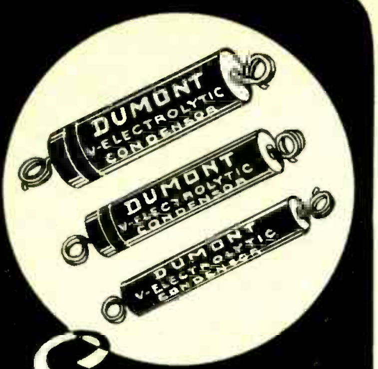

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ponents of H and both normal and tangential components of E; in another direction H would have both normal and tangential components and E would be only tangent to the plate. This causes the boundary conditions to enter into the problem in a different way and give the changing reflection properties with polarization as first stated by Fresnel.

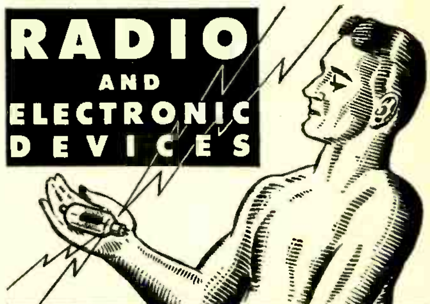
If we restrict ourselves to approximately normal incidence, however, the situation is not so complicated. For a wave initially traveling in air or vacuum the reflection coefficient is then given by

$$R = \frac{\sqrt{\epsilon} - 1}{\sqrt{\epsilon} + 1}$$

where ϵ is the dielectric constant of the target material if the target medium is a dielectric, and $\epsilon = 2\pi f\mu/\sigma$ if the target is a conductor. In order to further understand these, let us first look back at equation 6. If we wish, we may take this as a definition of ϵ. Whenever charge is present in a given volume an electric field may be observed. That is, a potential change measured in volts per cm may, in general, be observed in the neighborhood of the charge. If the charge giving rise to this field is unbound charge such as comes from a battery and flows in metals, we call the electric field E. If, on the other hand, the field in part arises from bound charge the total field is designated as D. By bound charge is meant the kind of charge found in insulators. There the electrons are not free to flow throughout the material but nevertheless may shift their position relative to the positive charge. This shift is called polarization and accounts for the fact that the D field in a material may be larger than the E field.

Dielectric Constant

Now looking at *Fig. 6*, we can at least in part see why the dielectric constant dictates the reflection coefficient. As the wave approaches the surface, an electric field E is obtained at the reflecting medium. This electric field E causes a polarization of the reflecting medium in accordance with the dielectric constant and thus creates a field D in the medium. Our equation 1 tells us that this, along with the current that can flow, influences the value of H at the surface. The same sort of argument can be made the other way around. The approaching H wave, gives rise to B in the target which by equation 2 influences the value of E at the surface. These two processes work in competition and hence fix the values of E and H at the boundary. These in



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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

of RADIO, published monthly at East Stroudsburg, Pa., for October 8th, 1943.

State of New York }
County of New York } ss.:

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Sanford R. Cowan, who, having been duly sworn according to law, deposes and says that he is the Business Manager of RADIO, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are: Publisher. Radio Magazines, Inc., 132 W. 43rd St., New York 18, N. Y.; Editor, M. L. Muhleman, 15 Bronxville Rd., Bronxville, N. Y.; Managing Editor, None; Business Manager, S. R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.

2. That the owners are: Radio Magazines, Inc., 132 W. 43rd St., New York, N. Y.; M. L. Muhleman, 15 Bronxville Rd., Bronxville 8, N. Y.; and Sanford R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock, and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) SANFORD R. COWAN, Business Manager.

Sworn to and subscribed before me, this 17th day of September, 1943.

(Seal.) RAY F. WIESEN, Notary Public.

Kings County, Kings Co. Clk's No. 208, Reg. No. 4245, N. Y. N. Y. Co. Clk's No. 694, Reg. No. 4-W-398. Commission expires March 30. 1944.

turn by our boundary conditions determine the reflection coefficient.

If the reflector material is really a dielectric the permeability μ is unity and does not influence the B of the reflector material; likewise the current term of equation 1 is negligible because of the very small conductivity, σ. Thus in that case, ϵ alone is the determining property of the material. If the reflector is a conductor, the charge is no longer bound and ϵ loses its meaning. The conductivity, permeability and frequency then become the determining factors. Sometimes in order to simplify the statement of Fresnel's equations we speak of the dielectric constant of a conductor. We then mean just the expression given above which fits into the equation for conductors in the same way as ϵ does for dielectrics.

