NINTH YEAR OF SERVICE

RADIO ENGINEERING

Vol. IX FEBRUARY 1929 Number 2

IN THIS ISSUE

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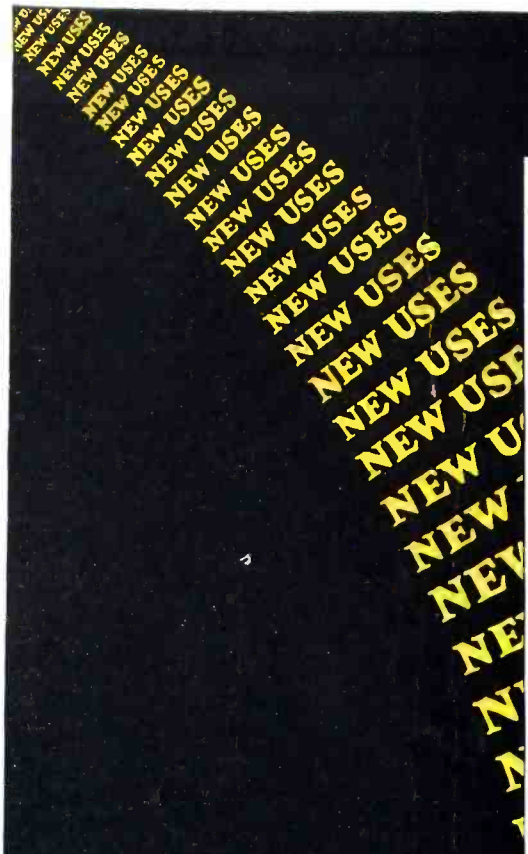
The JOURNAL of the RADIO INDUSTRY



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NEW USES

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Laminated BAKELITE

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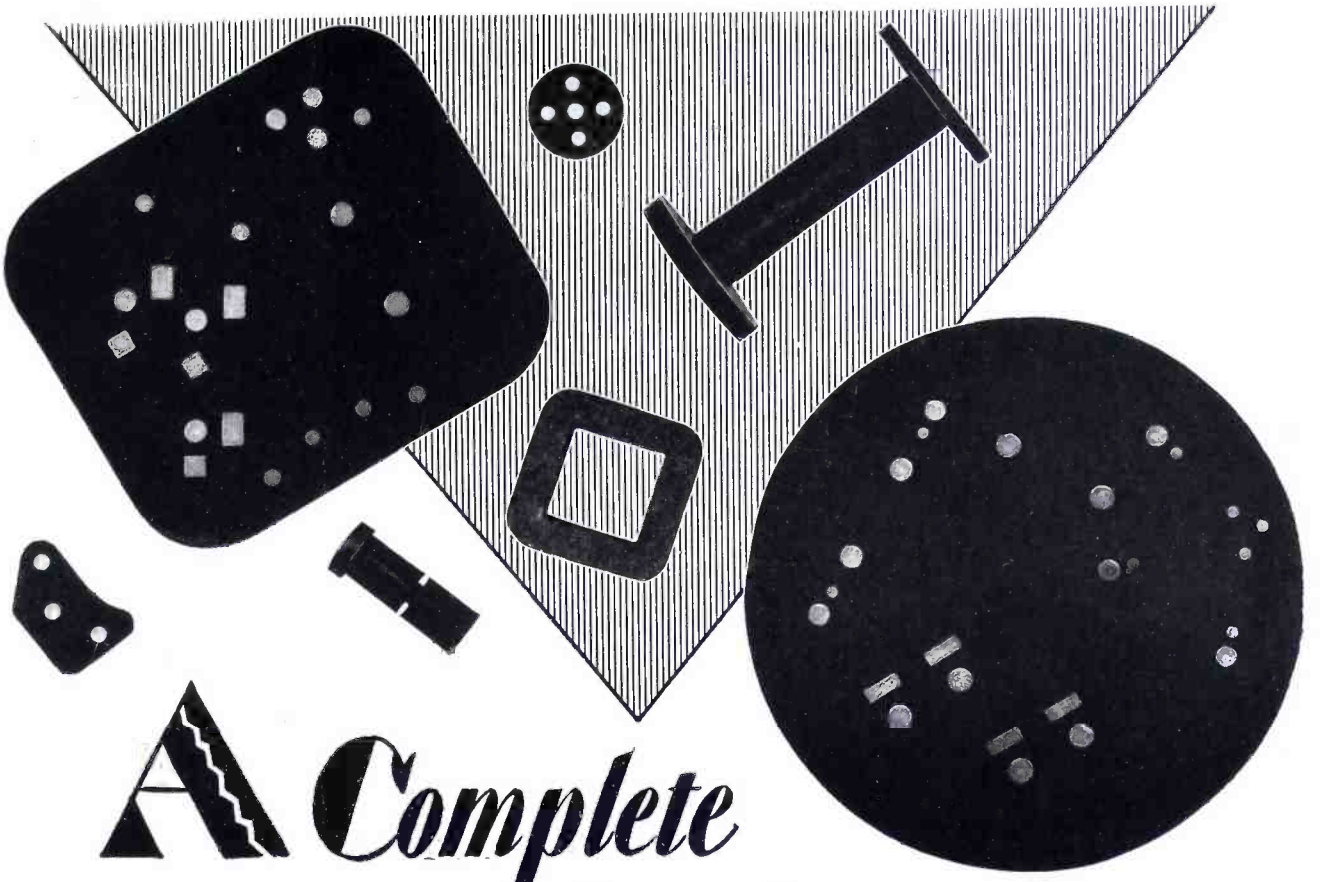

A Complete and Prompt Insulating Service

FORMICA provides promptly uniform and high quality phenol laminated insulating sheets, tubes and rods, and parts of any type that it is possible to machine from them.

The equipment both for producing the fundamental shapes and for machining them to your blue prints is the largest and most complete in the industry.

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FORMICA
Made from Anhydrous Bakelite Resins
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RADIO ENGINEERING

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Vol. IX FEBRUARY 1929 Number 2

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Departments

A Tip from John Bull

BY BOND P. GEDDES
Executive Vice President, R. M. A.

PARTS manufacturers and also producers of tubes may well profit from a tip coming from across the water, from Great Britain, regarding the stimulation of custom-set building and amateur-set building.

A prominent person in the British radio industry called recently at the New York offices of the R. M. A. and told an interesting story of how custom and amateur-set building had been greatly stimulated and maintained in Great Britain by wide-awake tube manufacturers, and this along lines advocated and followed in part by parts manufacturers who are members of the R. M. A., but not to the extent nor with the success of their British brethren.

It appears that the British tube manufacturers had the foresight and vision to back an enterprise stimulating not only what the British call their "valve" business, but also custom-set building and purchase of parts by custom-set builders and amateurs. The British tube manufacturers raised a fund last year, according to the information given to the R. M. A., of $200,000 for an extensive advertising campaign in newspapers and with booklets. They had the foresight to see that not only would custom and amateur set building stimulate the purchase of tubes, but also of parts and ultimately of large numbers of factory built receivers, according to the British visitor to the R. M. A. offices.

The result was, according to definite returns carefully compiled, large increase in the sale of tubes to custom and amateur set builders, and incidentally, a large sale of parts. The trade promotion project of the British tube manufacturers was so eminently successful that the plan is to be continued with a larger promotion fund this year.

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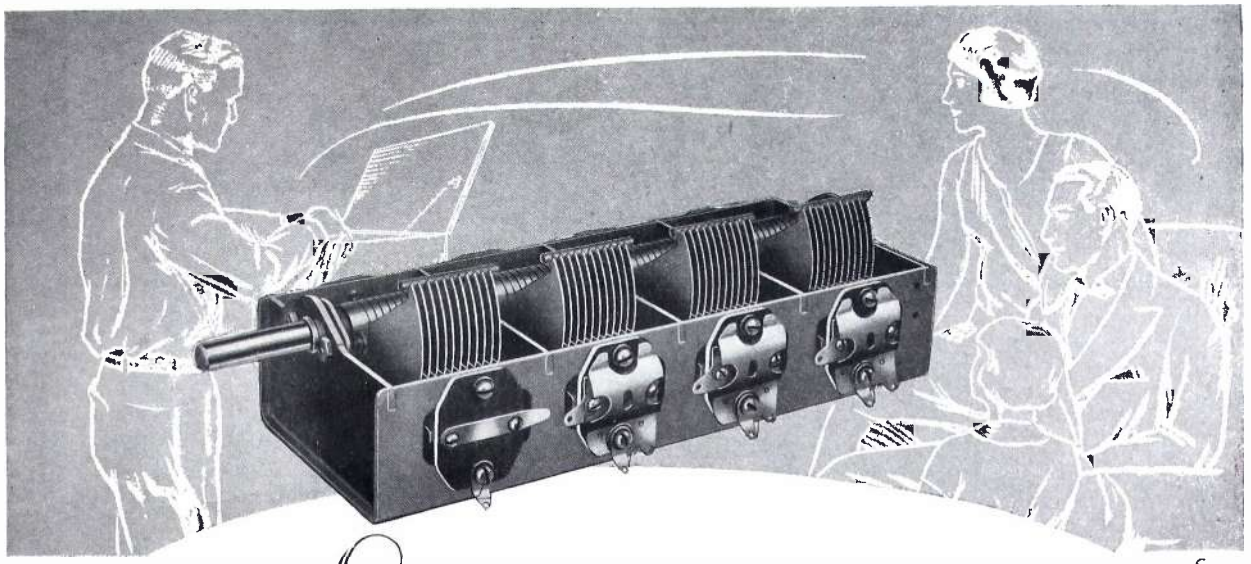

Scovill Craftsmanship An Aid to Sales and Profits

THE sales and profit possibilities of a product depend upon manufacturing quality and economy. This is especially true of radio, where every small and unseen part plays a prominent rule in the symphony of construction.

Because of this, manufacturers of repute select Scovill Craftsmanship. They adopt and make the gigantic and unequalled manufacturing facilities of a 127 year old plant a means of producing quality parts at a cost that helps sales and profits — a cost that helps to outdistance competition.

Scovill is essentially a creative organization as well as a manufacturing unit. Radio parts are made to specification from your blueprint, sample or suggestion. The cooperation and experience of this pioneer is at your disposal — as a merchandising aid. Phone the nearest office for a Scovill Representative.

Every step in the manufacture of Scovill Radio parts is under strict laboratory supervision.

SCOVILL
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WATERBURY, CONNECTICUT

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EDITORIAL

February 1929

RESEARCH AND INDUSTRY

IT HAS been the unfailing habit of the radio industry to release its whole bag of tricks at once. Intensive domestic competition is entirely responsible for this practice.

One cannot doubt the advantages gained through the introduction of new and attractive ideas, providing the ideas are well seasoned in every sense of the word. The danger lies in marketing sets embodying engineering developments that are not well rounded out; ideas that are abortive.

There is no necessity for quoting examples; everyone is only too well acquainted with the past trials of the industry, brought about by the wholesale release of premature contrivances.

This unstable and ineffectual period of adolescence appears to have passed. Last year, the majority of set manufacturers agreed to let the screen-grid tube rest in the laboratory until its numerous idiosyncrasies were better understood.

We are not attempting to suggest that engineering progress be delayed in order to satisfy some other condition. Quite to the contrary, we feel that more extensive research should be undertaken and new designs introduced just as rapidly as they are perfected. Certainly, engineering progress should be delayed only in the event that some other normal industrial function has not had sufficient opportunity to catch up with it. No such condition exists.

The point of the matter rests in the fact that engineering, or pure research, can be carried on in more than one channel. The correct channel can be selected only after the industry has made clear the objective—and objectives change from year to year.

The problem in the automotive industry is to sell new cars to people who have old ones. This necessitates constant change in design and the embodiment of convenience and safety features that the cars may strike the public's fancy. The matter of price is, in one sense, of secondary importance, and becomes a factor only because of domestic competition.

The main problem in the radio industry is to sell radio sets to people who have never had them before. Proof of this lies in statistics. The greater percentage of the people are yet to be sold for the first time. Reselling, therefore, becomes of secondary importance, principally because success in the former field will automatically increase the volume of resales.

Assuming the above as the main objective, the most vital necessity is that of price reduction rather than "greater performance." It is the main necessity for the simple reason that the radio industry as a whole must compete with every "luxury industry" for the consumer's dollar. As the matter stands, the price of the average radio set is out of proportion with such products as automobiles, vacuum cleaners, electric refrigerators, etc.

Reduction in the price of radio sets can be accomplished in two entirely different ways, i. e., through the element of quantity production and through simplification of engineering design. Obviously, the two should work together and if research is carried on with the object of price reduction uppermost in mind a great deal can be accomplished.

Before the passing of another season all tubes, including the rectifier, will have 2.5 volt filaments. This standardization of filament voltage will eliminate two and in some cases, three filament heater windings from the power transformer. The further development and inevitable acceptance of the power detector tube will eliminate the intermediate audio-frequency stage. The use of shunt feed systems and lapped joint transformers will further reduce costs. The screen-grid tube will eventually simplify the R. F. channel of every set. This form of engineering and research will do more towards building up the industry than the development of "greater performance" sets.

M. L. MUHLEMAN, *Editor.*

GOLD SEAL and what a tube!

THAT'S what the dealer says as he checks his sales. Not just "pretty good", "profits average", or any other half-hearted endorsement. More likely it's "wish my whole stock were half as lively as Gold Seal. *What a tube!*"

Gold Seal Electrical Co., Inc.

250 PARK AVENUE NEW YORK, N. Y.

Also Manufacturers of Gold Seal Electrical Appliances

Reduce the "Rejections" pile—*do it with Durez*

"FEWER rejections; fewer production operations," is the cry in every manufacturing industry. And nowhere is it more keenly felt than in the highly competitive radio field.

Do it with Durez. Here is a material unparalleled for efficiency and production economy. With incredible rapidity Durez can be molded into parts of most intricate design. It fuses and hardens quickly. It is amazingly tough—yet non-brittle. It can be drilled or tapped with ease. It scarcely ever splits or cracks when pins or studs are inserted. (Many forms of metal parts may be permanently imbedded in the molding process.) It is heat and acid resistant, and impervious to oil and moisture. Dielectric properties are perfect.

There is a special grade of Durez for tube bases and other important radio parts.

Durez cuts production costs to the bone. One operation, and the part is complete. No expensive machining, buffing or coating. Parts come from the mold with a smooth, polished-like surface; and where added attractiveness is desired, beautiful color effects—in solid shades or combinations—may be obtained. Every practical color is available. And whether your run is two or a million, the last part will be an exact duplicate of the first!

DUREZ

One, or a million just like it

Send for this free booklet: "Do it with Durez." Contains complete information about Durez—physical and dielectric properties, color ranges, and scores of practical applications.

Reduce your "Rejections" pile; cut down your production costs—*do it with Durez.* Our laboratory and engineering staff will gladly aid you in the solution of any problem in which a molding compound offers the possibility of a better method of manufacture. Write.

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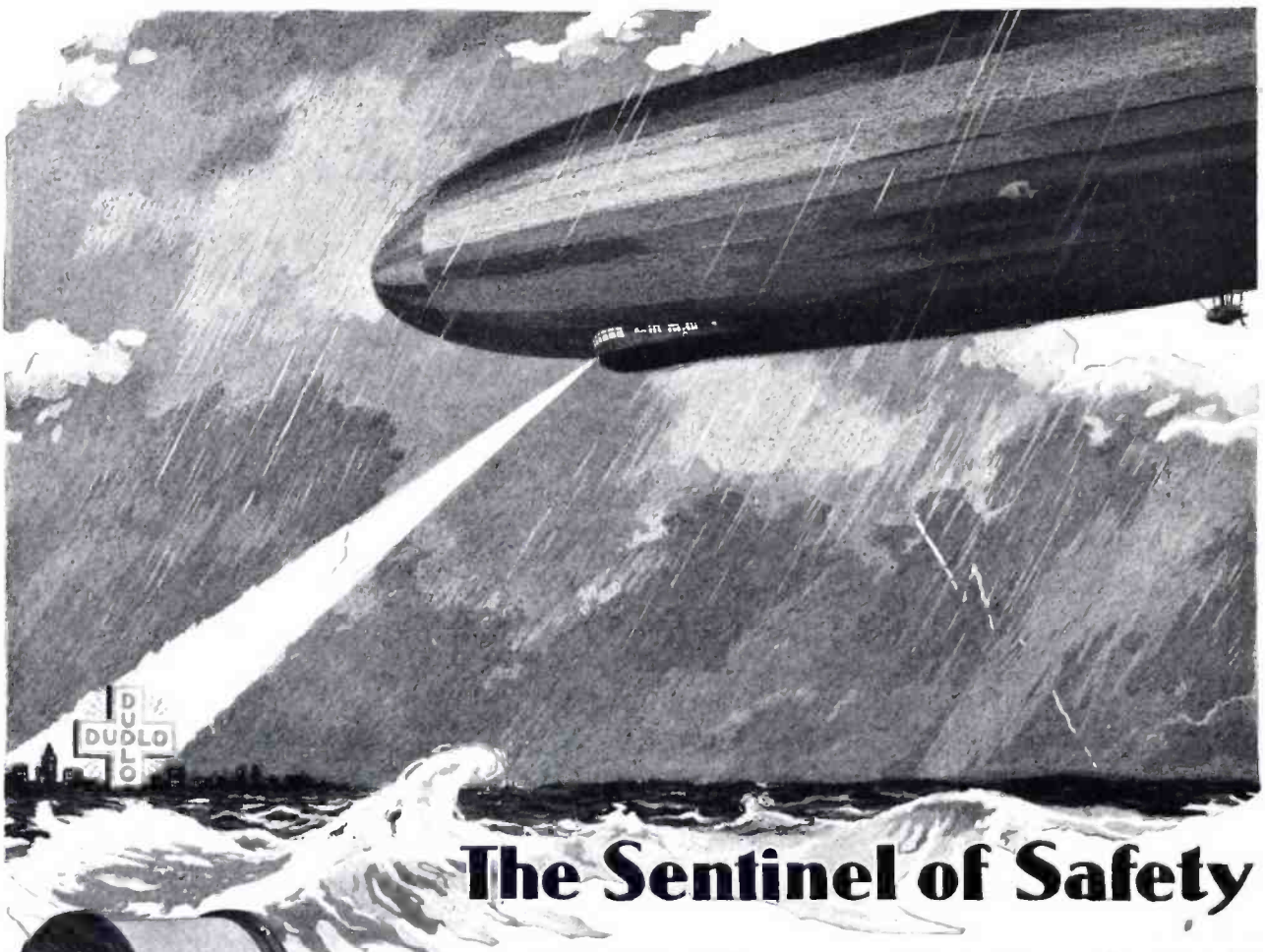
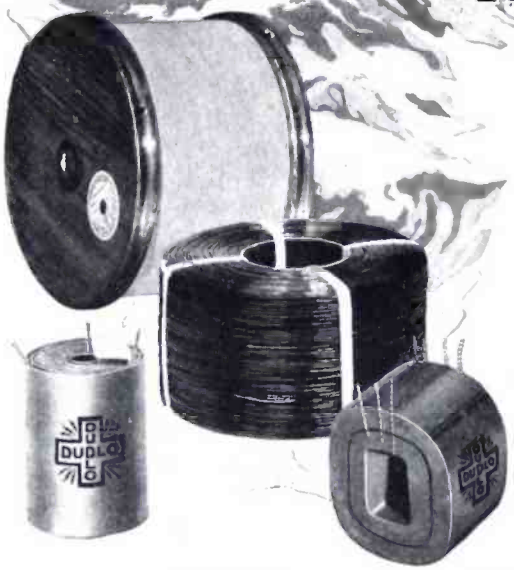


The Sentinel of Safety



Out of the darkness . . . a giant spectre . . . thrusting its nose fearlessly through the storm. Hours of flying over a raging sea . . . throbbing motors . . . dense blackness . . . then . . faint points of light ahead on the mainland. A new chapter in the stirring history of man's conquest of the air.

Every precaution has been taken in building and equipping the great ship . . . every chance of failure guarded against by the use of proven materials. And deep in the vital organs of the dirigible . . . the ignition and radio . . . Dudlo coils and wire, like unseen sentinels of safety, are doing their bit in making the great experiment a successful reality.

No test too severe, no strain too great for Dudlo magnet wire and coils. That great proving ground—aeronautics—has shown them superbly adapted to every requirement of the electrical and radio industry.

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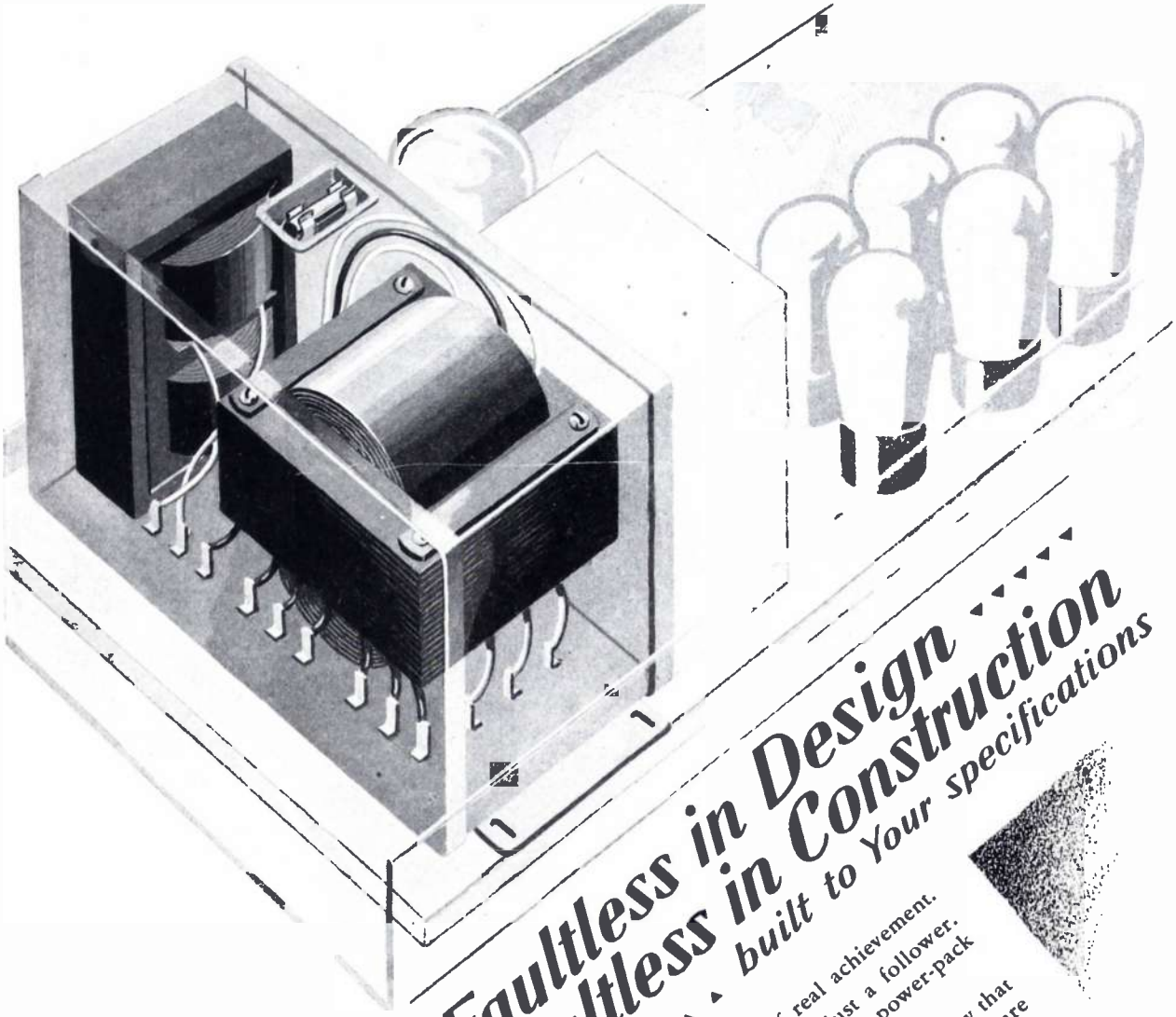

POWER PACKS

Faultless in Design
Faultless in Construction
built to Your specifications

The leadership conceded T. C. A. is founded on a record of real achievement. Pioneers in the field, T. C. A. has always been a leader—not just a follower. Many important, accepted features of present day transformer and power-pack design were developed in the T. C. A. laboratories.