Dielectric constant is probably an unfortunately chosen name for ϵ. Actually ϵ is not at all constant with frequency. Values obtained by optical methods may be very different from those in the radio wave, or microwave range. It should also be remembered that many other effects may arise if we are not working with very large surfaces relative to a wavelength.

★

CORRECTIONS

Characteristics of Radio-Electronic Components, by A. C. Matthews, RADIO for August: The expression in the fourteenth line, center column, page 37, should read: $0.00662 \sqrt{F_{mc}}$. Thus skin depth is slightly over one mil at a frequency of 1.75 mc.

Volume Expansion by Negative Definition, by G. E. Otis, RADIO for August: Capacitor *C13* in the diagram of *Fig. 3*, page 31, should not connect to the screen of the 6J7, but only to the mid-point of resistors *R19* and *R20*. Equation (6) on the same page should read:

$$M = \frac{e_f}{e_s} \cdot c \cdot \mu$$

and the term e_c in the last line of the footnote should read $e\beta$.

TECHNICANA

[*Continued from page 22*]

"When something is waved or brandished, the controlling law is different. The accelerating force is no longer inherently proportional to the distance from the position of rest but is independent of it, and may be made as great or small as desired within the limits of the force available. The time for one complete back-and-forth movement varies with the force and also

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with the mass, but since the force is variable at will, the period or frequency of the vibration is also variable. While with a given swing or oscillating circuit the frequency of the oscillation is inherently fixed, with something being shaken, the frequency is not at all inherently fixed, and may vary over a wide range."

This introduction shows why a multivibrator is properly called a vibrator and not an oscillator. The remainder of the article is an excellent treatise on the operation of the multivibrator, showing a mechanical analogy, waveshapes and means of synchronization.

SOLDERING TECHNIQUE

[*Continued from page 40*]

electric iron, high frequency, or carbon resistance soldering tools may do the job better.

5. Design your joints to have 0.003 to 0.005 in. solder thickness, and so that the two parts overlap. Lap or seam-type joints are better than butt-type joints. Have the solder fill the seam completely. Heavy fillets add little strength to the joint, and waste solder.

6. Don't hand a new solder, a flux, and a soldering job to a workman and expect a perfect job the first time. Let him get the "feel" of the new material. Don't give up a new solder after one unsuccessful trial — the chances are your technique is not what it should be for that particular solder.

BOOK REVIEWS

RADIO ENGINEERS' HANDBOOK, by Frederick E. Terman. Published by McGraw-Hill Book Co., New York, N. Y., 1019 pages. Price $6.00.

The purpose of a handbook is to provide a summary of the best and most important data currently available in its field. This Dr. Terman's book does in a thorough and rational manner.

Some 2000 technical papers were reviewed during the preparation of the manuscript and the book contains an extensive bibliography of some 1500 references for the user who desires more detailed information. The text refers to the bibliography in such a manner that the reader is advised as to what he will find in the references cited. Equipment descriptions and elementary introductory material, so fre-

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quently cluttering up the average handbook, has been avoided. The reader who wishes to make an intensive study of some particular topic is thus spared the necessity of engaging in a time-consuming search to find what he requires in the literature. Most of the essential information including formulae appear to be included in the manuscript. The reader, therefore, will generally not need to have a library within arm's reach to answer most of his problems, and yet is supplied with bibliographical information which tells him exactly where to look for additional details.

Certain sections of the book are particularly complete in that they present in one place material previously widely scattered. So far as the reviewer is aware, the formulae and curves on skin effect, inductance, mutual impedance, and capacity in Section 2 represent the most complete collections to be found in one place. The same is true of the transmission-line equations in Section 3, the formulae for field patterns and radiation resistance of antennae in Section 11, and the treatment of ground wave and ultra-high frequency propagation in Section 10. Similarly, the important subject of network theory is covered in a readable and comprehensive manner. Particular attention is paid to such important items as Foster's reactance theorem, attenuation and phase equalizers, lattice and latter structures of passive networks, impedance matching and insertion loss, the relation between attenuator and phase shift, etc. The treatment of electron optics is noteworthy in that it appears to be the first summary of the subject that has appeared in handbook form. This book also presents the most complete collection of data on electron lenses that the reviewer has seen in print.