Complete manufacturing facilities enable a step-by-step control over quality that would be impossible if these units were only "assembled." T. C. A. products are *dependable* because they are *right* from start to finish.

Those radio manufacturers who have adopted T. C. A. Power-Packs *know* that the performance of their receivers will never be crippled by the failure of the power transformer installation.

Why content yourself with a "second-best" when the finest costs no more?

Correspondence Invited

The Transformer Corporation of America
1428-1432 ORLEANS STREET, CHICAGO, ILLINOIS
Sales Offices In Principal Cities

The phantoms of music now become REALITY!

INSTRUMENTS—golden notes—formerly lost to radio now come through broadcast receivers in full tonal beauty. No longer does the bass viol come in thinly on overtones alone—no more do the shrill notes of the piccolo at top register die away in a shrill, reedy absurdity. The modern radio has TONE!

Better broadcasting—better tubes—better speakers—but it has remained for Sangamo to build transformers to match these improvements. And particular attention is called to Sangamo Push-pull transformers! The Sangamo Push-pull Input Transformer has an extremely high primary inductance to secure faithful amplification of low notes and an accurately divided secondary insures practically identical frequency characteristics. There are Sangamo Push-pull Output Transformers to match the impedance of the various type power tubes and special Output Transformers for dynamic speakers.

In the Sangamo line there are transformers which permit set builders and manufacturers to produce the real tone fidelity. Are you ready for us to send you the data?

Sangamo Condensers

Molded in Bakelite—unchanging value under all conditions of service.

Tone!

"X" Line Transformers

Type AX straight audio amplification, list price.....**$6.00**
Type BX Push-pull Input unit, list price.....**$6.50**
Type CX-171 Push-pull Output transformer, for 171 or 250 power output tubes for cone speaker, list price..**$6.50**
Type DX, same as CX except for 210 and 112 power tubes, list price.....**$6.50**
Type HX Push-pull Output for 171 or 250 Power output tubes to match the impedance of moving coil of Dynamic loud speakers, list price.....**$6.50**
Type GX, same as HX except for 210 and 112 power tubes, list price.....**$6.50**
Type E output choke to match impedance of the various type power tubes, list.....**$5.00**

"A" Line Transformers

(Similar to "X" line but with special core metal to give slightly better curve)

Type A straight audio amplification, list price.....**$10.00**
Type B Push-pull Input transformer for all tubes, list price.....**$12.00**
Type C-171 Push-pull Output, for 171 or 250 type power tubes with cone speaker.....**$12.00**
Type D-210, same as C except for 210 and 112 power tubes.....**$12.00**
Type H-171, Push-pull Output for 171 or 250 power tubes for Dynamic speaker.....**$12.00**
Type G-210, same as type H except for 210 and 112 tubes, list price.....**$12.00**
Type F Plate Impedance for use as a choke to prevent oscillation and for impedance coupled amplifiers, list.....**$5.00**

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Springfield, Illinois

For 29 years preeminent manufacturers of electrical precision instruments

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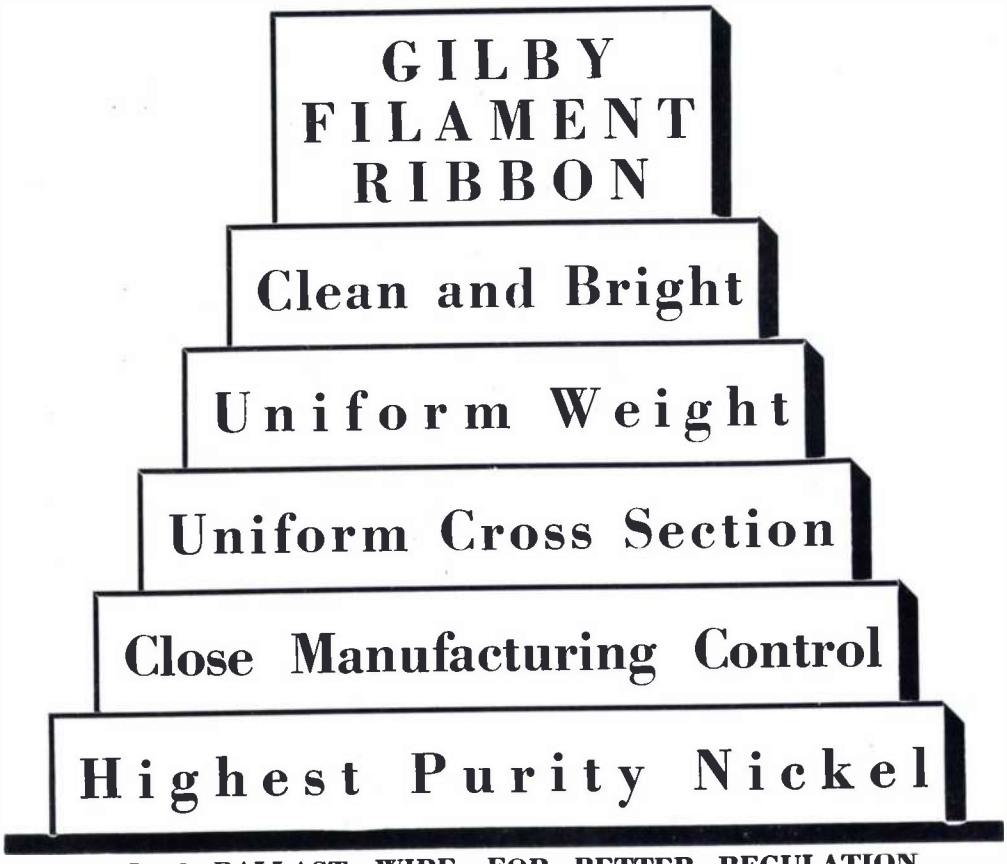

GILBY BALLAST WIRE—FOR BETTER REGULATION

This wire has been aptly termed "the safeguard of the A.C. receiver," because its characteristics assure perfect voltage regulation. It is made of a carefully selected, non-corrosive material, which has a higher temperature coefficient than any other wire of this type. The value of this wire has been proven by its adoption by some of the foremost electric set manufacturers in the country.

GILBY RESISTANCE WIRE

We offer a complete range of specific resistances for every requirement—bare, enamelled, cotton covered or silk covered. Each item represents the highest quality of its kind.

PURE NICKEL

We produce nickel of the highest commercial purity—free from cobalt—in wire, ribbon and sheet for plates, cathodes, support wires and other uses.

Suitable samples of any Gilby material will be sent to responsible manufacturers upon request.

GILBY WIRE COMPANY

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NEWARK, NEW JERSEY

GILBY
RESISTANCE WIRES

Refinement

THOSE new radio sets you are now designing will be judged and accepted purely on the basis of **refinements** or improvements or inherent goodness, rather than startling and revolutionary changes. Our radio art is stabilized, at least for the present. And in seeking those essential **refinements**, don't forget the CLAROSTAT line. ***For instance***—

for A BETTER VOLUME CONTROL—

a small device, neat, compact, one-hole mounting, inexpensive. Remarkable resistance range of practically zero to 500,000 ohms in several turns of knob — or any other range you may ask for. Also ideal as regeneration control in simplified short-wave receiver. ***Simply specify*** VOLUME CONTROL CLAROSTAT.

for ADJUSTABLE B AND C VOLTAGES—

a meddle-proof device, to be sure, yet instantly adjustable by factory tester or service man — neat, just recessed slots exposed for screwdriver adjustment; two variable resistances in one. Practically universal range. Inexpensive. A favorite with radio power device builders. ***Simply specify*** DUPLEX CLAROSTAT.

for RELIABLE FIXED RESISTANCE—

neat; threaded fibre strip with rounded corners; turns cannot slip, no danger of short-circuited turns. Firmly clamped ends with screw-holes and soldering tabs. Correct resistance value — within 5 per cent — stamped on one end. Inexpensive. ***Simply specify*** CLAROSTAT WIRE-WOUND RESISTORS.

for ADJUSTABLE HUM CONTROL—

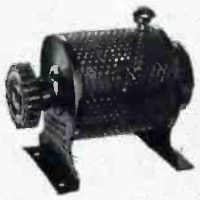
an unique device — smallest of its kind. Compact, Sturdy. Simple. Efficient. Screwdriver adjustment from panel front or top. Variable mid-tap over center half of resistance. ***Simply specify*** HUM-DINGER.

for PHONOGRAPH PICK-UP CONTROL

also loud-speaker volume control particularly in radio-wired systems — neat, handsomely finished in statuary bronze and nickel. Double cords with connecting block, for shunt or series resistance. Any resistance range required. Applied without tools. Inexpensive. ***Simply specify*** TABLE TYPE CLAROSTAT.

for LINE-VOLTAGE FLUCTUATIONS—

here's a means of correcting biggest factor in poor operation of A-C radio sets. A sturdy, durable, reliable, accurately adjustable resistance of any necessary resistance range. Will stand the gaff. Noiseless. Ideal in power packs. ***Simply specify*** POWER CLAROSTAT.



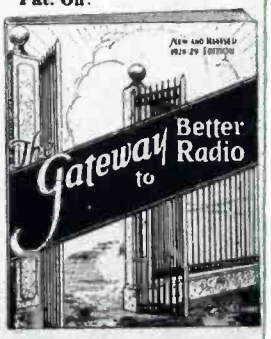
CLAROSTAT

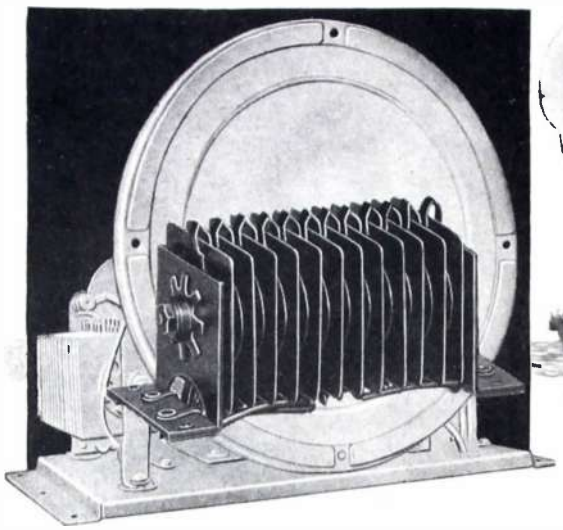
Reg. U. S. Pat. Off.

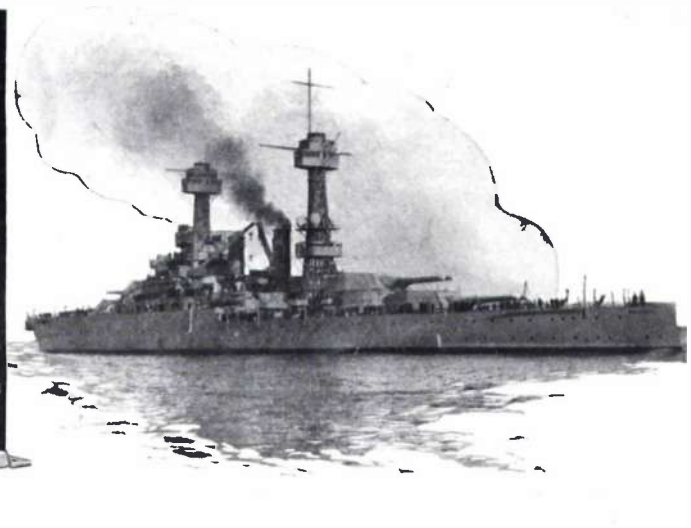
WRITE for the balance of our story. It is obviously impossible to do more than hint at the possibilities of the CLAROSTAT line in refining your present radio designs. Let us send you complete technical and general data, and, better still, place your resistance problems before us so that we may work with you in solving them.

Clarostat Manufacturing Company, Inc.
Specialists in Radio Aids

282 North Sixth Street, Brooklyn, N. Y.







The U.S.S. "Nevada" equips with Kuprox Rectifiers

Last year 90% of the dynamic speakers manufactured were equipped with Kuprox Dry Copper Oxide Rectifiers.

Now Uncle Sam vindicates the judgment of these manufacturers in adopting Kuprox Rectifiers for the new public address system of the modernized U.S.S. Nevada.*

Kuprox Rectifiers have consistently demonstrated their vast superiority over all other forms of dry rectifiers. For efficiency and dependability they have no equal.

The coming radio season will present a greatly enlarged field for dynamic speakers. With a full season of brilliant performance behind them, 1929 will see an enormous increase in the sale of these speakers.

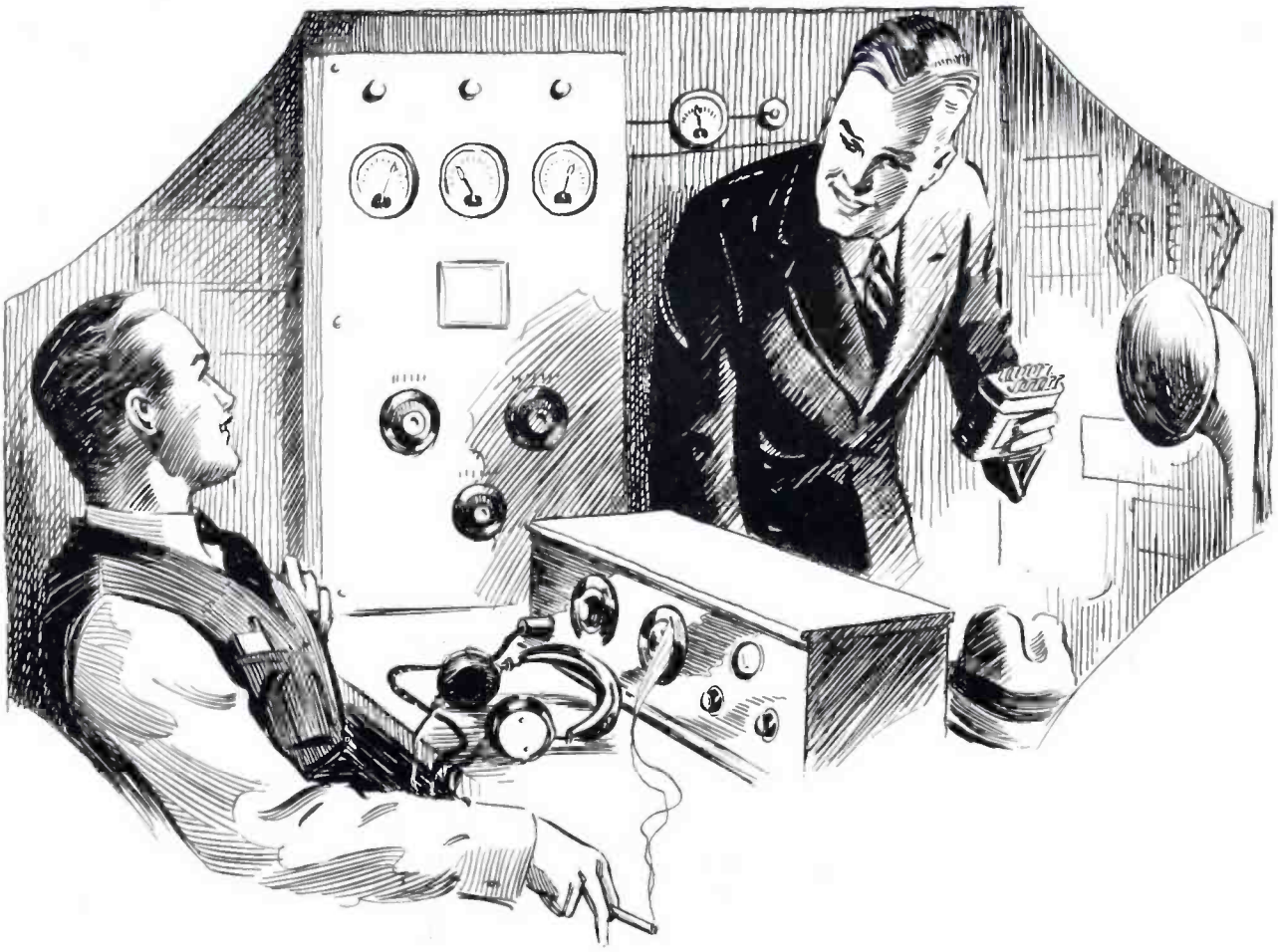
If you contemplate the manufacture or the purchase of dynamic speakers for 1929, we would like to discuss with you the past performance of Kuprox Rectifiers, and their application to your product for the coming season.

** The Kuprox installation on the U.S.S. Nevada is the largest copper oxide or dry rectifier installation ever made. It is designed to furnish three different voltages, 8 volts at 35 amperes, 20 volts at 10 amperes and 375 volts at 1 ampere, furnishing all these voltages and currents simultaneously.*

THE KODEL ELECTRIC & MANUFACTURING CO.
527 E. Pearl St. Cincinnati, Ohio

KUPROX

DRY COPPER OXIDE RECTIFIERS



In radio engineering circles

the widespread utilization of Faradon Capacitors is conclusive evidence of ability to deliver dependable service under all conditions.

Of course this result was not obtained over night. More than 20 years of painstaking fabrication experience with each step based on sound radio engineering data is behind it.

You are invited to avail yourself of the Faradon engineering cooperation on special applications not covered by the more than 200 types of Faradon Capacitors in regular production.

WIRELESS SPECIALTY APPARATUS CO.
Jamaica Plain, Boston, Mass., U. S. A.
Established 1907

Faradon

Electrostatic Condensers for All Purposes

2595

SMOOTH Power for Dynamic Speakers from the AC Line with the ELKON DRY Rectifier

Dynamic Speaker Series, especially designed to meet the needs of Manufacturers

THE Elkon Engineers have worked exceedingly closely with many of the manufacturers of dynamic speakers. The result of this work is an intimate knowledge of the problems of supplying smooth power to moving coils, and a complete series of rectifiers supplying just the voltage and current desired.

Already the Elkon Dry Rectifier has been specified by a majority of the Dynamic Speaker manufacturers. We would like to work with you as we have with them. Simply tell us your specifications, and we will submit a sample rectifier—May be supplied with or without power transformer.

Self healing, the Elkon Rectifiers have an exceptionally long life, are noiseless and require no attention or adjustment.

Let Rectifier Headquarters solve your problems. Send the coupon which will bring you the Engineering Bulletins on the Elkon Rectifiers and High Capacity Dry Condensers.

Radio Department

ELKON, INC.

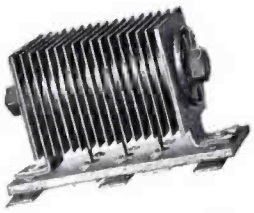
Division of

P. R. Mallory & Co., Inc.

350 Madison Ave.,

New York City

Row upon row of Elkon Rectifiers being seasoned under the careful eyes of skilled workers.



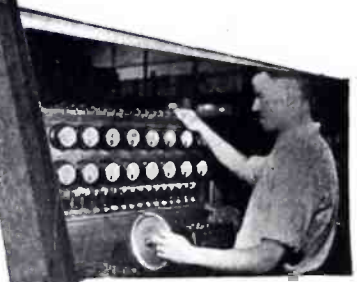
ELKON DRY RECTIFIER for "A" Eliminators

The Elkon Dry Rectifier has long been considered the ideal rectifier for "A" Eliminators. Standard equipment on the leading eliminators last year, and already specified this year by additional manufacturers.

The "A" Eliminator type is especially treated, ensuring smoothness and noiselessness. When used with the proper filter system including Elkon Dry Condensers the millivolt ripple is only from 3 to 6!

Elkon Rectifiers are Self Healing

Self healing, the Elkon Rectifiers have an exceptionally long life and require no attention or adjustments. Send the coupon for the Engineering Bulletins on Elkon Rectifiers and High Capacity Dry Condensers.



Every junction must have just the right pressure—18 meters to watch in this operation

Radio Department, ELKON, INC., Dept. E-23, 350 Madison Ave.,
Put me on your mailing list to receive the Engineering Bulletins as they are published.

.....

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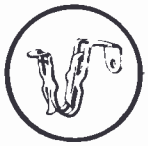
New!

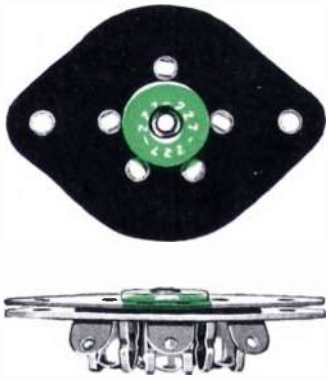
EBY SOCKET

In Colors

Illustrating the action of the guide for the tube prongs. The tubes *have* to go in *right*—no slipping or fumbling.



This is a close-up view of the new Eby double contact prong. Spring tension evenly divided between top and bottom of both sides.



Model 6 Socket is new and *much better*. Designed for manufacturers' use exclusively. Popular Eby features have been retained and new ones added.

Four different colors numbered — for identification of tubes.
Long two-sided prongs — for positive contact.
Guide for tube prongs — a famous Eby feature.
Rivet assembly — for economy.

New in performance, new in appearance — and a new low price.

NEW MOULDED TIP JACKS

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Please ship me one Model 400-A SUPREME.

Upon delivery of the instrument, I will deposit with the express agent either the cash price of $124.65 or $38.50 cash and 10 trade acceptances (installment notes) for $10 each, due monthly, at my option, subject to the following conditions:

It is agreed that the deposit made with the express agent shall be retained by him for six days. If, within that time, after testing the instrument I am not entirely satisfied, I have the privilege of returning the instrument to the express agent in good condition, with the seal unbroken (see note below) and all tools and parts intact. Upon such return and upon the prepayment of return express charges, the deposit I have made with the express agent will be promptly returned to me.

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NOTE:—The seal on the panel of the instrument covers the master screw in the assembly. It is never necessary to disturb this, and it does not in any way prevent or restrict the use of the instrument. Factory guarantee ceases with disturbance of seal.

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Three Weston Meters
Mounted in Bakelite cases.

1 Voltmeter, three scales of 0/10/100/-600, 1000 ohms per volt.

1 Milammeter, of 125 mils and 2½ amps.

1 A.C. Voltmeter, three large scales of 0/3/15/150.

All instruments are manufactured for 110 volts and 60 cycles. Instruments for other voltages or frequencies can be furnished special at slight increase in price.

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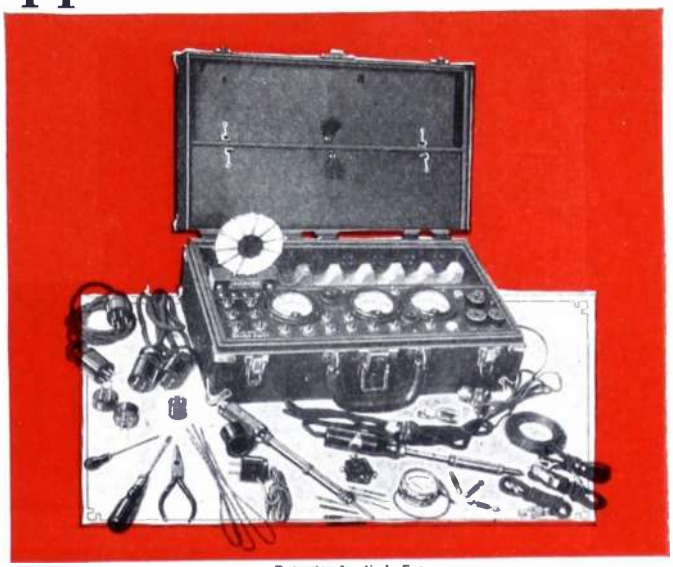

Patents Applied For

Makes every conceivable test on any Radio Set~

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Tubes, power units, loads, breakdowns, voltages, all instantly analyzed, peaking condensers, also modulated radiator. Everything you have ever hoped for is there, all contained in one compact instrument.

The only self-rectifying oscillation tester in existence.

The exact working conditions of any tube from 1½ to 15 volts, including screen grid, heater type, and rectifier tubes, are shown by meter readings; the only service instrument that shows output of rectifier tubes on meter.

The oscillation tests from alternating current are made possible by the exclusive self-rectifying SUPREME Power Plant. Every radio engineer and service man will appreciate this feature.

The SUPREME radiator sends out a modulated wave. Simply plug into A. C. line. No more wasting valuable time on broadcast stations; always at your service and finer adjustment assured.

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The SUPREME heavy duty rejuvenator provides scientific method of rejuvenation of any thoriated filament tube. Will reactivate up to 12 tubes at one time without removal from set. Push a plug—the SUPREME does the rest.

The SUPREME will give direct reading of amplifying power of tubes and will show actual working condition of all tubes.

The SUPREME will play radios with open transformers and will give condenser, choke coil output and capacity output on radios not wired for that purpose.

Access is provided to all apparatus through pin-jacks. Will test condensers for breakdown. Contains various fixed condensers from .001 to 2 mfd., a 30 ohm rheostat, a 500,000 ohm variable resistance, and an audio transformer, for instant use and various combinations.

It will give plate and filament voltage readings with or without load; will test voltage and current of all radios, including those using tubes such as 210 and 250. It will give grid circuit readings up to 100 volts; plate voltage readings up to 600 volts; will test output of trickle chargers, or any output up to 2½ amps.

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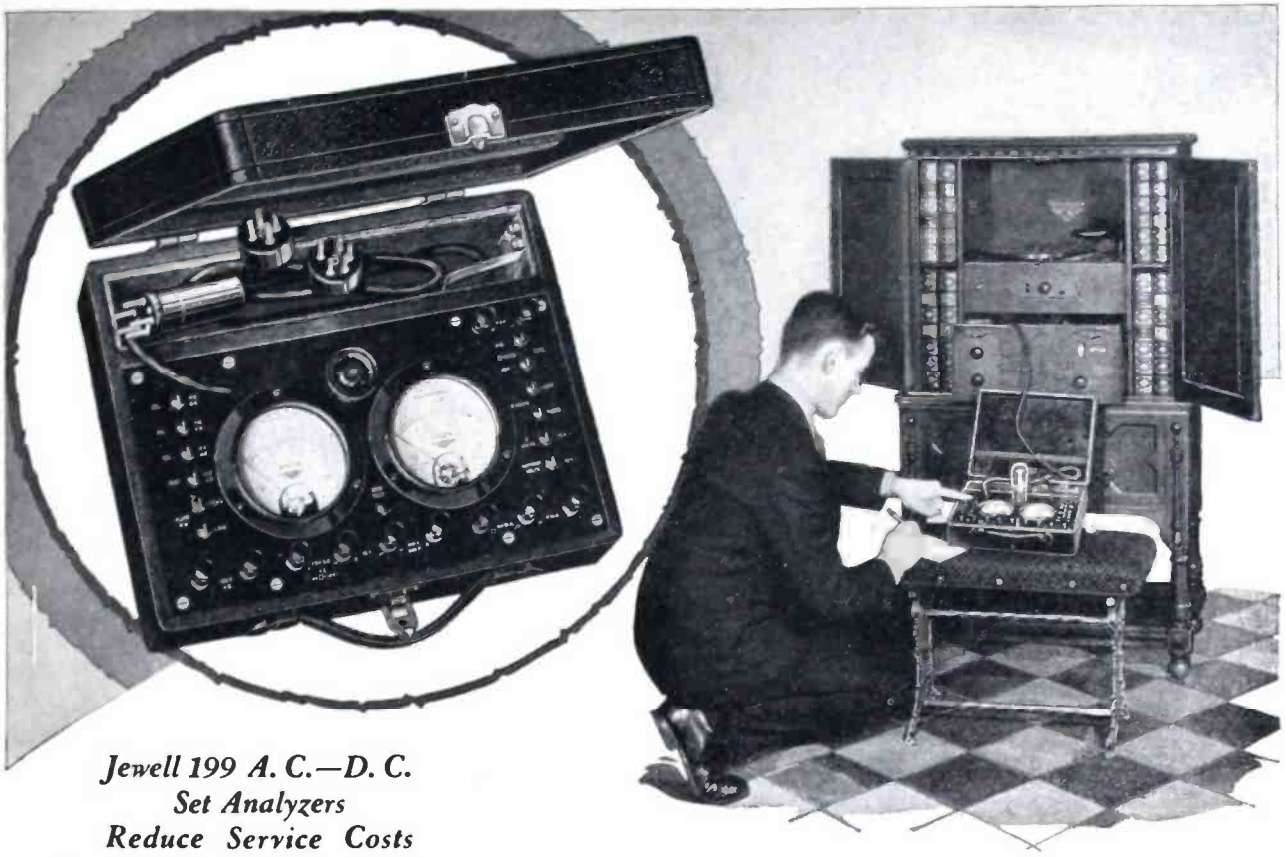

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Reduce Service Costs

This efficient radio service instrument quickly locates set troubles. In the Jewell Method of Set Analysis the convenient 5 prong plug or 4 prong adapter is inserted in the tube socket and the complete electrical operation of each stage is thus quickly and accurately checked.

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Every Service Man Should Have a Jewell 199 Set Analyzer

The Jewell Method of Radio Set Analysis enables service men to locate receiver troubles quickly and with unerring accuracy.

The systematic manner in which tests are made and readings recorded with the Jewell 199 Set Analyzer inspires the confidence of customers.

The accuracy with which radio troubles are diagnosed and eliminated by the Jewell Method assures the customers' satisfaction and good will.

A Jewell 199 Set Analyzer in the hands of every service man is an invaluable foundation for profitable radio business.

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Write for information regarding this "service man's friend," today. Mail the coupon.

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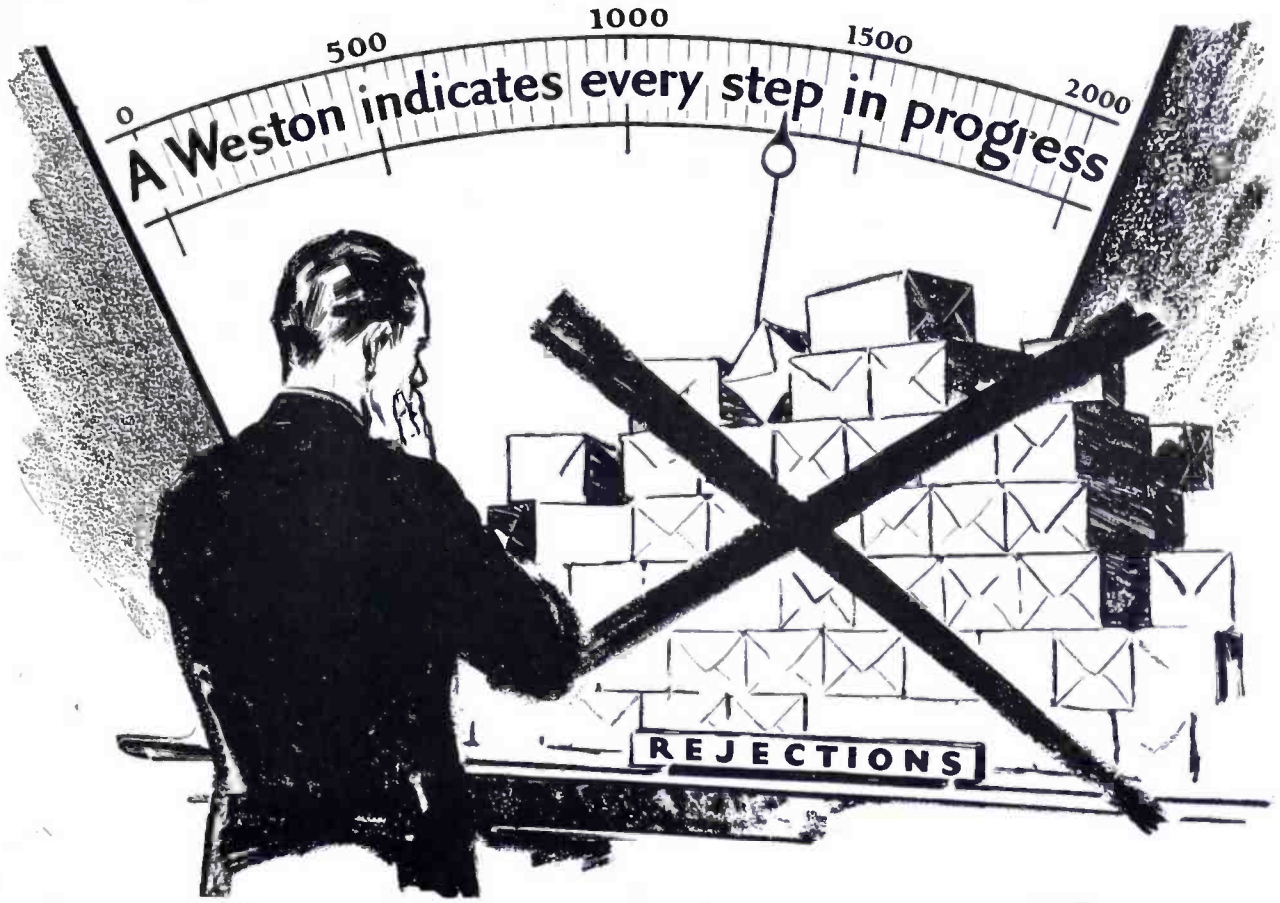

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"REJECTIONS" offer a grave problem to the manufacturer of electrical products. They exact a heavy toll from your business whether your inspections bring them to light on the floor of your plant or your customers create them in the form of goods returned.

And this one thing is certain: the men in your plant held responsible for the quality and performance of your products cannot ensure the production standards and accuracy which protect your guarantee unless given the proper equipment for accurate testing at various stages as the flow of production progresses.

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But make certain that "Westons" *are* employed throughout your plant — that only the world's highest standards of accuracy are selected for routine inspection tests which safeguard your profits and your business prestige. Our engineering and sales offices, each with its instrument specialists, are located in all the principal cities of the world. Ask them to make a survey of your requirements. They are prepared to give you prompt and authoritative counsel on any testing problem.

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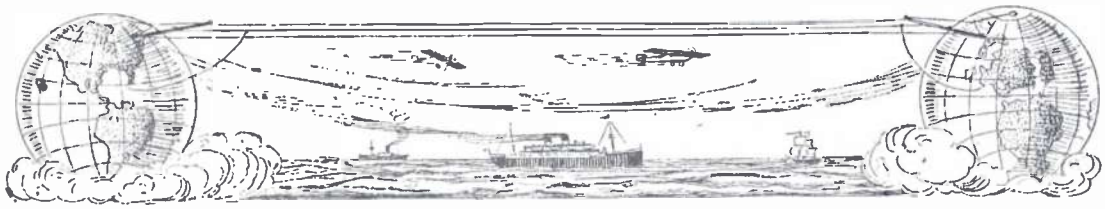


Broadcast Reception Trends for 1929

A General Survey of the Progress in Engineering Design and Standardization

By Austin C. Lescarboura, Associate Editor
Mem. I.R.E. Mem. A.I.E.E.

SOMEONE, obviously possessed of a fine sense of humor, has said that the real purpose of the R. M. A. Trade Show is simply to present any sort of an exhibit purporting to be the season's line, to look around and see what the other fellows have, and then to rush back to the drafting room in order to develop the real line of the season.

Perhaps the same spirit animates the answers the author has received in his quest of advanced engineering data regarding broadcast reception trends for 1929. Practically every manufacturer has gracefully sidestepped the request, either by dealing in meaningless generalities, or pleading inability to answer at the moment. However, in order that all may be merry by learning just about all there is to be learned from the other fellows, the author takes pleasure in presenting the findings of a general survey.

No Fundamental Changes in Circuits

From all indications, the 1929 season will feature the established forms of tuned radio-frequency circuits as well as the superheterodyne circuit. There are certain to be important minor refinements, however, mainly by way of increased selectivity. It is a fact that some of the best radio sets available have failed to provide the necessary signal separation in many localities, and this accounts for the sudden liquidation of many sets when they should be at the very height of popularity. The Federal Radio Commission has indeed placed a tough problem before the radio engineering group in the present wave length allocations, and far more intricate circuits are required where considerable congestion exists. In some instances this increased selectivity is being met by introducing additional tuning condensers and loose couplers, while in others the band selector method of tuning is being followed.

It cannot be denied that the superheterodyne circuit at this time is more attractive than ever, with its selectivity ratio of anywhere from three to one up to eight to one, as contrasted with the better radio-frequency receivers. However, inasmuch as this circuit is being kept for the exclusive use of the Radio Corporation of America, so far as regular production sets are concerned, there is only minor interest in superheterodyne operation so far as the engineer is concerned. Incidentally, the superheterodyne has been vastly improved from the standpoint of lay operation, with the changing of the intermediate frequency from 45 kilocycles to 180 kilocycles. This change has eliminated the troublesome mirror frequency effect which made itself obvious in former superheterodyne radiolas by tuning in a given station at two different points on the dials, and which also called for two separate controls, even though in many instances these might be worked as one. The present superheterodyne radiolas have but a single control, and tune in each given frequency at but a single point on the dial.

New Tubes in Sight

The year 1929 will feature the 227 or A. C. heater tube as the general purpose tube, taking the place of the 226 or A. C. filament tube. From the beginning of A. C. tube technique, it has been generally recognized that the heater type was by far the best practice, yet the many difficulties and disappointments encountered in producing a satisfactory heater tube were such that manufacturers naturally sought to use a minimum of this type and a maximum of the relatively foolproof filament type. During the past six months the remaining problems in heater tube design and construction have been mastered, so that satisfactory tubes are now available. As a result, many radio set manufacturers are counting on using all heater-type tubes with the exception of the rectifier tube and possibly the power tube. In short, this will be a 227 tube year.

Of course, the A. C. screen-grid tube is being talked about. Several manufacturers have planned to make use of one or more of these tubes in their set in order to obtain the enormous amplification of which such a type is capable, together with the automatic prevention of oscillation. However, in our modest opinion, this is perhaps a bold move—from the standpoint of rushing into mass production. It is quite one thing to use a brand new type of tube in an experimental set or again in a kit, but it is entirely another matter to build commercial sets around a new and relatively untried tube. There is no telling what may happen, for tube manufacturers are by no means infallible. They too make mistakes. They become highly enthusiastic with a new design. They send carefully made samples to set manufacturers for test and experimentation. And then, having found a good response, they engage in volume production, only to run into no end of grief. It is our prediction—and we happen to know quite a bit about vacuum tube production—that the A. C. screen-grid tube is going to prove a Tarter. There is so much metal in this type of tube that there will be considerable trouble from gas. The intricate assembly is going to mean high cost, and this, added to high rejections, is going to spell high selling prices. Our opinion is that the A. C. screen-grid tubes must sell for at least $8.00 each for the vacuum tube manufacturer to come out whole and perhaps he will not even prove that lucky. Hence it would be our modest suggestion that the A. C. screen-grid tube be not taken too seriously this season, giving the vacuum tube makers enough time to iron out the many wrinkles confronting them.

In our travels about, we have been shown sample sets employing one, two and even three A. C. screen-grid tubes. Of course, from a merchandising standpoint, this is perhaps good business. There is nothing that sells better than being the first with a brand new idea. Yet from the standpoint of servicing, we sense no little grief in sight, for the A. C. screen-grid tube is going to travel a rough road for a while—unless tube manufacturers have kept it back long enough to have it fully refined. We recall the grief encountered with the D. C. screen-grid tube. It is no secret that such tubes have proved quite uncertain. Some are good, some no good, from the moment they are taken out of the cartons. Others last for about 50 hours, while still others perform for a few hundred hours. In fact, it is much the same story of the old 199 tube all over again—and no

one in the industry is looking for that sort of history repeating itself in this day of radio prosperity.

Of greater and safer interest is the new 245, A. C. heater tube, which will be a power tube fitting in between the 171-A and the 250. From what we are told, it is a really good tube, well designed, with a long life. This is welcome news. In the first place, it is no secret that the 171-A tube was a sad mistake. It should never have been introduced. While there may have been some justification for the reduced filament current consumption on battery operation, or again the matching of the 201-A current drain in series-filament circuits, the fact remains it has been a bugbear to tube makers. The delicate oxide-coated filament has resulted in a high shrinkage in production, together with disappointing results in practice. No, the 171-A can hardly be called a shining success, although we have lived with it for a year past. Some sagacious tube manufacturers have very wisely used heavier filament, making an improved form of 171 or ½ ampere tube. This has been employed with excellent results in the average A. C. set without anyone being the wiser. And so in the 245—which we understand will be the number—we shall have a brand new deal for our power stage.

There are rumors of entirely new tubes with triple and quadruple grids, but these we need not take seriously for the present. The industry has enough new material ahead to work in peace and harmony at least through the coming year.

The Power Pack

One of the amazing successes of radio engineering has been scored in the power pack end. It seems only yesterday that no end of trouble was experienced with broken-down filter condensers and resistors, yet today the better type receivers go out in a steady stream with virtually no service calls because of power pack defects. The only cases where trouble has been reported is where manufacturers have failed to employ good condensers or resistors, or again where they have shamefully overloaded these components. There are instances where power packs are made with such small condensers that the original sections simply cannot stand up for long, while it is quite impossible to obtain replacements that will last any longer. However, such instances are fortunately rare.

Whatever trouble may have been experienced with resistors, particularly in the early days of socket power operation when the power pack was called upon to operate a wide range of receiving sets, and therefore had to make use of variable resistors, has been overcome. Today the tendency is to utilize fixed wire wound resistors throughout, since it is a matter of mathematical certainty as to the exact resistance values required.

The one remaining problem regarding the power pack has to do with line voltage variation. While we have seen the very positive statements issued by scattered electric light companies, asserting that they maintain their line voltage exactly at 110 volts with perhaps just a rare shade above or below, we have also seen and taken line-voltage readings over the very same systems, with an entirely different story to report. Obviously, the voltage reading at the power house means nothing. Neither does the voltage reading in the city districts mean much. Out in the suburbs and even farther out into the rural sections, the line voltage is about as certain as a wild-cat mining stock quotation.

This year there will be introduced several ingenious forms of real line-voltage control devices—not mere fixed resistors, which accomplish nothing more than to save the tubes from excessive voltage; nor again manually-operated resistors. We refer to the self-compensating or ballast type line-voltage controls now available, which will be employed either as an integral part of the well-engineered radio power pack, or again as an accessory. Surely the usual "high-low" switch or terminals on the usual A. C. set will not do.

Automatic Volume Control

Several sets have already appeared with the automatic volume control feature. This is little more than an additional tube which takes part of the carrier energy built up by the radio-frequency amplifier, rectifies it, and impresses the resultant D. C. voltage as a variable grid bias on the radio-frequency tubes. In this manner it becomes possible to have a uniform voltage impressed on the detector, therefore obtaining a practically uniform signal strength irrespective of variations in the antenna signal voltage. Of course, when a signal fades badly, the automatic volume control merely raises the noise background so as to compensate for the signal. Nevertheless, the device is extremely desirable in the better grade of radio sets, particularly since the operator can set the volume for any degree desired, knowing that it will be maintained irrespective of fluctuations in the station's signals or even in going from one station to another. Frankly, it is a treat for sore ears.

And a Better Manual Volume Control

Even in the matter of a manual volume control, it appears that more attention will be paid to this feature during the present year. The usual volume control is usually a grid bias adjustment on the R. F. tubes, or again a filament or heater control. In either event, while serving as a volume control in a sense, this is not a true volume control. It is really a sensitivity control. Certain manufacturers have worked out ingenious logarithmic variable resistors which are inserted in the antenna circuit and serve to vary the volume in proper progressive steps, which cannot be achieved with a uniform variable resistor. It is our personal opinion that a good volume control is an absolute necessity, and that it should preferably have nothing to do with the sensitivity control. True, it may introduce an additional control, but even so, it is worth while.

While dealing with volume controls, it occurs to us too that the question of remote volume control is one which is certain to come up for consideration sooner or later. If we were still working with separate receiver and loud-speaker, instead of with the self-contained radio set, there would perhaps be a greater acceptance at this time for the remote volume control. Nevertheless, to make the average radio set complete, it is necessary to have a remote volume control at the finger tips of the listeners. This may be in the form of a suitable variable resistor, with a long connector cord leading to a jack in the set. It is available when necessary—and what a boon in cutting down the volume temporarily when someone is called to the 'phone, or again when the conversation picks up for an instant and the radio entertainment can be temporarily subdued. A relatively inexpensive feature, but one which may become a big talking point in a highly competitive market, where standardization of essentials at least calls for striking originality in details.

The Question of Tone Quality

Marked strides have been made of late in the matter of tone quality, although the author seriously wonders whether many of the designers are not tending toward an exaggerated bass note reproduction. In other words, set after set appears to have a deep, tubby boom, particularly when the dynamic type loud-speaker is employed. Many designers make no bones about cutting off the higher frequencies. Some cut off at 5,000 cycles, while others claim they cut off as low as 3,500 cycles. Such practice is usually claimed to be justified on the basis that the higher frequencies are quite unnecessary, since they contribute nothing to the rendition. It is also claimed that the higher frequencies are not being broadcast. Nevertheless, anyone who has an audio amplifier and a loud-speaker capable of reproducing the higher frequencies, and makes a direct comparison with some of the present receivers with their tubby dynamics, will at once note the sparkle, crispness and refreshing tone which is only possible with the higher frequencies. Particularly for plain speech, the higher frequencies are essential.

It is the author's humble belief that the present frequency cut-off practice is deplorable. Some may claim that paper rattles occur when the higher frequencies are being handled. If so, there are better materials for diaphragms than paper, and these should be used. Some may claim that the inclusion of the higher frequencies may emphasize static. This is true, yet we hardly believe this justifies the sacrific-

ing of the sparkle and refreshing tone during the many months of very little static. Furthermore, with the general high signal level obtaining in most localities, the amelioration of static has been realized in the only practical way we now know of—at the transmitting end.

And so we look forward to more and still more treble effects, quite as well as the hard-worked bass notes. While our radio rendition gained much as we dug down into the lower frequencies, we frankly lost out when we began chopping off the higher frequencies. Both extremes are necessary for good reproduction.

Why Not a Tone Control?

Perhaps the ultimate ideal will be a variable tone, matched to the program and to the musical tastes. For several years the author has argued in favor of a tone quite as well as a volume control. Please note, they are by no means one and the same thing, although the radio trade has spoken loosely of volume and tone controls so that they have become interchangeable expressions among the uninformed.