This handbook is essentially a one-man job so that the different sections of the book are closely coordinated, and related subjects in different parts of the book are treated from one viewpoint, thus avoiding the inevitable duplication and gaps that appear when each section is prepared by a different author.

Unfortunately this edition of the book does not contain a section on television. It is hoped that this subject will be treated in future editions. Some material on this important subject does appear in several sections of the book, notably the antenna and amplifier sections, but a cordinated presentation of television systems is not included.

The author has covered such important topics as; circuit elements, to which some 102 pages are devoted; circuit theory, covering some 116

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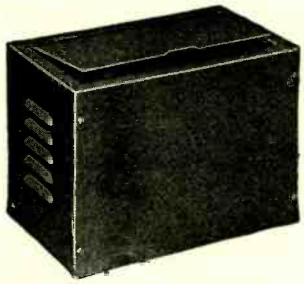

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pages; vacuum tubes and electronics—70 pages; vacuum-tube amplifiers—109 pages; oscillators; modulation and demodulation; power-supply systems; radio transmitters and receivers; propagation of radio waves; antennas, covering some 93 pages, as well as radio aids to navigation and measurements.

This book is exceedingly well written, covers each topic in a thorough and rational manner, and is adequately indexed and referenced. And, coming from Dr. Terman, it is very much an occasion. It goes without saying that it is a work of prime importance and a necessary addition to every radio engineer's "working" library.

★

REFERENCE DATA FOR RADIO ENGINEERS. Published by Federal Telephone and Radio Corp., 67 Broad St., New York 4, N. Y. 200 pages. Price $1.00 (75 cents per copy in lots of 12 or more).

This book is presented as an aid in radio research and development, as well as in factory and field engineering. The aim, in the compilation of material, was to provide for requirements of engineers as well as practical technicians.

A wealth of data is presented in compact form, covering a very broad field of application. There are seven engineering tables in the first part of the book, followed by chapters on engineering and material data, audio and radio design, rectifiers, vacuum-tube amplifiers, telephone transmission, r-f transmission lines, radio propagation and antennas, noise and noise measurement, non-sinusoidal waveforms, dimensional expressions, and mathematical formulas and tables.

A worthwhile addition to any engineer's or technician's library as well as a practical working tool.

★

TRAIL BLAZERS and REFERENCE GUIDE TO ULTRA HIGH FREQUENCIES, compiled by E. Kelsey. Published by Zenith Radio Corp., 680 N. Michigan Ave., Chicago 11, Ill. 56 pages. Free distribution.

Last year Miss Kelsey prepared a *Reference Guide to Ultra High Frequencies*, which was enthusiastically received in the field. The current edition—the third—has been brought up to date and includes much new material.

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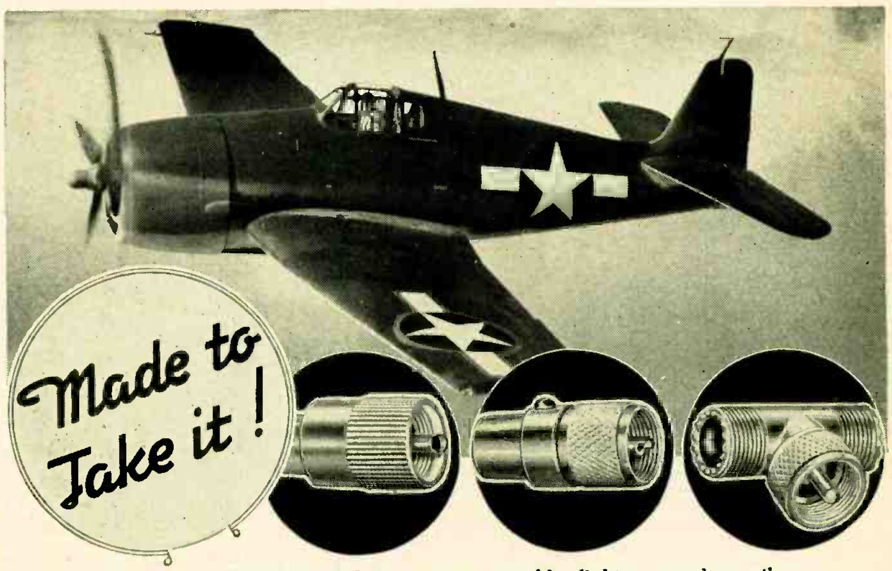

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to Radionics as an adjunct to the previous material widens its scope of usefulness. In writing this, every effort was made to present in a concise form important data that would not otherwise be obtainable without considerable research in a large library. The purpose of this work is to present biographies of great men of science and their research, and tell where such contributions are now used in the progress of science. The biographies themselves are gems.