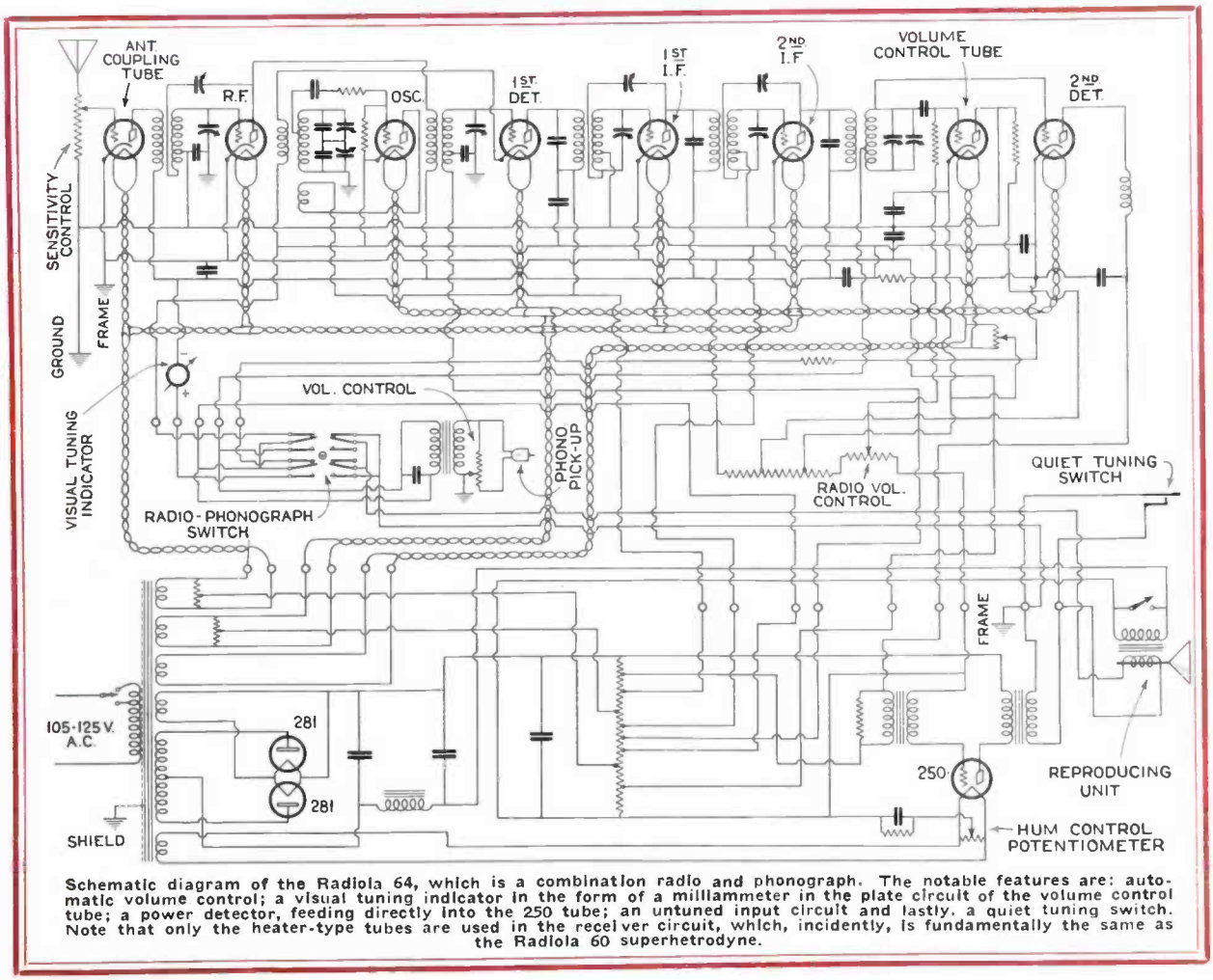
The volume control increases or decreases the entire output of the loud-speaker, but the timbre remains about the same. The tone control, on the other hand, exercises little influence on the entire output, but changes the timbre. Thus it is desirable to cut down on the higher frequencies in the case of soft orchestra music for the background to the dinner conversation. In this case the music is more mellow, soothing and pleasing. On the other hand, for dance music or brass band selections, the higher frequencies are essential, for the crispness. The same goes for speech. Again, on DX reception the higher frequencies are required, for they have a greater influence on the human ear strained to catch the faint sounds.

Already we note a move towards a tone control. At least one loud-speaker manufacturer has a "condition equalizer," which adjusts the tone in three steps for best results at all times. Usually, the tone control need be nothing more elaborate than several small by-pass condensers, with a suitable switching scheme, serving to by-pass more or less of the higher frequencies before they can reach the loud-speaker. Some have tried a variable resistor in series with a ¼ mfd. by-pass condenser, the resistance serving to by-pass more or less of the higher frequencies. At any rate, we believe the tone control is going to come into its own either during 1929 or certainly in 1930. The tubby loud-speakers now in use, while they may appeal to those who have been getting their radio programs heretofore through a tin horn, are going to wear badly.

Audio Amplification

Transformer coupling must continue in popularity, although there are many indications of important modifications. For instance, the shunt feed system, well known to the average radio engineer, is gaining in popularity. It permits of a greater effective inductance from the usual transformer, and thereby does a better job on the lower frequencies. Quite a few set manufacturers are already employing this method and more are certain to follow. Incidentally, smaller and cheaper transformers can be employed to do the work of much larger and costlier transformers with the conventional coupling method.

The use of lapped transformer laminations rather than butted laminations is also going to result in saving in transformer costs, particularly as suitable assembly devices are made available for arranging the laminations in the overlapped rather than the end-to-end arrangement. The costly nickel steel heretofore deemed indispensable in the better grades of audio transformer is being dispensed with by means of lapped laminations, which



Schematic diagram of the Radiola 64, which is a combination radio and phonograph. The notable features are: automatic volume control; a visual tuning indicator in the form of a milliammeter in the plate circuit of the volume control tube; a power detector, feeding directly into the 250 tube; an untuned input circuit and lastly, a quiet tuning switch. Note that only the heater-type tubes are used in the receiver circuit, which, incidentally, is fundamentally the same as the Radiola 60 superhetrodyne.

prevent saturated transformer cores, permit of good lower frequency characteristics, and provide what amounts practically to an automatic level control.

The standard practice of a first stage and a power tube is evidently going to continue, even though certain engineers have advocated a power detector tube followed directly by the power audio stage, such as in the RCA superheterodyne circuit. The ability of the 227 tube to take a full 180 volts on its plate has made it possible to dispense with the usual first audio stage. Nevertheless, in the average tuned radio-frequency circuit, there is not the necessary voltage gain to dispense comfortably with the first audio tube, hence we shall continue with our two-stage amplifiers.

Better Hum Control

While speaking of audio amplification and tone quality, it is well to say a few words regarding hum or A. C. background in many of the present A. C. receivers. Of course the advertising literature usually stresses the marvelous silence of the background, yet set after set which the author has had occasion to test has proved quite noisy. Investigation generally discloses that in these noisy sets a center-tap filament winding is employed, instead of a hum balancing device. Sets employing a hum balancing device are generally quiet. A simple point, yet it is one that has been overlooked by many engineers, or at least they have decided in favor of the center-tap filament winding on the ground of simplicity or lower cost. Frankly, there are hum control devices now available that certainly cost no more to use than the center-tap filament winding. The adjustment is so protected that it can be made only by the testing department of the set manufacturer or again by the service man. It is our belief that hum control will be featured in 1929 efforts, for there is nothing that takes away so much from tone quality, particularly when digging down deep for the low notes, as the 60-cycle hum background.

A Tuning Meter

At least one set manufacturer has already introduced a tuning meter, which indicates visually just when the set is sharply tuned into the radio channel. This device is rather costly, as costs go in radio production, hence it is doubtful whether the idea will get very far except for the highest priced offerings which, like the Rolls-Royce, must have added talking points. Basically, the idea is an excellent one; economically, it is perhaps an unnecessary touch.

Loud Speakers

In the loud-speaker field, there is every indication that the dynamic type will continue to gain in favor, for it possesses advantages over other types. The electro-magnetic type will also be employed extensively in the less expensive offerings, although with ingenious design and mass production the price of the dynamic type has been reduced to such a low point that it seems hardly necessary to employ the magnetic type today.

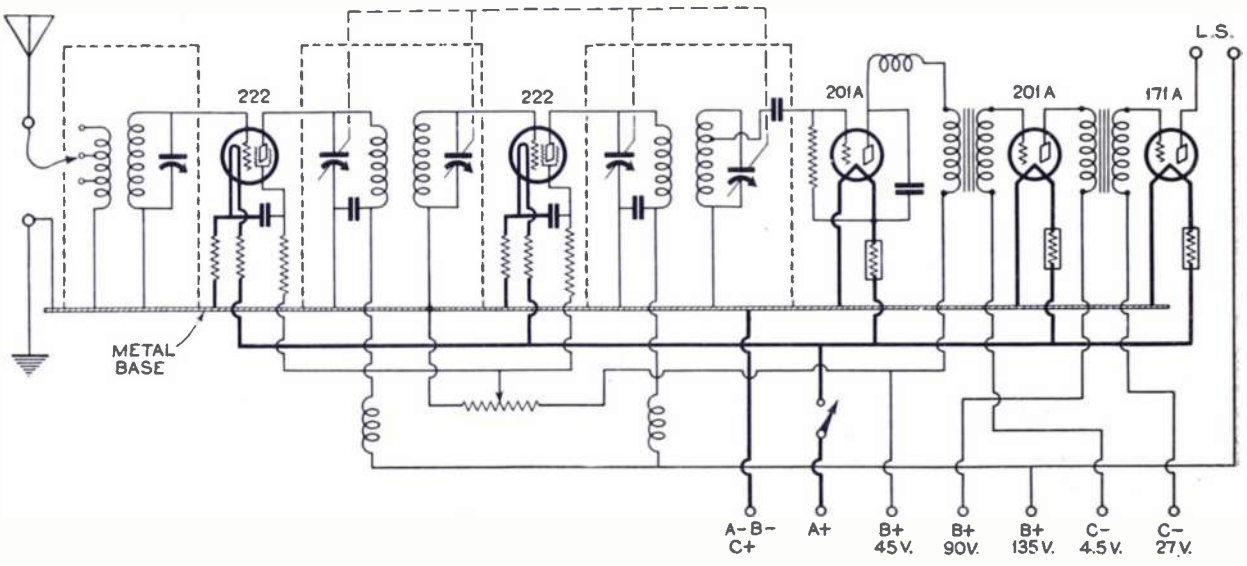
Let us not take the count so far as the magnetic type speaker is concerned. During the past few months several research laboratories have been at work on this type, with notable developments. Indeed, by a simple mechanical change, it has been found possible to quadruple the efficiency of the usual magnetic type—so much so, to be sure, that the author has found such a job almost capable of doing the work of the usual dynamic. More work along this line must lead to still better results, so we are no doubt going to have better and more powerful magnetic type speakers available during 1929.

Much has been said and promised regarding the electro-static loud-speaker, which makes use of the attraction and repulsion between two metallized surfaces, one being fixed and the other movable as a diaphragm. Without intricate mechanical driving mechanism, the electro-static loud-speaker would seem to possess decided advantages. It has, of course, in the matter of natural tone. However, when it comes down to volume and to efficiency, it is not prepared to compete with established types. Personally, the author is not prepared to take this loud-speaker innovation seriously. With 400 to 800 volts required together with large surfaces for securing a good tonal response, there will not be much call for this type for some time. Eventually, it may find some application in the home, although it is our belief that its foremost application will be in the large hall and theatre, where it can be placed against a wall, occupying a minimum of space.

Mechanical Details

So far as the mechanics of the radio set are concerned, we do not anticipate any marked change. In fact, everything tends towards standardization. Practically all sets today make use of the steel chassis, with the parts more or less entirely encased. The power plant is included in the same assembly, in most instances. Even the loud-speaker is beginning to be mounted in the same chassis, thus producing a complete job.

Certainly the idea of a minimum of different chassis which can be employed in a variety of combinations of loud-speakers and cabinets has made for the economic soundness and the unparalleled prosperity of the radio industry today. It is based on the same sound practices as the automobile industry which features a minimum of types of chassis, and a sufficient variety of body styles to meet all desires, purposes and purses.



A typical band selector circuit, with tuned plate and grid circuits, which provides a rectangular resonance curve.

Units of Electrical Transmission

*By J. W. Horton**

THE communication engineer, although he deals generally with very small amounts of energy, is frequently concerned with ratios of energy having enormous magnitudes. The ratios between the rates of energy flow in different parts of a communication system, if expressed numerically, may be quite as impressive as the figures used by the power engineer. As an example, the power delivered by an ordinary telephone transmitter is of the order of 0.01 watt. This may be used to control the output of a 100-kilowatt radio transmitter, in which case the ratio of the powers at the two ends of the system is ten million. Again it is quite possible for the energy delivered to its loud-speaker by a modern radio receiver to exceed the energy delivered by the antenna by one hundred million to one.

Because of the relations between the quantities involved the communication engineer finds it desirable in describing the efficiency of his apparatus to adopt a method differing markedly from that used by the power engineer. Until recently this method was to compare the performance of any piece of apparatus to that length of standard telephone cable which changed the amount of power delivered by the same ratio.

In making this comparison two factors must be taken into account, first the energy dissipation—or attenuation—within the apparatus, and second, the ability of the apparatus to receive and deliver energy across the junctions between it and associated circuits. To describe the performance of any apparatus, therefore, it is customary to consider the power which would be received by a given load circuit from a given generator circuit when they are connected directly together and the power received when the apparatus in question is included between them.

In the case of a length of standard cable it was assumed that the generator and receiver circuits were both long lengths of similar cable so that the only loss due to introducing the reference length was the dissipation within the reference length. Under these conditions the actual loss in a real cable when the current flowing has a frequency of 800 cycles per second is given by the expression:

$$P_1/P_2 = e^{0.218L} \qquad (1)$$

where e is the base of Napierian logarithms and L is the length of the cable in miles. From this the number of miles of standard cable which, when connected into a long length of similar cable, changes the amount of power received by the ratio P_1/P_2 is:

$$L = 4.587 \log_e P_1P_2 \qquad (2)$$

From the change in received power occurring when any piece of apparatus is introduced between given generator and receiver circuits the attenuation, or gain, of the apparatus expressed in equivalent miles of standard cable is given by the above formula.

One consequence of expressing performance in this way is that the overall value for a system is computed by adding together the values expressing the performance of the several parts. This differs from the practice of the power engineer who multiplies together the percentage efficiencies of his components.

The above method of expressing the transmission efficiency of a piece of apparatus as some function of the logarithm of a power ratio has two decided advantages for the communication engineer. In the first place it fits in conveniently with his transmission formulæ, of which (1) given above is a typical example. In the second place it is most convenient when used in connection with the sensation of loudness, which also follows a logarithmic law. This latter fact can be demonstrated by determining the amounts of energy required to give a series of sounds differing by apparently equal intensity intervals. If these amounts of energy are compared it will be found that successive values bear a fixed ratio to one another.

In spite of its convenient logarithmic character the "mile of standard cable" or "800-cycle mile" has certain disadvantages. First, it is associated with an arbitrarily selected physical cable and is significant only for currents having a frequency of 800 cycles. Second, it requires, when used in mathematical computations, the use of an arbitrary constant based on the physical cable. Because of these disadvantages an effort has been made to standardize a new unit which will be of greater simplicity. Several such units have been proposed. In Europe a unit known as $\beta 1$ has been employed for some time. Here the number of units is given directly by the natural logarithhm of the current ratio. In America the unit which has come into general use is such that the number of units is ten times the logarithm to the base 10 of the power ratio. That is,

$$N = 10 \log \frac{P_1}{P_2} = 20 \log \frac{I_1}{I_2}.$$

The European method is probably more convenient from the standpoint of mathematical computations. An immediate advantage of using the logarithm to the base 10 appears when it is recognized that the number of transmission units may be computed from the power ratio by the means of an ordinary slide rule or may be looked up in the nearest table of logarithms.

The use of the various units and their relative merits have been discussed at International Communications Conferences and it has been agreed that both shall be retained. The unit based on the logarithm to the base ten of the power ratio has for some time been known as the transmission unit (TU) for want of a more definite title. At the last meeting of the International Communications Conference, however, this unit has been given the name decibell. The nominal unit is such that the number of units is the logarithm to the base 10 of the power ratio. This has been done in order that the two units—the $\beta 1$ and the Bell—should be approximately alike in magnitude. The so-called practical unit will, however, be the decibell, which, since the number of units is 10 times the logarithm of the current ratio, is obviously one-tenth the size of the nominal unit. It has been decreed that the new unit shall be abbreviated as "db."

It was originally intended that transmission units should be used in referring to the performance of apparatus, that is, to the gain or to the loss resulting, when the apparatus was employed. Since, however, the unit is based on power ratios it is only natural that it has come to be used for expressing amounts of power. This is most frequently done by selecting, arbitrarily, some amount of power as a "reference level" and describing other amounts of power as being so many transmission units above or below this reference level. It must be emphasized that a power level expressed in this way can have no significance unless the reference power is specified. There may be as many reference points as there are systems for electrical communication. In telephone lines for example the standard output of a repeater is spoken of as "zero level" and the rate of energy flow at other parts of the system is thus referred to this level. In high quality broadcast transmission a power level of 0.006 watt has been arbitrarily chosen as zero level. Thus when we say that an amplifier is capable of delivering a "plus 10 db level" we mean that it is capable of delivering 0.06 watt. The use of transmission units in describing power levels emphasizes the advantage of using a logarithmic unit in connection with such phenomena as hearing which itself follows a logarithmic law. The practice should, however, not be carried to the point where the reference power level is lost sight of.

* *Chief Engineer, General Radio Company.*

The Importance of Scientific Research

An Engaging Discussion on General Research—With Particular Emphasis Placed on the Importance of Change in Design

*By Charles F. Kettering**

RESEARCH as a factor in industry today has assumed an entirely new place. In the old days we had hunches, we had inventors, and business was developed when, as and if a thing were made. Today we start out deliberately to develop and to do a perfectly definite thing to fulfill a perfectly definite need. The question of happenstance in development today has been removed by a very simple process.

The words, "scientific research" have been perhaps greatly abused and, therefore to enlighten you upon what we who are in the phases of scientific research think about it, I will give you our definition: A thing is scientific only when you do not understand it. As soon as you do understand it, it is no longer scientific. A research is something you can get an appropriation for with somewhat the same ease as that of an advertising appropriation.

This subject of research in engineering has been discussed a great many times. We have what is called a pure scientist and we have the commercial research men. We belong to the commercial research division. The chief and only dividing thing between those two types of activity are in the selection of the problems.

A pure scientist selects a problem which happens to appeal to him and which is so far removed from the commercial phases of the thing that he will never be checked up. The commercial fellow tries to fix what is wrong with the present-day product.

The two things lead to identical results. The only thing is that the commercial application begins to supply something long before the theoretical end is reached. The principles back of all of this have been very simple; the question of measurement, the question of invention after measurements and calculations have been made.

When you get back of the curtain on this thing called scientific research you see an interesting setup. You see a lot of highly trained men, you see a lot of technical apparatus and these are the things most people regard as the backbone of research. The chemical balance, the test tube and those things have absolutely nothing to do with it at all. All that expensive and elaborate equipment is simply the machinery for getting an idea from outside a man's head into the inside of it. We say that the more apparatus a man has to have to solve a problem the more dense is his skull.

All of these problems are solved inside of someone's mind and, therefore, all of this equipment in experimenting is simply the instrumentality of getting into concrete form in some fellow's mind what the problem is. A problem is solved when it is properly stated.

MR. KETTERING'S assertions regarding scientific research are specific in nature but general in application. We feel that his views on the subject will be of decided interest to the executives and engineers in the radio industry—our reason for injecting his discussion into foreign territory.

Mr. Kettering has an elfish way about him. His most profound statements are cloaked with a pleasant humor. We have not been able to detect any trace of specious reasoning, however.

We wish to call particular attention to his statements regarding the element of change. This is a matter of great importance to every industry.—EDITOR.

Why Research?

Why do we want to research? Two things, as I said. We are trying to fix what is wrong with the present-day trend and, therefore, one of the ways to approach and analyze the problem is to write down what is wrong with the thing you are doing or what is wrong with the article you are making. Maybe you cannot fix them all at once. Write down ten things that are wrong with it and that is enough for one day. It may take you ten years to fix it, but until you know and recognize that there is something wrong and that it needs to be fixed you have to understand that you have no crystallizing point around which information and facts will flow to help you crystallize that.

Back of all this talk as to whether research pays I was asked the question, one time, of what right a research man had to exist. They said, "You fellows are the great nuisances of commerce. You are continually changing what was a good product last year into an uncertain product tomorrow."

We have a reason and we have an answer for that question. It is a justifiable question to ask and it is also one which deserves a thoughtful answer.

A banker friend of mine told me this story. He said, "Two days ago I drove home in an automobile which was a very good machine. In fact, my chauffeur commented upon how good the machine was and how well it stood up."

He had thought it was good for a couple of years at least. He then continued: "That night when I went home there was an engraved invitation on my library table to view at a special showing—*where the whole town was admitted*—a new line of automobiles. I went down there and I looked at them. I was very much impressed with them, but they wouldn't allow me enough for my present car." (That seems to have been the problem in the automobile business for sometime back.)

He said, "I didn't buy one, but the old car didn't ride as good as it did last night when I went home in it."

I said, "What are you going to do about it?"

"I suppose I will have to buy a new automobile and take the loss," he replied.

"You are a banker and the word 'loss' means something definite to you. You will not take a loss when you buy the new car. You will take a gain. You say that research in engineering has depreciated the car which you have? You must admit that nobody has touched the car. We haven't scratched the paint, we haven't damaged the crankshaft and we haven't punctured the tires; we have done nothing to the car. If that car is less valuable to you today than it was yesterday something must have changed, and that change has been on your mind. You will not take $200 depreciation on your automobile but you will have paid $200 for a mental appreciation of what you can have."

In other words, we had increased this man's wants for something instead of supplying needs. Consequently the whole subject, then, of research goes back to this fundamental principle, *to make everybody reasonably dissatisfied with what he has got.*

Quantity Production

The question of quantity production is a new factor, but it is rapidly solving the question of supply and demand. The thing that we are trying to do is to get industry at large to recognize that the volume of business in dollars and cents is not a measure of prosperity at all, but that the measure of prosperity is the flow of useful ma-

* *Vice-President, General Motors Corporation and Director of the Research Laboratories.*

terial through the channels of trade. Therefore, if those useful materials do not flow through the channels of trade, the money will not flow back to the counting line.

The fellow who is satisfied with the automobile which he has, who is not willing to pay $200 for more, that is, the appreciation of his mental attitude, says, "I am satisfied. Nobody makes a new automobile, nobody cuts new timber and everybody stays put."

That fellow thinks he has saved $200, but he hasn't because of the fact that the minute the commercial activity slows down one enters into the thing called cut-throat price competition and the reduction on the return on capital goes down in proportion. Therefore, as long as you are supplying people with what they want, as long as you are developing their mental attitude towards the thing that they would like to have, then everyone is making a tremendous amount of progress.

Always the New

Years ago changes on automobiles were made regularly every ten cars but finally the expense of that got too great and there was talk. The factors said, "It costs too much; we don't want to change." Consequently the automobile business slowed down as far as changes were concerned and everybody said, "We are going to stay put because it is too dangerous to make a change."

The engineer said, "We can fix that. We can design this thing and run the test and prove the thing and give you a car a year before you need to put it on the market and you can study its manufacture and everything else. You can't tell what they are going to want next year. You can't furnish it if you are not going to try to find out why they might want something."

We started out to try to project what people might want in an automobile. You can see the trends, where they have come from and these trends are not very likely to have sudden ruptures one way or the other.

So the research end of an industry is the more advanced side of engineering. We are simply not interested in the automobiles that are built today or are going to be built next year or the year after; we are interested in the automobile that is going to be built in five, ten, fifteen or twenty years from now. The reason we are so interested in those automobiles now is because some of the problems that have to be solved between now and the next fifteen years must be started immediately. It means a hand-to-mouth existence if we don't start them now—just like it used to be.

We started to research fourteen years ago on something that today is an accepted principle—only two years ago. That thing is the first stage of a research that will continue for the next fifteen or twenty years and be a complete revolution, a complete change in what we know regarding combustion gasolines, and so forth. It is going to change the picture for the reason that we had to start years ago to work out a few fundamental principles and make a few measurements. Why didn't anybody do it before? They said you couldn't measure that thing.

We couldn't do that fourteen years ago and we finished an instrument three months ago, after working on the thing that measured the quantity in connection with the combustion engine when they said it couldn't be measured.

If you say it can't be measured, what steps in in place of that? Everybody's guess and everybody's opinion.

CHARLES F. KETTERING

We put up a motto on the wall in the Research Laboratory which read, "Opinions will only be tolerated in the absence of facts."

The Practical and the Theoretical

Everybody gets a research hunch. The company decides to hire the best fellow obtainable for research work. They think that Professor XYZ at the University of W. is good, so they get him. They throw him into the thing and give him a laboratory and he starts, and the first trouble that they get into is down in the foundry.

This fellow goes down there and begins to use some chemical or physical terms that the practical foundry man doesn't understand and he says to the boss, "Keep that guy out of here." He will also say, "He doesn't know anything."

The boss says, "Well, he does. He is a very highly educated man."

Finally they let Professor XYZ do the work and they ball up the foundry and spoil everything else that is in there and then out goes research. It is typical history and has been written in thousands of chapters exactly alike.

What was the trouble there? The trouble was they had no business to let that fellow go into the foundry in the first place and in the second place, they ought to have had him ten years before. There is where the difficulty comes in. You can't expect to start research today and get results tomorrow. Too many people have started what is a research division and canned it out before the thing got acclimated. You must know first what you are trying to accomplish and then remember that it takes time to do these things.

There are two important factors that we must recognize in every business whether it is research, engineering, advertising, or anything else, and that is the universal law of change. That is one unalterable law, yet human nature, by virtue of something, wants to always stay put. Why it is that the human mind should want to react to the most powerful law in the world, which is the law of change, it is hard to say. It is just as powerful as the law of gravitation. You can't get a guy to jump off the top of a building without his being drunk. Normally he wouldn't do it because he knows he will get hurt.

Change Factors

Can you get any number of people to defy the law of change with the idea that they can get away with it? You can't.

Here is the reason you can't get away with it. There are certain numbers of units of change in every unit of time, whether that unit of time is a minute of what not. If you hold your breath for three minutes, you will have a change. It might be a week or a month or a year or a decade, or any old length of time, but there is a perpetual condition of change. Therefore, the important thing is to recognize those change factors which come into your industry and to use them in phase with the time in which they happen. If you try to postpone them, you have to take them up later on. If you try to use them in advance, you get into another kind of trouble. One of the great problems of research is to analyze the current type of changes, when they are due, and when it is necessary to meet payment on them. You have to be studying this thing in advance.

Here is the reason for it. The day a fellow is born every fellow in the world was older than he was. The next year two and a half million people were younger than he was, and the next year 206½ million were younger, and at the end of twenty-five years, half of the people or more are younger than that fellow because the average life of a human being is fifty-four years.

We learned from the older people, when we were kids, and finally we keep straight ahead, but after we pass the thirty-year mark we are learning nothing up there.

Turn around and look back the other way and then you will see why you have to have change.

Height of Airplane Above Ground by Radio Echo*

The Description of an Improved Form of Radio Altimeter Which Can Serve a Number of Purposes

By E. F. W. Alexanderson

ONE of the most important aids to navigation of the sea is depth sounding. By means of his soundings and his chart the sailor can usually find his way in foggy weather. We are told that a corresponding aid is needed in aviation and many suggestions have been made. One of these proposals is to make use of the echo or reflection of a radio wave. Depth and distance measurements are sometimes made by sound waves in water and in air. In that case the time is measured for the return of the reflected wave. With radio waves travelling at the velocity of light, this time interval is extremely short and indirect methods of measurements must be adopted. I am going to describe one such method that has proven successful.

Reflected Radio Waves

If we decide to measure the time interval in units equal to the time of one oscillation or cycle of the antenna current, the time interval of the echo is equal to the number of wavelengths the reflected wave has travelled on its way from the antenna to the ground and back again. If this distance is varied by an amount which is a fraction of a wavelength this variation will manifest itself in a variation of phase of the returning wave relatively to the phase of the transmitted wave. If the distance is varied by an amount of several wavelengths then the phase of the returning wave will go through the corresponding number of cyclic changes of phase. Thus if we have means for ascertaining the phase of the returning wave and are able to count the number of cyclic changes, we are thereby able to make absolute measurements of the height over ground.

The problem thus resolves itself into finding means for detecting the phase of the reflected wave in relation to the transmitted wave. A direct measurement of phase under these circumstances is difficult and we are therefore taking advantage of a fact which we discovered during tests made from an aeroplane, that the reflected wave modifies the frequency of the original wave. This change in frequency is dependent on the strength as well as the phase of the reflected wave. These cyclic changes in frequency are used to detect the phase of the reflected wave. The cause for these changes of frequency will however, need some further explanation.

Ordinarily, we assume that the frequency of an electrical oscillator is determined by the inductance and the capacity of the circuit, in the same way as the frequency of a mechanical oscillator is determined by the inertia and the restoring force. From these considerations we are tempted to draw the conclusion that the transmitted wave has the natural frequency of the antenna and that the reflected wave which has the same frequency as the transmitted wave, will only modify the phase but not the frequency of the original oscillations. This conclusion is however a fallacy as we discovered when we started to make practical tests. The reason for this fallacy is that an oscillator will swing at its natural period only when the restoring forces which are contained in the oscillator itself are the only ones that exist. When the oscillator is acted upon by forces from outside, these forces may add to or subtract from the inherent restoring forces. It is, however, the resulting restoring force which determines the actual period of the oscillator. Thus if the force coming from outside is in phase with the inherent restoring force and increases it, the oscillator will swing with a higher frequency, and conversely, if the force from outside is in opposition to the inherent restoring force, the oscillator will swing at a lower frequency. This relation between the phase of the force impressed upon the oscillator from outside and its actual frequency can be demonstrated with mechanical as well as electrical models.

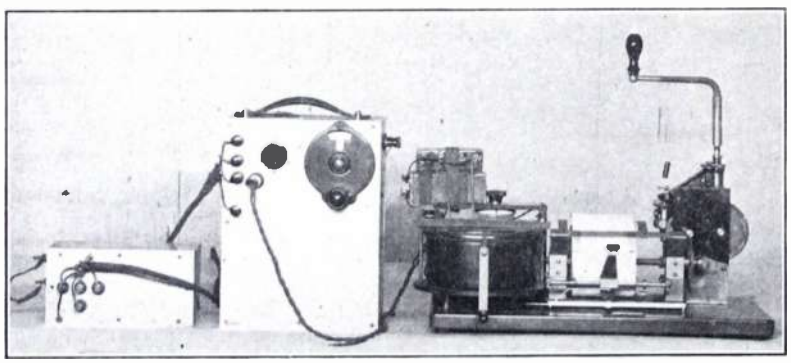
Practical Application

As soon as it is understood that the cyclic change of phase of the reflected wave manifests itself in a corresponding change of frequency of the antenna oscillator, a basis has been established for the design of a practical altitude meter.

The object is to measure the distance that the reflected wave has travelled when it returns to the antenna. This distance may be measured in two ways, by the strength of the returning wave which in its turn determines the amount of frequency change; and by the number of cyclic changes in phase which the wave has passed through before it returns. The indications may be oral, graphic or visual or in the nature of a warning which would call the operator's attention when certain limiting values had been exceeded.

In the measurements so far made, we have used an instrument that traces a graphic record of the frequency variations. Quite a number of such records have been taken. Up to altitudes of 4000 feet the cyclic nature of the frequency variations is unmistakably shown by the record. Observations were also made on a barometric altitude meter and the observations were written down on the graphic record, during the progress of the flight. We have thus observations of altitude by two independent means set down side by side on the graphic record. The barometric log gives altitude over the starting point whereas the radio echo log gives actual alti-

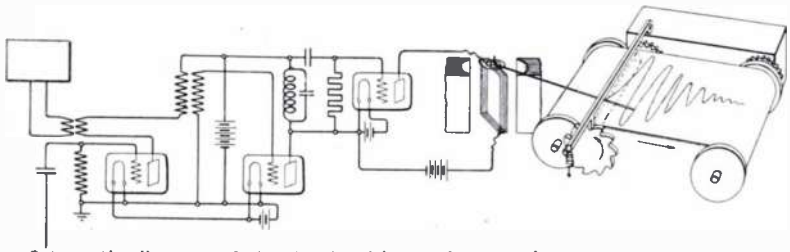
* *Paper delivered by Dr. E. F. W. Alexanderson, Consulting Engineer of the General Electric Company, at Autumn Meeting of National Academy of Sciences, Schenectady, N. Y.*



View of the combination receiver-oscillator and mechanically driven tape recorder employed for obtaining altitude readings. The records indicate the altitude of the plane from the surface of the earth rather than the sea level.

tudes over the ground. The results should therefore not necessarily be identical., The agreement of the general shape of these curves is however quite convincing that we have in the radio echo a basis for absolute altitude measurements of height over ground.

How this principle may be best applied for practical aerial navigation we are not yet able to say. Continuous graphic records may be used on larger craft and it may thereby be possible to positively identify the course flown with the maps and previous experience. Such graphic altitude logs may also be used for surveying.



Schematic diagram of the "radio altimeter," which includes a receiver and an oscillator. The variations in the plate current of the last tube operates the galvanometer recorder.

Further Possibilities

A very desirable development will undoubtedly be an instrument which permits of positive determination of altitude over the ground at any time desired.

Some suggestions of how this can be accomplished may be sufficient at the present time. Suppose that an aviator is flying in a fog and he wishes to reset his barometric altimeter for the actual level of the ground. The navigator will put the graphic radio echo meter in operation and start to climb. The amplitude of the wavy line will give an immediate indication of height over ground but he may desire a more accurate determination. Let us then assume that he can change the wavelength of the instrument 8% by pressing a key. By periodically pressing the key he may then trace two graphic curves one at 100 meter wavelength and one at 92 meters. The phase relation of these two curves will be clearly shown by the record. If the two curves are in phase it means that the distance travelled by the echo wave may be measured in exact whole wavelengths for both frequencies of the transmitter. Thus the 100 meter wave may have travelled 12 wavelengths and the 92 meter wave 13 wavelengths. In this case the distance over ground would be 600 meters (2000 ft.). If on the other hand the cyclic variations of the two records are 180 degrees out of phase it may be concluded that the altitude is either 300 meters (1000 ft.) or 900 meters (3000 ft.). The amplitude of the echo indication will indicate with sufficient accuracy which of the two figures should be accepted.

A definite calibration of the barometric instrument with reference to ground may therefore be made at 1000, 2000 or 3000 feet altitude.

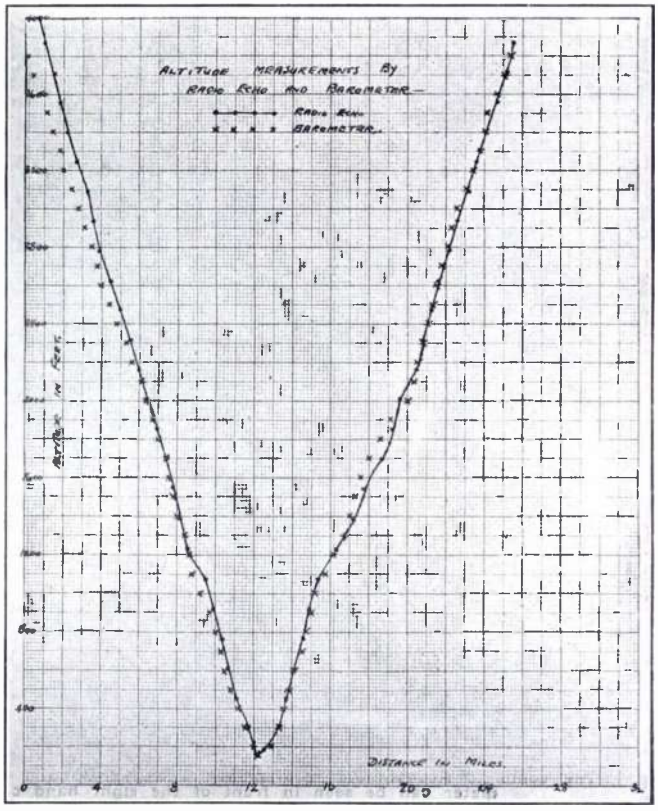
Application of Beat Frequency

Another suggestion for the development of direct indicating instruments is to use two antennas with an oscillator in each antenna. One antenna may have a wavelength of 10 meters and the other 11 meters. The beat frequency between these two oscillations is detected and observed. This beat frequency will be of the magnitude of three million cycles but the frequency will change cyclically when the plane changes altitude. It will pass through maxima when the echo wave tends to decrease the frequency of the eleven meter oscillator at the same time as it increases the frequency of the ten meter oscillator. The maxima of the beat frequency will occur at heights of 25 meters (80 ft.), 75 meters (240 ft.), 125 meters (400 ft.), etc. Such a scale of indications may be a guide for landing in fog. For instance, the next strongest and the strongest maximum may light a green and a red lamp at respectively 240 and 80 ft.

Indications for Landing

If the oscillators are set with an interval of 2% instead of 10% a scale of maxima is obtained where the steps are five times as large. The strongest maximum will thus be at 400 ft.

These two scales may be used in succession during a landing in fog. The green and red lamps at 1200 and 400 ft. for the approach and the same indications repeated at 240 and 80 ft. for the final glide. A third scale may then be established by measuring the radio frequency of one of the antenna oscillators which will pass through maxima at 45 and 15 ft. It is assumed that other radio indications are given to determine the position of the landing fields. Such signals may be received by the same radio set as the altitude indications and may be brought to the attention of the pilot by sight or sound without interfering with operation of the altitude indicator. If these radio indications of height and position are combined with a mechanical landing device touching the ground at 10 to 15 ft. it is conceivable, at least we are told so by our associates who are skilled aviators that safe landings may be made in fog without any vision of the landing field.



Representative set of altitude readings taken in an airplane equipped with a barometric altimeter and the "radio altimeter" described in this article. Note that the readings differ somewhat at high altitudes.

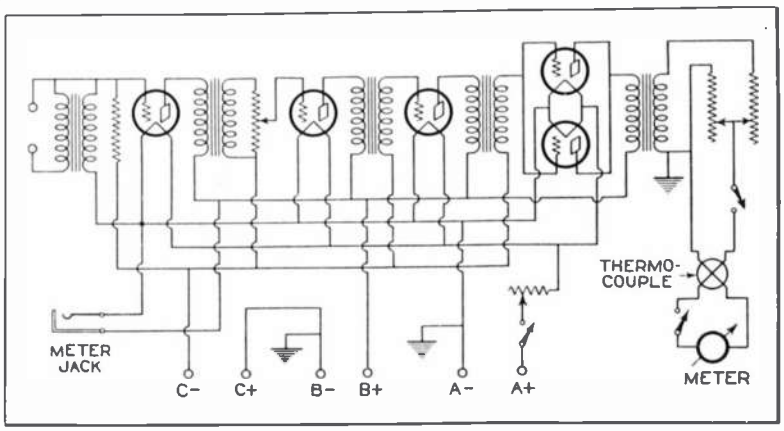
The Acoustimeter

An Electrical Means for Measuring Sound Intensities

*By R. F. Norris**

IN development work of any kind, it is necessary to be able to measure very slight degrees of progression or retrogression, which in themselves are of no great importance but which may indicate clearly the course to be followed. These almost imperceptible indications are the straws which tell us which way the wind blows and but for them we might waste a great amount of expensive effort in directing our investigations in wrong and barren paths. Briefly, the first tools of the investigator are accurate and dependable instruments with which his progress may be measured, be it ever so slight. If such instruments are not available, he had better lay aside the seemingly more important parts of his work until they have been developed. Otherwise he may miss the guide posts which are to lead him to his goal.

This is particularly true of acoustical work since the ear, which is the obvious instrument of comparison, while sensitive to very minute sounds, responds to their stimulus in a peculiar way. The physical loudness or intensity of a given sound is measured by the square of the amplitude of its wave while its apparent loudness to the ear is ten times the logarithm of this intensity. That is, a sound having a physical intensity of 1,000,000 will have a loudness factor of 10 log. 1,000,000 or 60, while a sound of only one-tenth the physical intensity 100,000 will have a loudness factor of 10 log. 100,000 or 50. Thus though the physical loudness of the second sound is only one-tenth that of the first, it will sound five-sixths as loud. From this simple illustration it is evident that the ear is of little or no use in the measurement of physical intensities of sounds. Yet in the problems to be investigated such measurements were of prime importance. An instrument which would be rugged, reliable, and not affected greatly by small variations in pitch was sought without success. It was, therefore, necessary to develop such an instrument. Instruments of several designs were built and discarded, the good points of each being retained until in this process of evolution the instrument now in use was evolved. The present instrument though far from perfect, gives reliable results, is rugged enough to be transported with impunity, and retains its calibration to an amazing degree.

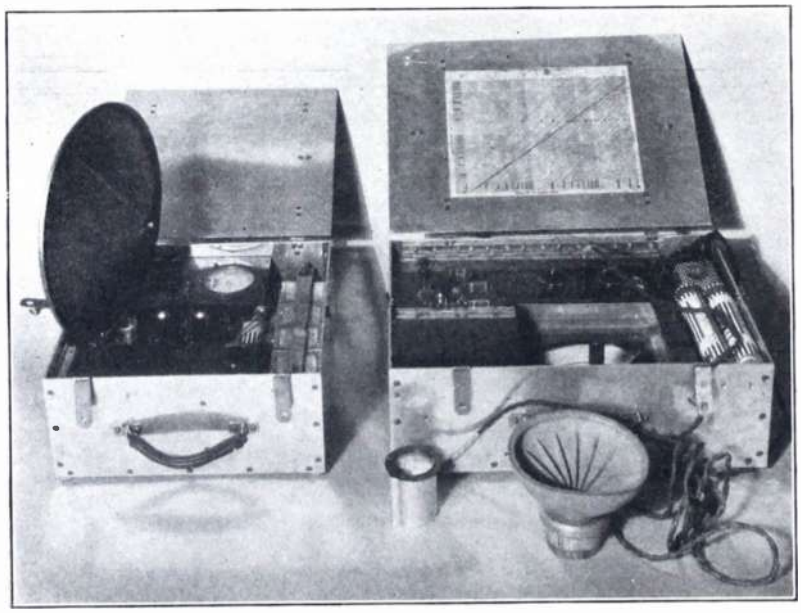


Schematic diagram of the Acoustimeter. The pick-up is not shown connected in the circuit.

The instrument consists of an electrical sound pick-up, a four-stage, transformer-coupled audio amplifier, a resistance network which, while keeping the output impedence constant, provides a gain control by which the range of the instrument may be controlled; a vacuum thermocouple and a very sensitive millivoltmeter.

Magnetophone Pick-up

The sound pick-up is a magnetophone of the Baldwin type. The sound waves to be measured impart a motion to the diaphragm which is proportional to their amplitude. This motion generates a minute current which is also proportional to the amplitude of the sound waves. This small current is amplified by the amplifier and fed in whole or part to the thermocouple, which supplies a direct current to the millivoltmeter, which is proportional to the square of the current from the amplifier. Since the intensity of a sound is the square of the amplitude of the sound waves, and since the current is proportional to the square of the current which is generated by the pick-up, the meter reading may be said to be true intensity units. To evaluate these units, the instrument must be calibrated. To do this a sound source of such an intensity as to give a readable indication on the meter is placed one foot from the pick-up. The observers then move away from the source to such a



The complete Acoustimeter equipment. The pick-up and the indicating meter can be seen in front of the right hand case.

* *Chief Engineer, C. F. Burgess, Laboratories, Inc.*

distance that the sound just becomes inaudible. The average distance for all the observers is measured and the loudness of the sound at the pick-up may be computed as follows: Say the average distance is 40 feet. The audibility of the sound at 40 feet is then 0 and the intensity is log.-10 or 1. The formula representing sound intensity at various distances from the source is

$$I = \frac{K}{d^2}.$$ Were I is intensity, K = a constant depending on the loudness of the source and d is distance from the source. Substituting 40 feet for d, we have $I = \frac{K}{1600}$ or K = 1600. Our constant is now determined for this case and the intensity at the pick-up, which is 1 foot from the source, will obviously be $I = \frac{1600}{1^2}$ or 1600 physical units.

Dividing this value by the number of divisions registered by the instrument meter, we obtain the value of each division in intensity units. Since this calibration method is tedious and inconvenient, it is fortunate that in a majority of the work encountered relative results only were required in which the calibration factor of the instrument cancelled out of the final results, making frequent recalibrations of minor importance.

Applications

With this instrument which has been named the Acoustimeter, a considerable amount of work has been done in the design of sound-proof partitions, gas engine mufflers, sound absorbing window ventilators and the investigation of faulty auditorium acoustics. In each of these investigations, very slight differences of sound intensity were found to be the deciding factors in the direction of the research and in the final solution of the problems encountered.

Dynamic Speaker Hum Elimination

Covering the General Methods of Eliminating Hum and a New System of Electrical Counteraction

*By P. G. Andres**

THE present-day electro-dynamic speaker, brought to the front by Rice and Kellogg of the General Electric Company in 1925 and marketed as the type 104 speaker, has undergone but little change since that development. This type of speaker consists essentially of a strong magnetic field, usually made in the form of a pot-magnet, or with a central core over which an exciting winding is placed. The magnetic return of this central core has a small air gap surrounding it in which a small coil is mounted, moving freely in the air gap. A cone, or other type of radiator, is mounted on the coil. If the field winding is excited by a suitable direct current and voice currents caused to flow in the movable coil, the interaction between the magnetic field set up by the voice coil and the permanently excited field causes the movable coil to move in accordance with the current fluctuations through the voice coil.

In order to obtain a high degree of efficiency as well as to reduce the air gap of the permanent field to a reasonable value, the movable coil is generally wound with a relatively few number of turns of copper wire. In order to couple it to the output tube, the voice coil is in this case supplied with its energy from a step-down transformer, termed the "voice coil transformer." Its ratio is usually in the neighborhood of 20 or 30 to 1.

Excitation Current

In order to obtain the requisite direct current for exciting the field, the field may be connected to a conventional direct current source, such as a 110 volt direct current or 6 volt storage battery circuit, depending on the design of the winding. Ordinarily, however, such sources of current supply are not available when used in connection with all-electric radio sets, in which case the excitation is obtained from the rectifier incorporated in the radio receiver, if the circuit has been designed with this in mind, or by means of a separate rectifier more commonly associated with the speaker. The latter usually takes the form of a low-voltage rectifier of the type recently developed, consisting of copper-oxide or copper-sulphide discs. To obtain the low-voltage alternating current before rectification a suitable step-down transformer which lowers the house voltage from 110 volts to 12 or 13 volts is customarily used. High voltage types of rectifiers operating directly from socket power without use of the step-down transformer but using a special transformer and a high-voltage rectifying tube, such as the gaseous type or the filament type, have received some attention.

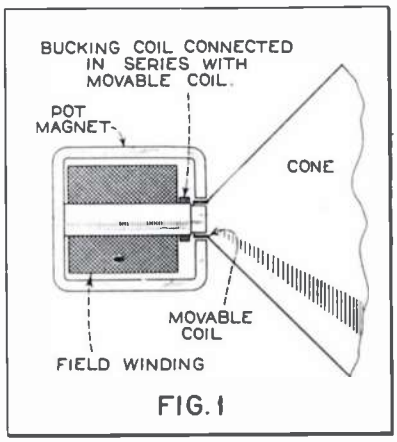


FIG. 1

The bucking coil method of eliminating dynamic speaker hum.

Current Fluctuations

Inasmuch as the rectification does not result in absolutely smooth direct current, the field is excited with direct current which has super-imposed on it a 120 cycle ripple in the case of full-wave rectification and a 60 cycle ripple in the case of half-wave rectification.

With a fully saturated magnetic structure it would appear that these fluctuations are not of much consequence. However, it must be borne in mind that the field winding acts as a primary of the transformer while the moving coil acts as the secondary. The secondary circuit is closed and consequently a current will be induced in it which reacts against the permanent field. Below saturation of the magnetic structure, the effect just mentioned is increased due to the greater permeability of the magnetic field structure. Obviously it is possible to design the moving coil and diaphragm or cone so as to make it least responsive to the 120 or 60 cycle tones and in this way eliminate much of the hum. In addition the speaker, because of its lack of sensitivity, does not readily reproduce the low tones associated with these frequencies. Obviously, some method must be devised which will prevent this interaction of the fluctuating field current and its corresponding induced current in the movable coil.