★

HYPER- AND ULTRA-HIGH FREQUENCY ENGINEERING, by Robert I. Sarbacher and William A. Edson. Published by John Wiley & Sons, Inc., New York. 644 pages. Price $5.50.

The authors of this book are professors of electrical engineering at the Illinois Institute of Technology. Their work in this text covers all phases of hyper-frequency engineering, including the generation, transmission and reception of quasi-optical waves. Though the treatment is predominantly mathematical, complexity has been studiously avoided.

This book is intended for use by senior students of electrical engineering, and by men with equivalent training who have had at least one course in radio engineering. The authors have obligingly and sensibly included in the front of the book a table of symbols and their designations, running to seven pages, which removes the possibility of confusion over the manner in which they are employed throughout the text.

In treating problems arising in hyper- and ultra-high frequency engineering, the ordinary low-frequency circuit theory is inadequate, and the more general electromagnetic theory is required. Since the usual electrical curriculum does not emphasize general electromagnetic field theory, the first three chapters of this book serve to review the subject.

The contents of the book, by chapters, includes Electrostatics and Magnetostatics, Electromagnetic Equations, Maxwell's Equations, Reflection and Refraction of Plane Waves, Parallel Plane Wave Guides, Rectangular Wave Guides, Cylindrical Wave Guides, Wave Guide Experimental Apparatus, Transmission Line Theory, Cavity Resonators, Radiation From Horns and Reflectors, The Behavior of Vacuum Tubes at High Frequencies, Amplifiers, The Negative Grid Oscillator, The Positive Grid or Retarding-Field

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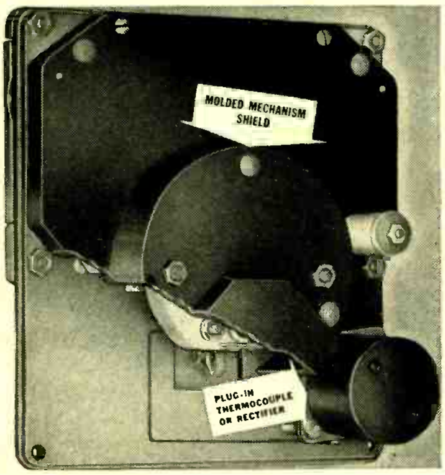

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Oscillator, The Magnetron, and Tubes Employing Velocity Modulation.

The book is well indexed, and contains a group of excellent bibliographies, each having reference to a single chapter—an idea that should be generally applied to textbooks. As a whole, the book is unique in its presentation and should enjoy wide acceptance.

★

RADIO HANDBOOK, Ninth Edition, 1942. Published by Editors and Engineers, 1422 North Highland Ave., Los Angeles, Calif. 640 pages. Price $2.00.

The Radio Handbook has long been a standard text for Amateurs and, along with other books, has been currently used as a standard text in training centers. Since it combines theory and practice under one cover, it has a practicality not to be found in many other radio textbooks.

The ninth edition, first printed in 1942, has been brought up to date by proper revisions and additions to chapters, and contains a completely new chapter on Radio Mathematics and Calculations. This chapter, written on the assumption that the reader has had little if any contact with mathematics, is notable for its clarity and smooth progression from arithmetic to trigonometry. It serves to give the reader a proper grasp of mathematical methods without becoming complex.

Other chapters cover vacuum-tube, transmitter and receiver theory; frequency modulation; ultra-high frequencies; and similar subjects dealing with the actual design and construction of Amateur equipment, and test procedures—28 chapters in all.

THIS MONTH

[*Continued from page 54*]

ployees, and invited guests. *Admiral Harold G. Bowen*, USN., presented the flag which was accepted by *William A. MacDonald,* President of the Company. *Colonel Oscar C. Maier,* U. S. Signal Corps, presented the "E" pins to a delegation of employees. The address of welcome was delivered by the *Honorable Newbold Morris*, President, New York City Council. *Mr. Fielding Robinson,* Assistant to the President of Hazeltine, was master of ceremonies.