The early tests of Rice and Kellogg disclosed the use of the copper spool head. This has some effect toward the reduction of coupling between the pulsating field and the movable coil

* *Chief Engineer, Temple Corporation.*

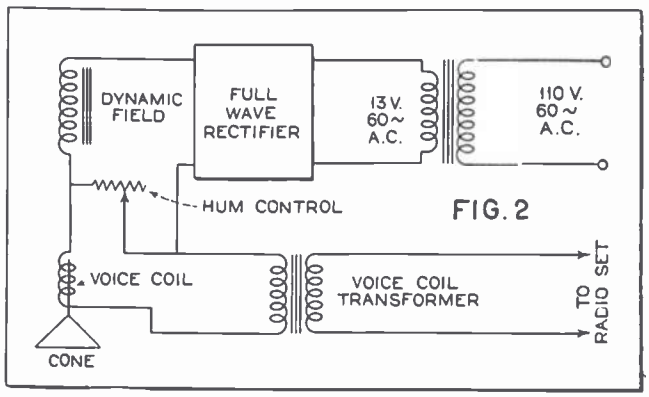
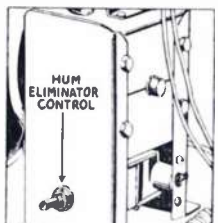


FIG. 2

Arrangement employed for electrically counteracting dynamic speaker hum, with the aid of a variable resistance.

but also introduces an impedance of the movable coil at higher frequencies.

In the early developments of the magnetic driving unit by Pridham and Jensen in 1913, they devised a means of connecting an additional stationary coil in series with the movable coil. This stationary coil was originally mounted on an auxiliary magnetic circuit. Subsequently Evershed and Kelroy developed a method where this auxiliary or bucking coil was mounted directly on the field structure carrying the pulsating flux. See Fig. 1. In either case, this small stationary coil is connected in such a direction so that the current induced in it by the pulsating field is in opposition to the same current being induced in the movable coil. Under conditions of proper design and when both the stationary and the movable coil receive equal and opposite induced currents, the net result is of course the elimination of the objectionable hum. The efficiency of this method of hum reduction is of course impaired by the stationary coil in series with the movable coil and unless the induced current in both coils is equal, the resultant current may again introduce hum. In practice this scheme works out unusually well.



The variable hum control is conveniently mounted on the speaker chassis and can be adjusted by the user.

Electrical Method of Counteraction

A more recent arrangement has been developed where the hum current in the movable coil is counteracted and balanced out by electrical means instead of magnetic. In practice this takes the form of a small adjustable resistance having a value of approximately two or three ohms and connected in series with the field winding. The alternating current voltage drop across this resistance is then fed in opposite phase relationship into the movable coil circuit, causing this current to be completely opposed and resulting in zero hum. This device in addition has an advantage that if the hum is introduced into the speaker from the radio set, that this hum can also be balanced out, provided it is in phase or in opposite phase to the hum current flowing in the movable coil. Fig. 2 gives a circuit of the electrical method of hum elimination.

Numerous methods of hum elimination by the use of condensers across the field winding have been proposed from time to time. In the case of high-voltage types of rectifiers, using vacuum tubes, this method works out satisfactorily, while the use of high capacity, low voltage, condensers across the field winding in the case of the dry disc type of rectifier invariably result in a decided shortening of the life of this device, due to the greater current passed through the rectifier. In general, it may be said that with the advent of loudspeakers which actually reproduce the lower frequencies in greater proportion than before, any slight pulsating effect due to the fluctuating current through the field winding should be counteracted by a suitable method of hum elimination.

Improved B-Power Circuit for Raytheon BH

EVER since the Raytheon gaseous rectifier tube was first placed on the market in 1925, there has been a great deal of research work carried on in the Raytheon Laboratories at Cambridge, Mass., not only aimed at improvements in the tube itself, but also in the associated circuits. As a result, the improved Raytheon BH 125-milliampere rectifier has now replaced the original 85-milliampere or B rectifier. The new circuit changes have also been recently developed, which are of considerable importance in reducing the size and manufacturing costs of Raytheon-equipped power units, both for A-C set use and as separate B-eliminators.

The first of the circuit improvements deals with the use of the buffer condensers. The function of these devices is to absorb any periodic disturbance that might be set up by the break-down of the gas in the rectifier tube itself. In the original Raytheon circuit, two high-voltage 0.1 mfd. condensers, connected across the transformer secondaries, are employed for this purpose. It has been found, however, that by employing two .02 mfd. condensers between the two anodes and the single cathode terminals, it is possible to obtain superior performance. This improved performance with smaller capacities results from the placing of the condensers at a more advantageous place in the circuit, namely, as close as possible to the electrodes of the tube, within which the disturbance is set up, and also by the operation of the buffer condensers at a higher voltage than when in their former location.

In addition, there has been added an R.F. choke in the cathode lead, comprising an air-core affair of 100 turns of No. 34 D.C.C. wire, wound 1 inch in diameter, for the purpose of keeping any radio-frequency disturbances out of the filter circuit. In commercial application, the two small buffers and the R.F. choke may be mounted directly on the tube socket itself so as to provide extremely short leads. In fact, much of the effectiveness of the new arrangement depends upon the use of short, direct connections. A marked saving in condenser cost is a further advantage of this new buffer condenser arrangement.

However, the greatest gain in the new Raytheon B-power circuit is in the matter of the filter choke coils. In the customary type of filter chokes, a large air gap is provided so as to prevent D.C. saturation. As a result, it is necessary to employ a large amount of both copper and iron in order to obtain sufficient inductance. The Raytheon engineers, however, have found it possible to place the two choke coils on the same core, so that their D.C. flux cancels out and thus prevents core saturation without the use of an air gap. As a result of this flux-bucking choke, a saving of from 15 to 25 per cent is obtained, without decreasing the effectiveness of the chokes. A further though somewhat incidental advantage of the single-core construction, other than saving in labor and material, is the elimination of the necessity for shielding or careful placing of the chokes, relative to each other.

The performance of the Raytheon B-power circuit can be still further improved by "tuning" the filter circuit for minimum ripple, which is accomplished by so varying the values of the capacities with relation to the choke coils, that the maximum hum suppression is obtained.

Mechanical and Electrical Life Tests for Tubes

Combination Rack Subjects Tubes Simultaneously to Mechanical and Electrical Stresses

*By Herbert Chun**

THE ordinary mechanical and electrical scrutiny to which tubes are subjected in leaving the production run in the average tube factory is not sufficient to show up many defects which, in later operation, shorten the life of the tubes.

That this is the case is evident in the personal experience of the average listener who returns to his dealer one tube out of every ten purchased.

Measuring the electrical constants of the tube in a necessarily abbreviated mechanical inspection is only approximately indicative of the manner in which the tube will stand up under the mechanical and electrical strains of average usage. Spot welds and base sealing that appear satisfactory to the eye are often subtly defective, a fact that shows up only after transportation and the wear and tear of transfer from socket to socket.

An Electro-Mechanical Tube Tester

It is possible by means of a simple arrangement to subject a tube or, in production, a rack of tubes, simultaneously to electrical and mechanical stresses in excess of those experienced in average operation.

The accompanying illustration is a photograph of the device designed by the writer and which consists, briefly, of an aging rack so mounted that it may be oscillated in a vibrating fashion by an electric motor operating through a suitable arrangement of gears and eccentric cams. It is almost needless to say that the rack may be built to accommodate as many tubes as it is expedient or convenient to handle at one time. The test rack photographed accommodates 90 tubes.

An inspection of the photograph indicates the mechanical features of construction.

The vibrating apparatus consists of a motor bolted to the solid frame of the test rack. An eccentric cam on the shaft of the motor engages with slots in the solid steel plate fastened to the moveable tray on which the tube sockets are mounted. The tube rack rests on four rollers which permits longitudinal motion.

When the motor is turned on the tray is moved back and forth by the cam, setting up vibrations, transmitted to the tubes, which may be varied in rapidity and intensity by the rheostat governing the speed of the motor, on the left hand side on the instrument board. The heating transformer for the filaments is shown in the lower right hand portion of the shelf. The transformer is of the variable voltage type and is rated at 500 watts for a 90 tube rack.

CENTRALIZED RADIO

The development of special radio equipment for apartments, hotels, hospitals, etc., has been given considerable attention by numerous engineers. Some very interesting systems have been worked out.

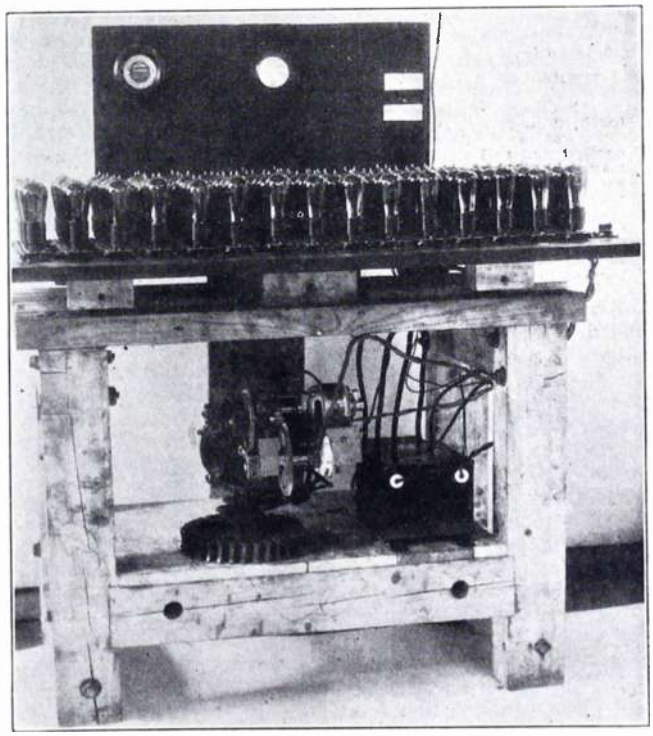
Centralized radio is a comparatively new field and one that is due for a rapid growth. Demand for such equipment is on the increase and there is little doubt that enterprising Radio Contractors are going to find the business a very profitable one.

A very interesting article giving complete details of an improved Centralized Radio System will appear in the March issue of *Radio Engineering*. Read it, by all means.—Editor.

Automatic Switch for Tubes

An automatic switch arrangement is mounted in the center of the shelf which turns the tubes on and off, simulating the voltage and current conditions of average operation. Many filament or heater failures are due to inherent weaknesses that do not show up when the filament is burned continually and only become evident when subjected to the surges coincident with the repeated turning on and off of the filaments. A variable speed motor operates a two-way snap switch through a chain of reduction gears. The speed of the motor is regulated so that the switch is snapped once every two minutes. The snap switch is so wired that one-half of the tubes are turned on at a time, the other half being given a thorough cooling between alternate heatings.

Thirty minutes on the mechanical-electrical rack are sufficient to eliminate practically every tube characterized by the inherent weaknesses described. The device can of course be modified to meet the requirements of all types of tubes and by the inclusion of a plate supply can be made to perform a dual function of a test and aging rack.



An illustration of the electro-mechanical tube tester. This contrivance subjects the tubes to electrical and mechanical stresses in excess of those experienced in average operation. The unit shown accommodates 90 tubes.

* *Engineer, Arcturus Radio Tube Co.*

The Engineering Rise in Radio

By Donald McNicol

Fellow A.I.E.E., Fellow I.R.E., Past-President, Institute of Radio Engineers

PART IX

Advancing Knowledge of Wave Propagation

AN examination of the technical literature of radio throughout the two decades 1900 to 1920 together with personal recollection of discussions which took place at periodical meetings of scientists and engineers during his period, emphasizes the fact that a very creditable amount of practical progress was made notwithstanding that all investigators were not in agreement in regard to the mechanism of electric wave production and propagation.

Following the Kennelly, Heaviside announcements of 1902, the theory of refraction gained credence, and as the function of the earthed sending antenna became better understood, the sliding, surface-wave theory seemed based on logical reasoning. Technical writers of 1905–1906, presented both of these theories of transmission, giving students the opportunity to take their choice. The thought had not yet become clear that radio waves from a given transmitter might travel to a distant receiving station in the form both of a "sky" and an "earth" wave.

Experience gained from actual operation of radio telegraph stations, in time contributed materially toward a clearer understanding of the travel of radio waves through space. Lowenstein's paper of 1915, previously referred to, summed up the general understanding current at that time, in the words:

> "Also, in view of the curvature of the earth, does it not seem more natural to speak of a conducted radio frequency current and to look upon the electric and magnetic field traveling with it as its accompanying result than to designate radio transmission as identical with the radiation of a Hertz oscillator *modified* by a conducting equatorial plane *and* by bending of radiation lines due to the earth's curvature *and* to the existence of the conducting upper strata."

Here was a summation of the various theories which had survived, but there was present the implication that the waves might travel long distances and perform their signaling function, whether they journeyed as waves on the surface of the earth or were continuously bent in the direction of propagation by diffraction from an upper reflecting layer.

In discussing the Lowenstein paper, Dr. L. W. Austin made the point that it should be remembered that neither the upper wave nor the lower wave can exist without the other.

In Lowenstein's paper, as in Ives' paper; in earlier writings of Poincaré and Fleming, and in Pickard's paper of May, 1909, presented before the Wireless Institute, New York, electric wave phenomena were explained from the electrostatic side alone. While the advanced physicist had no difficulty with this interpretation there is no doubt that omission of reference to the magnetic component was confusing to less advanced students and to practicing engineers. Indeed, it was not until J. H. Dellinger boldly called attention to discrepancies of expression and statement that the literature of the art began to show uniformity of statement, in such fashion that students of the subject thenceforth encountered less of discrepancy, and less of omission of important factors.

Dr. Dellinger, in his paper on "Principles of Radio Transmission and Reception with Antenna and Coil Aerials," read before the American Institute of Electrical Engineers, in October, 1919, discussed mathematically the mechanism of radiation. If there was a notion that the electrostatic effect and the electromagnetic effect neutralized each other, Dellinger dispelled the idea by showing that the two disturbances do not exactly neutralize each other, due to the finite time of propagation from one side of the circuit to the other—the result giving rise to radiation from a metallically closed circuit. He showed that the electrostatic and magnetic fields, in a radiated wave, are not independent phenomena; being strictly equivalent, and but two aspects of the same thing. Further, he demonstrated that the current received in an antenna, calculated from the electrostatic field, was exactly the same as calculated from the magnetic field, making it clear that any effect of a transmitted wave may be considered as due either to the electrostatic or the magnetic field accompanying it.

Naturally, the science writer, especially in the early days of an art, is handicapped somewhat by a lack of terminology common to all students. It is inescapable that he should have to draw on analogy and upon the terminology of older arts, long established. In the early treatises on radio the term "whip crack" as applying to the action of a discharge oscillator in producing electric waves was widely used, accompanied by such terms as "snapping off of lines of force," to account for the formation of detached waves moving outward from an antenna. Such terms were ambiguous, but perhaps unavoidable in the beginning. The gradual development of an accurate terminology for radio engineering has largely corrected this situation; this development being an accompaniment of the development of radio engineering itself.

Wave Lengths

In the early radio telegraph operations wave lengths of from 300 to 600 meters were employed, but in long distance projects, the tendency, as time went on, was to employ much longer waves, in some late applications waves 30,000 meters long have been used. On the trans-Atlantic radio telegraph circuits wave lengths from 12,000 to 20,000 meters have been employed. Beginning in 1920, due to the great demand for radio channels for radiophone broadcasting purposes, it became advisable to explore the possibilities of wave lengths shorter than 200 meters, the latter having been about as low on the scale as it had been necessary to go in providing a sufficient number of channels.

Soon it was discovered that much of merit in the short waves had been neglected, and within a few years highly satisfactory radio telegraph operation was being maintained over extremely long distances by the use of waves of less than 100 meters in length. In fact, the scale was explored with good results, down to fifteen meters, with possibilities in fractional wave lengths.

It may be well, however, to summarize the situation with respect to theories of wave propagation as these had survived the wear and tear of time up to the beginning of the year 1925. The very exhaustive tests and observations carried out by the United States Naval authorities 1910 and 1913, under the direction of Dr. L. W. Austin, on waves longer than 500 meters, brought forth data of a very interesting and suggestive nature. Out of these observations came the Austin-Cohen formula for radio transmission, which indicated that the intensity of the received wave fell off more rapidly than the distance traversed by the wave from its source, than would be indicated by a simple inverse square law.

The attack directed upon the problem by a number of mathematical physicists (for instance, B. J. Von der Pol, Holland; see Phil. Magazine, 38, 365, 1919), pointed to the probability that with diffracted waves the intensity reduction factor of received waves would be greater than suggested by the Austin-Cohen formula.

A search for a basis of the discrepancy suggested that agreement might appear if the phenomena of refracted waves, as in the Kennelly, Heaviside conception, were accepted as an element. W. H. Eccles, in 1912 (Proc. Royal Society, 87A, 79, 1912),

set up the hypothesis of an elevated reflecting layer so intensely ionized as to prevent any considerable penetration; thus reflecting the waves, aided by ionization of the middle strata of atmosphere tending to bend them earthward.

There is no occasion to attempt to go far in the elucidation of physical phenomena without having recourse to the aid of electron physics, but the writer believes it would be regarded as an unwarranted digression if this subject were gone into here in sufficient detail to be enlightening. The interested student will find in the foot note[9] at the bottom of this page references to dependable and instructive sources of information on the subject of electrons, of particular value to the radio engineer.

Assuredy it was a most fortunate circumstance that electric waves were found to be effective in signaling between points on the earth's surface thousands of miles apart and screened from each other by the intervening hump. Had it been discovered in the early trials that stations screened from each other by the earth's curvature could not communicate, it would have been immediately apparent that the radiated waves travelled only in straight lines, through the atmosphere and tangentially out into space. As Sir Oliver Lodge stated in February, 1928: "That ether waves are constrained by the atmosphere to follow the curvature of the earth's surface is an unexpected bonus on the part of Providence, such as is sometimes vouchsafed in furtherance of human effort." To the operating engineer it may have been sufficient to know that the waves in general follow the surface of the earth; as conduction currents; as waves gliding along the surface, or as waves in the ether residing in the space between the earth and an upper layer of refracting properties; or as a combination of these effects. The research engineer, on the other hand, is not a man of prescribed stint. His unsolved problems may be laid aside temporarily, but may not be shelved until the entire truth is uncovered.

Eccles' renewed investigation of 1912, into the nature of the upper atmosphere, with respect to its wave refracting properties, attracted the attention of investigators in all parts of the world, with the result that within a decade or so organized research produced a considerable amount of observational data which has been of real value to the engineers engaged in establishing and carrying on radio service.

It is well known that the earth's atmosphere is made up of two concentric spherical shells. The inner layer is called the troposphere, wherein masses of air are continuously in motion, while the outer layer is known as the stratosphere or isothermal layer.

Fading

With respect to the position occupied by the hypothetical Kennelly-Heaviside layer it may be stated that "height" means the distance above the earth at which in the thin atmosphere the rate of increase in the electron density with the height becomes less. In other words, the region of maximum electron density.

The admirable researches of Pickard[10] into the cause of short period variations in radio reception disclosed well-defined short period variations of more than ten per cent amplitude in transmission over a distance as short as seven miles. In this case the direct path from transmitter to receiver was at least ten times shorter than the angular path over which refracted waves would have to travel. While observations made over a range as short as this may deal with conditions not present in transmission over long distances, Pickard concluded that the principal factor affecting transmission was absorption due to ionization alterations in the atmosphere.

In the course of the years has grown the general agreement that the ionization in the upper air continues because of high velocity electrons reaching the atmosphere from the sun. The action of the earth's magnetic field on the electrons is to concentrate them in the region of the poles, accompanied by a herding effect toward the dark side of the earth. S. Chapman and E. A. Milne,[11] in England, by calculation concluded that the distribution of ionization as a result of absorption of high velocity electrons in the atmosphere remains at practically zero below a height of twenty-five miles. From that approximate height up to a distance of thirty-three and one-half miles above the earth ionization gradually increases, falling again slightly more gradually to a small value at about fifty-six miles. In 1927, Breit and Tuve of the Carnegie Institution from observation concluded that the ionized area or layer extends from a height of about fifty miles upward to over one hundred miles.

A well organized attack on this problem was well under way in 1925 by the American engineers; notably Taylor, Hulburt, Bown, Potter, Heising, Schelleng, Southworth, Martin, Baker and Rice.[12] In England, Joseph Larmor[13] and in Germany, A. Meissner and G. H. Barkhausen carried on researches which also brought to light much information of value.

Up to the end of the year 1927 the state of knowledge of wave propagation, for both long and short waves, was founded on observational data obtained by the engineers mentioned, and others.

Recognizing that sunlight produces at least some of the ionization in the refracting region it was important to note that on the dark portion of the earth's surface, at night, there is a height above the earth where sunlight may be found. For instance, in the neighborhood of New York the vertical distance to that region in the sky to the north at midnight on June 21, where sunlight prevails, assuming no refraction by the atmosphere, is 363 miles.

This has a considerable bearing on the variations in effective range of short and long radio waves. In carrying on communication between points widely separated on the earth's surface there are instances where both sending and receiving stations are at the same time in the sunlight zone. There are instances where one station is in the dark while the other is in the light, and instances where both stations are in the dark.

In the transmission of 16⅔ meter waves it appeared that sufficient ionization for satisfactory refraction is produced only by sunlight, refraction occurring probably in the neighborhood of two hundred miles up, and probably not over four hundred miles up. It would appear also that after midnight in the absence of sunlight the ions present in the upper regions may not be sufficient to effectively reflect the shorter waves while still being sufficient to refract the longer waves—67 to 111 meters. With the latter signals are strong during the night-time, but are very greatly reduced in strength when sunlight appears at either sending or receiving station.

It was, and still is, an intriguing problem; that of investigating electron distribution in the upper atmosphere, with the objective of determining the heights above the earth at which radio waves are refracted earthward as a result of variations in the electron content (density) of the attenuated air.

The popular conception of radio waves is that they penetrate solid materials, and that progressing through space in the form of ether waves the presence of air in the path presents an obstacle no less transparent than wooden walls or glass windows.

But, radio waves are Maxwell, Hertz waves and are electric. While radio wave motion may be set up as an ether phenomenon, progressing outward from a radio transmitter, through the atmosphere, the fact that the atmosphere at certain elevations contains clouds of electrons at once establishes the atmosphere in a place of importance as a factor in radio transmission studies.

The investigations of H. W. Nichols, J. C. Schelleng and R. A. Heising, in America, particularly, 1924–1927, have been useful in that from these inquiries came deductions which offer plausible explanations of some of the most

[9] *Electrical Engineering (Chapter VII) L. A. Hazeltine. The MacMillan Company, New York. (1924). The Study of Ions and Electrons for Electrical Engineers. H. J. Ryan. Journal of A. I. E. E., September, 1925.*

[10] *Short Period Variations in Radio Reception. G. W. Pickard. Inst. Radio Engineers, Proceedings, December, 1923.*

[11] *Quarterly Journal, Royal Meteorological Soc., V, Vol., 46, 1920.*

[12] *Refraction of Short Waves. Baker and Rice, Journal A. I. E. E., February, 1926.*

[13] *Phil. Mag., Vol. 48, 1924, p. 1025.*

puzzling of the problems of radio transmission.

The astonishing results obtained in 1924, and thereafter, with long distance, short wave signaling, focused universal attention on the puzzling differences in signaling range of waves of various lengths, at night, and in daylight hours. Very long waves, of the order of 10,000 meters, and short waves of the order of 100 meters, were found to be suitable for long distances, while, in daylight hours, waves of intermediate lengths had little value for signaling over long distances.

The investigations above referred to seemed to confirm the opinions which had been to the fore since 1902, that all long distance radio communication is dependent upon refraction of the transmitted wave from the upper atmosphere.

From the tables worked out by Chapman and Milne, previously referred to, it has been shown that for given wave lengths there are heights at which maximum absorption occurs. For fifty meter waves this height is approximately forty miles, and for wave lengths 3,000 to 10,000 meters, the level is approximately sixty miles up. Obviously, from what has been learned about the heights at which refraction takes place, it is apparent that waves traveling from an antenna skyward and which are turned back earthward at an angle dependent upon the length of the wave, pass through the absorbing region twice—once on the way up and once on the way back, for each excursion aloft and back.

The eminent Danish radio savant, P. O. Pedersen, in 1927, published a review of his own and others' researches into radio transmission phenomena, stating that ultra violet radiation from the sun is the chief determining factor, although radiation from stars of very high temperature also has some influence on the propagation of very long waves. Pedersen's correlations indicate that ionization is at its maximum value at an altitude of about 81 miles (130 K.M.) by day, and 100 miles (155 K.M.) at night, with the lower boundary at a height of about 56 miles (90 K.M.).