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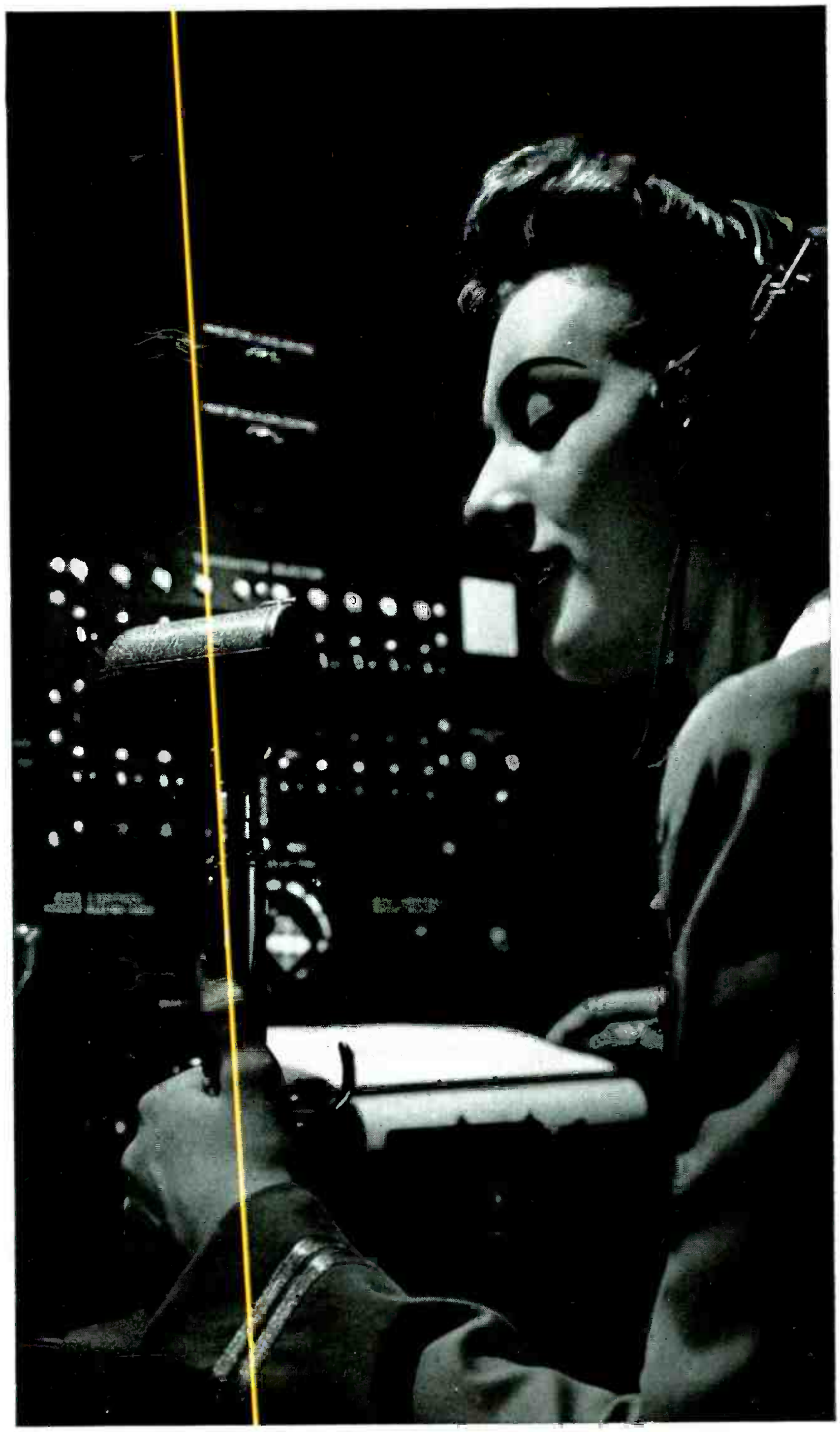

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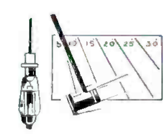

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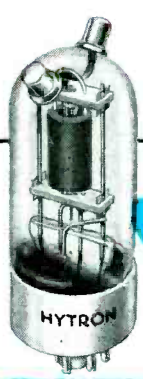

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