As Pedersen points out, the ray path depends on both the earth angle and the frequency. Long waves will be reflected without severe losses from a height of about 56 to 62 miles (90 to 100 K.M.) even for great earth angles, both electrons and ions being effective in turning the rays earthward.

Advancing knowledge of radio transmissions through space was, throughout a half dozen years prior to 1928, materially aided by recognition of the importance of the meteorological aspects of the subject. This, in addition to the methods devised for determining refracting heights and angles might suggest terming this division of the general subject: the science of *cataditadio*, according with the companion terms *catacoustics* and *catadioptrics*.

The different behavior of long waves from that of short waves, and the various results with day, night and seasonal transmission, in the course of the years produced tabulations which, though elementary, served as bases for investigations and explorations which it is hoped will yield a fuller knowledge of the conditions.

The condition referred to as a "skip distance" effect which for some time had puzzled observers, was, in 1925, subjected to investigation on a promising scale. This is the distance from the radio transmitter to the first point at which the refracted wave returns to the earth, and, as pointed out by Baker and Rice, for a given wave length the skip distance is a minimum in the middle of the day and a maximum on a winter night, the variations being accounted for by alterations in the height, the thickness, and the state of electron density in the refracting area.

Short Waves

Observations on a comprehensive scale by A. Hoyt Taylor of the U. S. Naval Research Laboratory, up to 1925, resulted in the compilation of a large amount of data dealing with short wave working, skip distances and "fading." Classified as reported from a large number of observer stations these showed that a day-time wave thirty meters long registered effectively at any distance up to fifty miles, but in some cases at distances between 50 and 500 miles the signals were not in evidence, while at distances between 500 and 1,500 miles they were again readable. Shorter waves showed a longer skip: for instance, fifteen meter waves ceased to be audible beyond ten miles, skipped 1,500 miles and were again audible at 3,000 miles. Transmission was in the daytime from a five-k.w. transmitter.

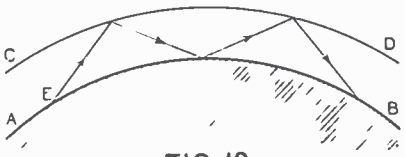


FIG. 12

Radio waves travel in accordance with the Refraction Theory. The curved line AB represents the surface of the earth, and CD the refracting ionized layer at a height above the earth. A wave sent out from a station at E may be reflected to-and-from earth and upper layer, as it progresses from E, the skip-distances depending upon the length of the wave.

At night-time in winter 100-meter waves were heard at distances up to 8,000 miles; fifty-meter waves up to 10,000 miles, while forty-meter waves skipped 500 miles and reached all distances beyond. Thirty-meter waves skipped 4,000 miles; twenty-meter waves skipped 7,000 miles, and both could be heard at all distances beyond.

In general, Taylor noted that for the shorter waves observations indicate better reception in the region extending from the first skip zone to 2,000 miles, than in the region 2,000 to 4,000 miles where at least one reflection downward to earth is involved; and that from 5,000 to 10,000 miles, short-wave signaling is dependable. This is explained on the basis that with increase of distance naturally a larger number of wave paths are presented, making it unimportant should one wave encounter obstruction.

The term "fading" signifies a variation with time of the strength of a received signal at a given point and, as pointed out by Nichols and Schelleng, variation with time of the characteristics of the transmitting medium implies that a signal having variable amplitude at a receiving point may result from a signal transmitted originally with constant amplitude and frequency.

Extending the investigation into the nature of electric wave propagation to the broadcast range of frequencies, Bown, Martin and Potter, in America,[14] reached the conclusion that the amplitude of received signals is subject to any misfortune which may befall the *carrier wave*, and that one way to reduce the fading effect would be to suppress the carrier wave, replacing this with a constant amplitude carrier at the receiver. In radiophone broadcasting the transmission of a carrier wave and two side-bands requires on the part of the medium very uniform behavior—a service not likely to be rendered. The Bown-Martin-Potter investigation brought to light definite indications of selective fading, showing that fading is a function of frequency as well as of time.

The fact that oscillographic records obtained by these engineers showed that in the case of broadcast transmission the carrier and side band signals do not fade together as a unit, led them to conclude that a major cause of fading is wave interference of this nature.

Appleton and Bagnett, in England, in 1925 reported observations indicating that fading was due to the interaction of two sets of waves arriving at the receiver; one set travelling along the surface of the earth, the other reaching the receiver by the angular route upward to the refracting layer, thence downward to earth. When the two waves reach the receiver simultaneously the energies are additive, but when they arrive consecutively, or out of step, interference results which has the effect of decreasing the energy actuating the receiver.

De Forest,[15] in America, as early as the year 1913, suggested the probability of the plural path of wave travel between transmitter and receiver as being the cause of night-time short-period variations in signal strength. A. Hoyt Taylor, in America, in 1925 regarded the skip distance observations as demonstrating clearly that two portions of the transmitted wave may be

[14] *Studies in Radio Broadcast Transmission. Ralph Bown, D. K. Martin, R. K. Potter. Presented before Inst. Radio Engineers, New York, November 4, 1925.*

[15] *Proc. Inst. Radio Engineers, Vol. 1, No. 1. (1913).*

differentiated; one following the surface of the earth and decreasing rapidly in strength until it is dissipated, while the other travels upward to the refracting region and thence downward to earth having suffered very little attenuation. For the broadcast band, 300 to 600 meters, receivers situated within one hundred miles from the transmitter are very little affected by variations contributed by the overhead components, owing to the fact that the ground wave within that distance is strong.

American Amateurs' Organization Studies

The astonishingly long ranges of radio telegraph operation reported, beginning in the year 1924, were the result in large measure of wave band explorations carried on by American amateur radio experimenters. For radio telegraph purposes the amateurs had been allotted a swath in space represented by wave lengths in the neighborhood of 200 meters. The popularization of radiophone broadcasting which began in 1920, at once blocked the amateur's excursions into regions beyond 200 meters; if he was to retain standing as a law-abiding, live-and-let-live citizen. Vacating the troublesome frontier the amateur trekked to regions in space known to be unoccupied by signaling services, and out of his explorations into the bands ranging from 200 down to five meters, and lower, has come knowledge of the greatest usefulness, a result of which is that many additional useful channels through space have been discovered; or at least, recovered.

In transocean radio telegraph service the large commercial companies have almost from the beginning employed very long waves, from 8,000 to 25,000 meters. A sort of dictum grew up that for satisfactory working, twenty-four hours daily, over long distances, a wave length of 1/500 part of the distance separating the stations would be the most suitable. From the Nauen station, in Germany, to New York this means a wave length of approximately 12,000 meters.

When the first trans-Atlantic telegraph cable was laid (1858) it was ruined as a conductor, within a few hours, because of the application to it of a voltage considerably in excess of that to which it should have been subjected. In long distance radio telegraph operation, especially when but a few circuits were in operation, there was no need to consider the delicacy of the elements of space serving as the medium of transfer of signal energy. Long distance commercial radio telegraphy then became largely a matter of long waves and high-power transmitters, the objective being to try and have at the receiver a working margin of signal current over energy reaching the receiver as a result of extraneous artificial or natural electric disturbances; a received-current strength sufficient to maintain a working margin in spite of fading and daylight vicissitudes encountered by the waves through space.

Widespread Observation of Short Wave Performance

Short-wave achievements of importance were out of the question prior to the development of tube oscillators, and amplifiers for detected signals. The availability of transmitting and receiving devices which were capable of close regulation as to wave length, called for the development of a more refined technique of radio, in which direction the amateurs were materially aided by studies carried out by advanced engineers. C. S. Franklin,[16] in England, in 1919, and later, experimented on a large scale with short waves, devising the required terminal apparatus; for the first time, perhaps, presenting data based on observation, and which at once attracted attention to the subject. Franklin's determinations, however, had not the advantage of widespread cooperation such as that afforded by numerous observers situated at various distances away from the point of transmission. A. Hoyt Taylor, J. L. Reinartz,[17] Lucien Levy, in France, and H. Yagi, in Japan, E. O. Hulbert, and others, in America; E. V. Appleton, in England; A. Meissner and A. Esau,[18] in Germany; were enabled by collaboration of this order to reach conclusions which constitute much of the present knowledge of short wave radio operation.

It took some time for the theory to prevail that short waves travel over one route along the surface of the earth, but that reception registered at distances of several thousand miles from the transmitter does not result from transmission along the earth; signals received at such long distances reaching their destinations because of a progressive series of tacks, skyward and earthward. Obviously, as pointed out by E. V. Appleton, the skip distance increases as the wave length is decreased, because the smaller the length of a wave the less the amount it can be bent back (refracted) by the upper ionized layer. From this an assumption would be that very short waves, would not be turned earthward, but would continue on through space, through and beyond the Kennelly-Heaviside layer.

(To be continued)

[16] *Jahrb. Drahtlose Tel.* 21 (1923).
[17] *QST Magazine, Hartford, Conn., No. 9, 19*
[18] *Zeitschrift Tech. Phys. No. 5* (1924) 485, 538.

New Knowledge About Lightning Effects and Damage

THE approach of the Spring and early Summer months, when damage and fire hazard to radio antennas and radio receivers, due to the prevalence of local lightning storms, presents a subject for consideration at the present time.

The efforts of the standardization laboratories are directed toward setting up specifications governing the design of and installation of lightning protective equipment which will adequately protect against fire risk.

As indications of the progress that has been made in the study of lightning it may here be stated that the wave shape of lightning has been pictured by means of the cathode ray oscillograph, and by this same means the time required for a cloud to discharge has been measured accurately. The oscillograms measure time in microseconds.

It has been determined that the value of the applied voltage is the factor governing whether the front or the tail of the wave causes the sparkover.

Measurements made by F. W. Peek, at Pittsfield, Mass., were by means of short antennas consisting of three parallel wires 120 feet long and 40 feet above ground. As stated by Peek, the lines assume a potential opposite to that of the cloud (the wires grounded through a 2,000,000-ohm resistance) when the lightning discharge takes place. Since the charge cannot move along this line but must be dissipated by leakage, the potential of the conductors rises at a rate and to a magnitude dependent upon the collapse of the cloud field. The time for the conductor voltage wave to reach maximum is a measure of the time required for the cloud to discharge. Peek's experiments showed that the wave fronts are of the order of one or two microseconds; the induced voltage crests on the antenna being 50 to 75 kv, from storm clouds at least a mile away.

Deductions made from the Pittsfield, and other experiments, are that the potential of lightning is of the order of 100,000,000 volts, and the current of the order of 100,000 amperes.

These disclosures support designers and manufacturers who, from practical experience with arresters and arrester failures, aim to so design their protector product that there will be dimensions of terminals and arrester parts adequate to safely pass and dissipate short duration currents of large volume.

The fact that in the majority of cases of indicated lightning effects the small field created in an antenna is the result of discharges between distant cloud and cloud, has often misled manufacturers into designing arrester equipment totally unfit for its purpose when subjected to direct discharges to earth, and high induced potentials from cloud fields near at hand.

How Much Selectivity?

An Instructive Article Dealing With the Relation Between Selectivity and Circuit Resistance, and the Role Regeneration Plays in Modern Receivers

*By J. E. Smith**

IN these days, in which the ether is working overtime trying to accommodate all the waves which are being emitted into it, it is clear that the question of selectivity is of paramount importance. There are, however, several sides to the story, so it happens that there is a practical limit to the selectivity which may be usefully employed in radio receivers.

However, before going into all this, let us understand something of the difficulties resulting from this crowding of the ether channels. In the first place it has been ordained that all broadcasting shall take place in the wavelength range from 200 meters to 550 meters. This means that the frequency range is from 545 kilocycles to 1500 kilocycles.

Furthermore, it is generally understood that a broadcasting station does not transmit a wave of a single frequency. There is a main frequency which is called the carrier wave, and this carrier wave is modulated by the musical or other audible sounds actuating the microphone. The range of audible sounds extends from about 30 to 20,000 cycles but for practical purposes it is found sufficient for obtaining good quality to transmit frequencies only up to about 5,000 cycles.

So we find that the transmitting station transmits a complex wave—a wave which may include all frequencies between 5,000 cycles above and 5,000 cycles below the main or carrier frequency. Thus, if the carrier frequency is 1,000,000 cycles, or 1,000 kilocycles, the complete wave may include all frequencies between 1,005,000 cycles and 995,000 cycles, or, between 1,005 and 995 kilocycles.

The usual way of explaining this is to say that the wave consists of a carrier and an upper and a lower sideband. The carrier frequency is the frequency of the oscillator at the transmitting station; the side bands are due to the sounds sent into the microphone and amplified by the speech amplifier.

Cutting of Sidebands

The need for preserving all the frequencies of the sidebands is well known, for the "cutting" of the sidebands causes the loud-speaker reproduction to sound drummy. The reason for this is that the upper or higher frequencies determine the quality or timbre of the sounds and when these are lost it is difficult to recognize the particular sound. For example, if a violin were deprived of a lot of its higher harmonics it would sound like a cello. A baritone may be made to sound like a basso, if sufficient of the overtones are lost.

IN THIS article Mr. Smith explains some of the less widely known points about selectivity and its relation to circuit resistance and regeneration. He illustrates the manner in which the engineer increases the sharpness of tuning in a commercial receiver by the injection of negative resistance into the grid circuits of the radio-frequency amplifiers.

A clear perspective of this relationship is a valuable aid to set-builders and servicemen.—Editor.

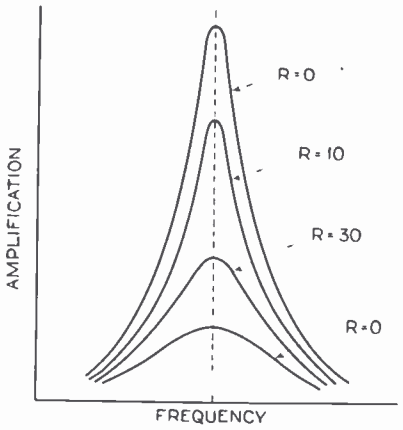


FIG. 1

A group of four resonance curves of tuned radio-frequency circuits.

All this is well known, so that it will not be necessary to go into this phase of the discussion here. There is another phase of it which has not generally been considered by engineers; there are certain limitations to the selectivity which may be attained which have been imposed by Dame Nature, in addition to certain practical considerations which we shall discuss as we go along.

How much selectivity do we want? Certainly, you will say, we can't expect any more selectivity than the laws of nature can furnish us. That is a reasonable answer, but unfortunately, it seems that the demand is for an almost impossible degree of selectivity. Let us see!

In the first place, you are aware of the fact that the selectivity of a tuned circuit consisting of a condenser and coil in series is rigidly defined by the amount of resistance in the circuit. You may say there is nothing new about this. We knew this long ago. Yes, but do you have any idea as to how low the resistance of your tuned circuits must be made in order to be able to separate all the local stations in a metropolitan district like New York or Chicago without having them overlap?

That is another question, and is one that can be gained only by experience and experimentation. It is not possible at the present time to calculate it, for the radio-frequency amplifiers in our receivers are so complicated that it is impossible to take into consideration at one time all that goes on in them.

Resonance Curves

The selectivity of a radio-frequency amplifier can easily be determined by obtaining what is known as a selectivity curve, such as is shown in Fig. 1. This illustration shows a group of curves, each curve for a different resistance tuned circuit. In the hypothetical case where the resistance of the tuned circuit is zero, the amplification would rise to an enormous or infinite value at the peak. When resistance is added to the circuit the whole curve drops, but the loss of amplification is greater at the peak than elsewhere.

Now, suppose we had several receivers, all designed identically, excepting that the tuned circuits in each receiver had different values. Then suppose we tuned all these receivers to the same frequency and adjusted the volume controls of them all so that we had the same volume from all of them. The relative selectivity of the group of receivers could then be pictured as in Fig. 2. It is clear that the receiver whose selectivity curve is a-a is the more selective.

Now we get to the new phase of the situation—that is, new as far as consideration by the *ignobile vulgus* is concerned. In order to obtain greater selectivity it is necessary to design the tuned circuits to have less resistance. But less resistance means larger coils, with spaced turned-coils much larger than we are using in our receivers today. This, of course, is an uneconomical procedure, especially in the commercial production of radio receivers, where size means money.

The radio-frequency resistance of the tuned circuits in the usual radio receivers may be found to vary from say 5 to 10 ohms at 550 meters to say 10 to 30 ohms at 200 meters. *It has been found experimentally that in order to separate all the local stations in the New York area in a receiver em-*

* *President, National Radio Institute.*

ploying about the usual values of inductance and capacity, the resistance of the tuned circuits has to be in the neighborhood of 7 or 8 ohms!

This is no doubt an astounding statement and you are probably saying, "How can that be true, when you have just stated before that the resistance may be as high as 30 ohms at 200 meters? Why, I have a receiver which has small coils of fairly high resistance, and I can easily separate all the stations that come on my dials."

Well, you are right, and so am I. It seems as if I have contradicted myself, but, honest, I haven't. You with your extremely selective receiver, are actually able to separate all those stations, yet your tuned circuits have undoubtedly a resistance somewhere near 25 ohms at 200 meters, and yet they are acting like circuits whose resistance is 7 ohms or less. This is all admitted, yet, how come?

The answer is easily given. Your tuned circuit is acting like one whose resistance is so small because of—regeneration.

Negative Resistance

The regeneration in your radio-frequency amplifier is a feed-back of power from one stage to the other, or from the plate circuit to the grid circuit of the several stages, and this amounts to the same thing as adding negative resistance to your tuned circuits.

Your tuned circuits have a resistance of say 25 ohms at 200 meters when you measure them by themselves outside of the amplifier. But when they are placed in the R.F. amplifier and are acted on by regeneration, the negative resistance introduced in them may be somewhere in the neighborhood of say, 17 ohms, so that the circuits act as if they had a net resistance of about 8 ohms, which results in a highly selective receiver.

The same is true at other wavelengths. At 500 meters the resistance of your tuned circuits by themselves may be about 10 ohms; when regeneration acts on them at that wavelength they may act as if their resistance is perhaps 7 ohms. The feed-back is much less at the lower frequencies (longer wavelengths) but at the same time the tuned circuits have a true resistance which is much less than the resistance at shorter wavelengths. Thus, at 500 meters, the negative resistance introduced into the tuned circuits may be only about 3 ohms, whereas at 200 meters it may be as great as 17 ohms, as we have mentioned. So, by controlling the feed-back, it is possible to build a radio frequency amplifier in which the tuned circuits will have about the same resistance and the same degree of selectivity at all wavelengths in its range.

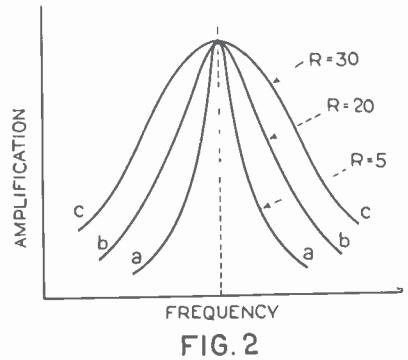


FIG. 2

Depicting the relative selectivity of three R.F. receivers with different values of circuit resistance.

And now we come to a phase of the question which may cause quite a surprise, and which I fear may even cause quite a bit of controversy, regardless of the fact that figures don't lie. Let us consider the hypothetical case of a radio-frequency amplifier which employs a bridge circuit for balancing out the feed-back, and in which it has been possible to obtain a *perfect* balance at all wavelengths. If such a thing were possible it is clear that there would be no negative resistance introduced into the tuned circuits.

From this it follows that if the usual style of coil and condenser were used in these tuned circuits, the resistance of these circuits would range from say 10 ohms at 550 meters to say 25 ohms at 200 meters. This is true especially of shielded circuits.

From what we have said before, where we stated that a circuit resistance of about 7 ohms is required for adequate selectivity, this receiver would be so broad that it would hardly be worth using in the metropolitan districts where the congestion of the ether is greatest. It would no doubt be a very good receiver for the country districts, and would no doubt furnish us with very good quality of reproduction, since there would be little sideband cutting, but in New York and Chicago it would not be possible to tune in some of the stations without having another station in the background.

Necessity of Feed-back

Your next question is anticipated. I know what you are thinking, and I know that there are a lot of people who will object to what I am going to say next. There are many people who claim that their bridge circuits are very accurately balanced. Perhaps there are such circuits—most likely not. At any rate, even if they wish to believe that their bridge circuits are accurately balanced, it is fortunate for them that they are not, for the unbalance which is found in these circuits is, unknown to them, making a good receiver out of a poor one.

There is required to be, in all such circuits sufficient unbalance of the bridge system that a sufficient amount of feed-back can take place, and so reduce the circuit resistance to such a point that a decent degree of selectivity is secured. (See Fig. 3.)

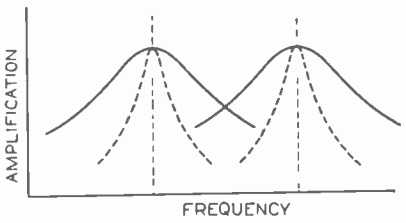


FIG. 3

Illustrating the effect of regeneration on a tuned R.F. circuit. Selectivity is increased, as indicated by the dotted curves.

Any bridge circuit which happens to be accurately balanced is required to use rather large diameter, space wound coils, in order to secure the required selectivity. Otherwise the selectivity will be more or less poor, depending upon the true resistance of the tuned circuits.

It is unfortunate that the great congestion of the ether has made it necessary to secure such great selectivity. We are forced to work our tuned circuits, we might almost say, at more than one hundred per cent efficiency, through the application of regeneration. Of course, this is not an accurate way of speaking, but you know what I mean. It almost seems as if nature did not intend us to have such selective circuits, yet conditions make it imperative.

As to the sideband cutting, although we do not intend to go deeply into that matter here, the amount of sideband cutting that occurs in even rather broad receivers is surprising. And when we obtain such a great amount of selectivity as is required, can you imagine how much more of the sidebands is lost to us? Is it any wonder that such poor reproduction is obtained from so many receivers. And in spite of it all, designers still go on trying to bring out stronger and stronger the low notes. Is it any wonder that so much of the music coming from loudspeakers is drummy?

Compensating for Losses

It has been suggested by other writers, and this writer agrees with them, that it would be well to make one part of the radio receiver compensate for the losses in another part. For instance, in order to compensate for the sideband cutting in the R.F. amplifier of the higher frequencies, why not design the audio-frequency amplifier so that it amplifies these frequencies more strongly.

However, let it go at that for the present. We have accomplished our purpose, we feel, in giving you something interesting to think about in the matter of selectivity. It is an interesting view-point, and one that should be carefully studied by all engineers—that is, the relation between the selectivity required for practical purposes, and the value of the circuit resistance that is required in order to furnish this degree of selectivity.

A Modern Radio Aircraft Installation

A Description of a New Transmitter and Receiver Designed for Airplane Communication

*By E. N. Pickerill**

A GREAT deal of research and experimenting have been performed recently in the further development of radio communication facilities between ground and airplanes and between two airplanes in flight. Of course, there have been numerous airplane installations up to the present time, but these have had some drawback, such as excessive weight, inability to communicate over relatively short distances, difficulty of operation, etc.

The average airplane pilot, due most likely to his training and experience, considers a radio installation in a plane as so much extra and unnecessary weight. They say that they are too busy flying the ship to bother with a set; also that the hundred or so pounds of weight of the set might better be in so much more fuel—and so on. The majority of them do not take into consideration the fact that a radio installation is really an added safeguard.

Much has been written recently concerning the use of short-wave apparatus for airplanes. This is certainly excellent from the point of view of weight, but the main drawback here is that the distances over which reliable communication can be maintained are so great as to be more or less useless. For instance, if a plane were equipped to transmit on a wavelength of 30 meters they could be picked up at a distance of about a mile and then there would be a zone of silence up to about 3,000 miles, where the signals again could be detected. This obviously is useless for a plane sending an SOS out over the water, for here the pilot is chiefly interested in nearby communication.

In the designing of a new type of radio installation for airplanes the matter of wavelength has received, therefore, much serious attention and also its attendant factors, power and distance of communication. These three factors are closely dependent upon one another. For example, with a certain given power it is possible to transmit over a certain distance on a long wavelength. With the same power and using a shorter wave greater distance can be covered. Now the question was, just where is the happy medium, so that maximum efficiency may be had with a minimum of weight.

It was first of all decided that the distance to be covered efficiently was 300 miles for telegraphy and 125 miles for telephony. The wavelengths were from 109 to 133 meters and from 600 to 950. The power necessary for these wavelengths and distance was found to be 100 watts.

These wavelengths were assigned for airplane communication by the International Radio Convention. Six hundred meters is the wave universally used for the transmission of distress signals by marine shipping and 900 meters for aircraft. Eight hundred and fifty to 950 meters is the channel assigned for communication with aircraft, as is also the channel between 109 and 133 meters. Nine hundred meters is the calling wavelength for all aircraft.

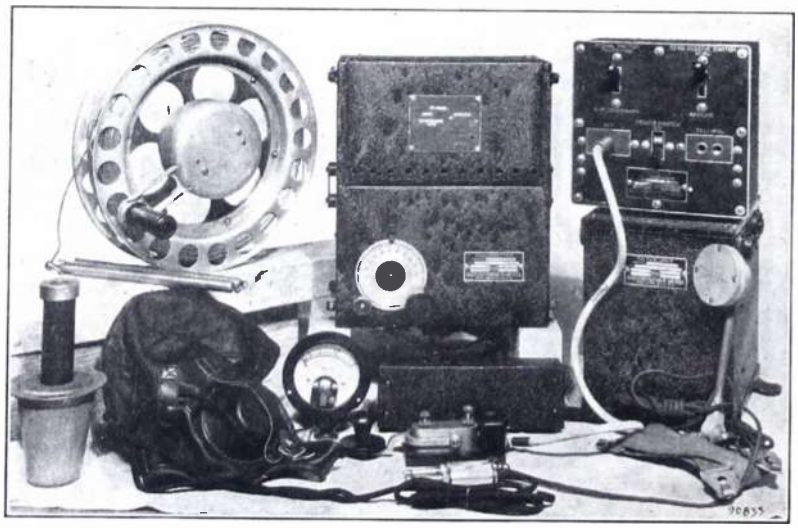
Description of Apparatus

The apparatus used in the installation of the 100-watt set is so designed that it is in several small units that can be distributed about the fuselage in convenient location. Only three of these units and an antenna ammeter need be within the reach of the radio operator. The total weight of these several units is approximately 86 pounds.

It has been assumed in the design of this apparatus that the airplane engine has been adequately shielded so as to reduce interference from this source to a negligible quantity. It has also been assumed that the airplane on which the apparatus is to be installed has been thoroughly bonded. By this is meant the connecting of all metal parts of the plane by means of electrical conductors during the process of manufacture, which is a requirement of good airplane design, in that it eliminates the danger of sparks between metal parts.

The simplest possible form of circuit

*Aeronautical Dept., Radiomarine Corp. of America.



The complete transmitting and receiving apparatus for airplane communication. At left the fairlead, helmet with headset, flame-proof key, and at right, the microphone.

is employed in the transmitter. It consists of a Hartley type master oscillator using a 75-watt tube and a neutralized power amplifier, using a 75-watt tube. This power amplifier is modulated by the Heising system, employing another 75-watt tube. A 5-watt tube serves as a special amplifier which is resistance coupled to the modulator.

When using the apparatus for telegraphy, the filament circuit of the last mentioned two tubes is opened in the control box. In case of tube failure in flight, these two tubes may be interchanged with the other two and telegraphic communication can then be continued, since the modulator and speech amplifier tubes are unnecessary for telegraphy.

The keying system used is of the type employing a change of grid bias sufficient to produce and stop oscillations alternately. No meters and other unnecessary weights are included in the transmitter unit. Jacks are used instead for plugging in meter cords when making adjustments on the ground.

On the front panel of the transmitter is mounted the control dial for tuning this unit. The frequency of the transmitter is continuously variable throughout its range from the front of the panel and can be set to operate on any one frequency between 109-133 meters and 600-950 meters.

The construction of the box is such as to provide a strong, light-weight equipment, and also makes an excellent shield for the apparatus. The box is divided lengthwise by a duraluminum partition, on the back of which are mounted the antenna coupling, neutralizing condenser, several fixed condensers and the master oscillator tuning. In front of the partition are the four tubes together with a variable condenser, grid leak, resistors, choke coils and transformer used in the generation and modulation of high-frequency currents.

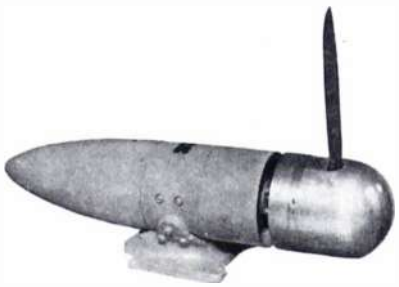
The top half of the front panel and the front half of the top panel are of one piece of duraluminum and are hinged to the lower half of the front panel. When this section is open the tubes, which are mounted on sponge rubber cushions, are easily removed.

The Receiver

The receiving apparatus is also mounted in a duraluminum box and the weight, including the tubes, is approximately 11 pounds. The box is so constructed that it is rain and splash proof and may be placed in any position convenient to the radio operator or pilot. Clamps suspended in sponge rubber provide a cushion support and permit the receiver to be easily and quickly mounted or unmounted. The top of the front panel is hinged and opens downward, allowing access to the five tubes.

The first two tubes constitute a radio-frequency amplifier, the third one a regenerative detector, and the other two are the audio-frequency amplifiers. The receiver is tuned with one dial and the tubes are mounted on sponge-rubber cushions. A vernier control is provided for the accurate tuning of weak signals as well as an adjustment for controlling the regeneration of the detector.

No batteries are required for this receiver, the power for this unit, as well as the transmitter, being derived from a wind-driven generator. The wavelength range of the receiver is from 50 to 150 meters and 580 to 1,100 meters.



The wind-driven generator, which supplies all the necessary current for operating the transmitter and receiver.

Control Box

This unit is used to control the operation of the transmitter and receiver, and contains switches for changing from "send" to "receive" and from CW telegraphy to telephony. It also includes telephone jacks, interphone transformer and all other equipment necessary for the control of the entire transmitter and receiver. This unit is contained in an aluminum box, which weighs approximately 8 pounds complete. It has the same type of construction and finish as the main transmitter unit, and contains a switch for changing from radio telephone connections to those required for telegraphy, and one for starting either the transmitter or receiver at will. Jacks are provided for connecting the key, microphone, and helmet phones. This unit, the receiver and the antenna reel must be located within easy reach of the operator or the pilot. In some cases, it may be found desirable to locate one or two of these units near the pilot. Since the operator and the pilot are in constant telephonic communication, either may instruct the other as to what adjustments should be made.

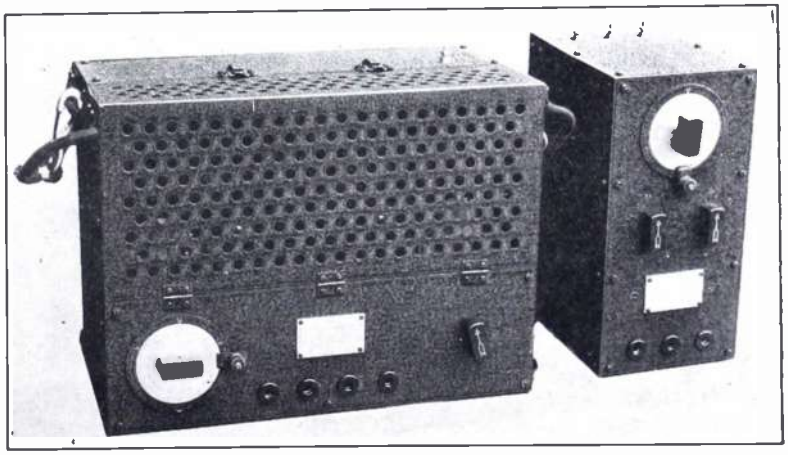
Filter Box

This unit is included in order to simplify the problem of power supply. Two voltages are supplied by the wind driven generator to this unit which includes a suitable combination of reactors, capacitators, resistors and a relay. All of the voltages necessary for the operation of the transmitter, receiver and inter-phones are obtained. Ordinarily, this unit requires no attention whatsoever after its original installation and adjustment. The relay in this box is used for keying.

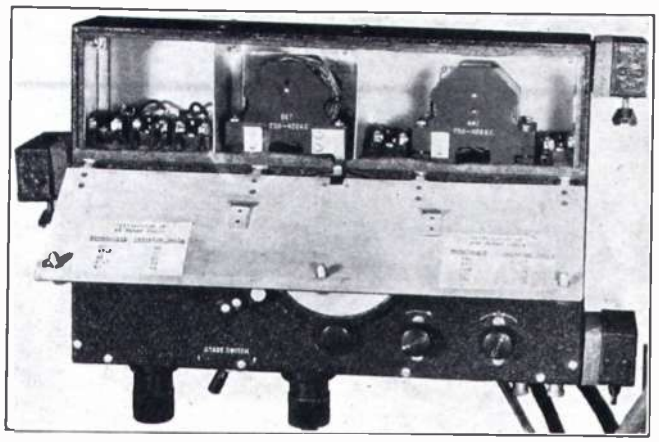
The antenna wire is carried upon an insulated reel. The antenna wire itself is of copper-clad steel and is very light, considering its strength and high conductivity. The reel is provided with a clamping device so that it may be locked against rotation when the desired length of antenna wire has been reeled out. A crank is provided to enable the operator to reel in the antenna when a landing is to be made.

In order that the antenna wire may float properly, it is necessary to have a small weight attached to the remote end. The type of weight furnished is such that if the one originally attached to the wire should become detached in flight, another one can be added from within the fuselage of the plane. Ten antenna weights are provided, two for normal use and eight as spares.

The antenna wire passes out through the fuselage by way of an insulating tube or fairlead. The fairlead is constructed of micarta tubing with moulded bakelite terminal block and metal end flange. This tube is so arranged that the connections from the



The transmitter and control box of the 100-watt airplane installation.



The five-tube receiver has wave-length ranges of 50 to 150 meters and 580 to 1100 meters. Notice the special suspension mounting clamps, which facilitate mounting. The weight is approximately 11 pounds.

antenna to the control box are made at both ends of the tube while the outside of the tube is insulated so as to prevent accidental contact to surrounding objects.

Power Supply

A double-current wind driven generator furnishes power at voltages of 1,000 and 10. The 1,000-volt commutator supplies the power for the plate and grid circuits of both the transmitter and receiver. The 10 volt commutator supplies the power for the filament circuits of both transmitter and receiver, and also for the interphones. This double-current generator is driven by a 500 watt Deslauriers constant speed self-regulating air-fan. The maximum output rating of the generator is 800 watts from both windings combined. At normal operation the generator furnishes 450 mills or 0.450 ampere at 1,000 volts for the filament supply of the transmitter tubes, and 9 amperes at 11 volts for the filament supply of the tubes, and for excitation purposes. The high voltage commutator is at one end of the generator and the low voltage commutator is at the other end. The generator is made of streamline construction. This generator maintains a normal speed of 4,000 R.P.M. regardless of wind speeds or load, as long as the plane is in the air. This regulating feature is due to the employment of a centrifugal governor which changes the pitch of the propeller blade as the speed of the plane changes.

Accessories

The microphone is of the breast mounting type developed especially for aviation purposes. It is so constructed that motor and propeller noises have almost no effect on it while the operator's voice is transmitted clearly.

Two standard aviators' leather helmets, complete with head telephone receivers, cords and plugs are provided.

A special type of key is supplied which eliminates the danger from sparking at the contacts. This key is air-tight and cannot ignite fumes from gasoline. A clip is furnished so that the key may be attached to the operator's leg if desired.

The small jack-box permits the pilot and operator to communicate with each other at all times, or it permits the pilot to communicate with the ground stations by telephone or telegraph while the operator listens in or vice versa. The box contains three telephone jacks which are for the microphone, key and helmet.

In order to make it possible for the operator to adjust the antenna tuning, a small indicating ammeter is mounted conveniently within the range of vision of the radio operator or pilot. It is provided with a 0-5 ampere scale and is operated from a thermocouple mounted in the transmitter box. The meter tells at a glance whether or not the set is functioning properly.

Radio Beacon Receiver

There has been recently developed a new Radio Beacon Receiver which can be operated either direct or by remote control. The remote control feature of this receiver permits it being mounted at any convenient place within 30 feet of the operator. The swaying of the usual trailing wire type of antenna used in planes was found to make impossible the fine tuning necessary for reception of signals from directional radio beacons, therefore, a six-foot vertical metal rod projecting above the cockpit was substituted for an antenna. This extremely sensitive receiver requires only a few feet of metal conductor for an aerial. The International Radio Convention held in Washington in 1927 allocated frequencies ranging from 285 to 315 kc for all radio beacon services and 315 to 350 kc for aircraft communication services, 333 kc being adopted as an international calling and distress frequency for aircraft, therefore, consideration was given to these frequencies in the design of this set, as well as providing for its use either as an aural or visual receiver. It may be used either as a beacon receiver or as a telephone or telegraph receiver for communication purposes. The visual reed indicator can be plugged in and used with this receiver if desired. The ground radio beacon antenna system used in conjunction with the aircraft visual reed indicator is comprised of two triangular loops erected at 90° to each other, each loop being modulated with a different frequency, namely 60 and 85 cycles, which actuate the vibrating reeds. The reed showing the largest amplitude of vibration indicates the side from which the radio beacon signals are being received. When the aircraft is heading straight for the radio beacon the amplitude of vibration of both reeds are identical. One advantage of this visual type of indicator is that the pilot is not required to wear head phones and another is that its operation is not seriously affected by static.

PAUL REVERE UP TO DATE

AN experiment recently conducted by the Operadio Manufacturing Co., of St. Charles, Illinois, proved the feasibility of using an airplane equipped with a positive voice electrical amplifier for speaking from the airplane to persons on the earth, while in flight.

The ship flew over St. Charles, Geneva and Batavia, Illinois, to the Aurora airport and at frequent intervals, the pilot spoke into the microphone located in the cockpit the following message: "If you hear me, call St. Charles 2300." This is the telephone number of the Operadio Manufacturing Co., and within three minutes, the factory switchboard was blocked with calls. These calls came from every town along the course as well as from isolated farm houses, individuals in automobiles on the roadways, etc. The telephone operator was instructed to take the names and addresses of the people who called and every town was heard from.

The equipment used consisted of a microphone mounted on the instrument board just in front of the aviator, a four tube power amplifier and batteries in the cockpit and an especially designed high-powered exponential tone chamber, which is mounted just beneath the fuselage in the center of the wings. The tone chamber has a stream line housing to cut down air resistance in accordance with best aeronautical practice. The entire equipment occupies very little space and the experiment was made using a very small Waco three-place ship.

At 500 feet altitude and over an area of approximately one-half mile square, the pilot's voice could be plainly heard and understood. The ship flew at full throttle over the Fox River valley and the quality and quantity of reproduction resulting from the first test was sufficient to cause hundreds of people to call the telephone number spoken to them from the plane.

The amplier is being developed now by the Operadio Co., and the completed equipment will weigh not over 100 pounds and will be so thoroughly worked out that it may be installed in not more than five minutes' time.

NEWS OF THE INDUSTRY

Report of R.M.A. Board Meeting

NEW services for RMA members and developments of many established services, were ordered by the RMA Board of Directors at its two-day sessions at Briarcliff Lodge, January 11-12th. The Board approved a report of and made a large appropriation requested by the Foreign Trade Committee, headed by George H. Kiley of New York, to develop export trade promotion service. RMA members will be sent free of charge an extensive compilation of information regarding radio trade and means for its promotion in many countries. This will be in loose-leaf form to be supplemented with additional information monthly.

Merchandising Bureau

Establishment at New York headquarters of the RMA of a merchandising bureau, next month it is hoped, was recommended by the RMA Merchandising Committee, headed by Mr. L. E. Noble of Buffalo, New York, and approved tentatively by the Board. Merchandising services of many kinds for RMA members and also for radio jobbers and dealers, including special services and collection of statistics, is planned. Mr. Lloyd A. Hammarlund of New York, Chairman of the RMA Statistics Committee, reported progress in developing reliable and accurate industry statistics. He will present further plans at the next Board of Directors meeting.

Credit and Collection

New and valuable measures to extend the credit and collection service of the RMA were reported by Mr. Theodore Sheldon of Chicago, Chairman of the RMA Credit Committee. New branches at Philadelphia and Boston in the Eastern Division, in addition to that at New York, have been established. The credit interchange information service, through the National Credit Office and the collection service of the New York Credit Clearing House Adjustment Corporation, will be continued and expanded for the use of RMA members.

Patent Interchange Plan Progressing

The RMA patent interchange plan was ordered forwarded by the Board of Directors, through Mr. Le Roi J. Williams of Cambridge, Mass., Chairman of the RMA Patent Committee. Detailed information will be given to RMA members regarding the patent interchange plan with a view to its adoption by the necessary 51 per cent. of RMA membership.

Further participation by RMA members in broadcasting and many measures to support broadcasters to develop programs, as well as to improve radio reception, were recommended by the RMA Broadcasting Committee, headed by Mr. B. G. Erskine of Emporium, Pa., and approved by the RMA Board.

Interference Manual Under Revision

The RMA Interference Manual, "Better Radio Reception, of which 100,000 copies have been circulated throughout the country, with excellent results in assisting listeners in solving their interference problems, will be revised and improved. The new booklet will be ready in a few weeks, after approval by the Engineering Division, headed by Mr. H. B. Richmond of Cambridge, Mass.

Director Richmond reported that the RMA series of articles on television, to correctly advise the public regarding the status of television experiments, had been the most helpful and that no further action in this respect was needed at present.

Railroad Rate Reductions

Progress toward securing railroad rate reductions on radio products was reported by Captain William Sparks of Jackson, Michigan, Chairman of the RMA Traffic Committee. Several rate reductions urgently pressed by the RMA Traffic Committee and the RMA Traffic Bureau, in cooperation with the Federated Radio Trade Association, are expected to materialize shortly.

New RMA Directors

Three new radio industry personages have been added to the RMA Board of Directors to fill three vacancies.

The three new directors chosen by the RMA Board are:

Joseph L. Ray of New York, General Sales Manager of the Radio Corporation of America; B. J. Grigsby of Chicago, President of the Grigsby-Grunow Company, and Allan G. Messick of Chicago, Chairman of the Board of the U. S. Radio and Television Corporation.

All elections were unanimous. Mr. Ray was chosen to fill out the two year term, and Mr. Grigsby and Mr. Messick each one year terms.

The vacancies on the RMA Board were caused by the resignations of Mr. Donald MacGregor of Chicago, formerly Treasurer of the RMA and formerly with the All-American Mohawk Corporation and now with the Utah Radio Products Corporation; Mr. L. G. Baldwin of Cleveland, Willard Storage Battery Company, and Mr. Alex Eisemann of New York, formerly with the Freed-Eisemann Company.

Chicago Trade Show

To the radio industry probably the most important and interesting action taken by the RMA Board of Directors was the expansion of the Trade Show at Chicago. Early demand for space has been so large that in the interest of its membership the RMA decided to take over the Blackstone and Congress Hotel accommodations, dividing the Trade Show between the Stevens and these two additional hotels, and hold the big RMA annual banquet in the Stevens Hotel Ball Room. This insures a bigger show and bigger banquet. At the Stevens the Exhibition Hall will be used as usual, and the larger and smaller manufacturers exhibiting will be divided between the three hotels.

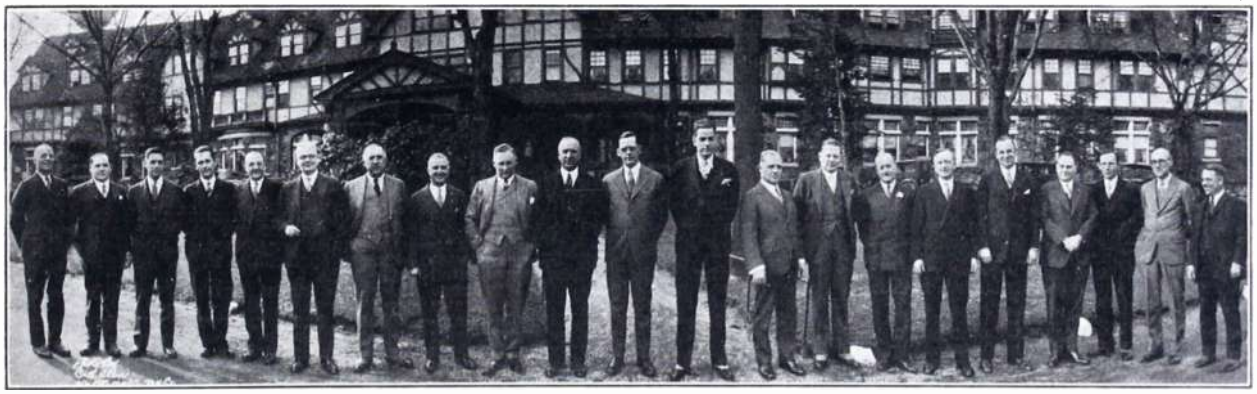
Mr. G. Clayton Irwin, Jr., of New York, will again manage the Trade Show for the RMA.

Arrangements to continue the great public shows in Madison Square Garden, New York, and the Coliseum, Chicago, in 1930, also were concluded by the RMA management with Herrmann & Irwin. The public shows for next fall already have been contracted for and the extension contract for 1930 now assures another year of the public shows sponsored by the RMA.

Improvement of Radio Reception

Improvement of radio reception received much attention by the RMA Board of Directors. C. C. Colby of Canton, Mass., Chairman of the RMA Legislative Committee and former RMA President, with the help of the Legislative Committee, its Washington Legislative Counsel, Mr. Frank D. Scott, its general counsel, Judge John W. Van Allen, and with the assistance of most of the RMA members who responded to a questionnaire giving their advice and information regarding the new broadcast allocations and their views on radio legislation and regulations of the Federal Radio Commission, presented detailed recommendations.

The RMA Board adopted and declared the general policy that the industry interests and those of the radio public are identical, sales of radio apparatus depend-



R. M. A. Board of Directors Meeting, Brincliff Lodge, Briarcliff, New York, January 11-12, 1929.

Reading left to right: Bond P. Geddes, Executive Vice President, R. M. A.; H. B. Richmond, N. P. Bloom, Lloyd A. Hammarlund, B. G. Erskine, C. C. Colby, H. C. Forster, H. H. Eby, J. B. Hawley, John W. Van Allen, General Counsel, R. M. A.; L. E. Noble, 3d Vice President, R. M. A.; L. E. Parker, W. L. Jacoby, G. Clayton Irwin, Jr., Manager, R. M. A. Trade Show; Morris Metcalf, 2d Vice President, R. M. A.; T. K. Webster, Jr., H. H. Frost, President, R. M. A.; V. W. Collamore, 1st Vice President, R. M. A.; J. C. Tully, Treasurer, R. M. A.; Frank D. Scott, Legislative Counsel, R. M. A.; M. F. Flanagan, Executive Secretary.

ing on public satisfaction with radio reception. The RMA Board declared as a fundamental and permanent policy "that the welfare of the radio manufacturer is represented in the favorable and healthy interest and approval of the listening public as a whole, and that the RMA shall direct its efforts toward attainment of radio broadcasting and reception most suitable and satisfactory to the radio listener throughout the nation." For the information of Congress and the Federal Radio Commission, the RMA Board of Directors agreed to recommend the following modification of existing radio laws:

(1.) That Sub-Section 3, of Section 9, of the Radio Act of 1927, as amended, be further amended to extend the period of broadcasting licenses, as 90 days is too short a period to encourage healthy investment and deprives the industry of a stability which is essential.

(2.) That Section 16 be amended to permit an appeal from a decision of the Federal Radio Commission by an aggrieved station, the public, and a state or political sub-division affected thereby.

(3.) That Section 28 be amended to prevent the interception and transmission of radio broadcast programs in any manner without the consent of the station, person or company originating such program.

(4.) That Section 2 be amended to rearrange the zones (the five Federal Zones) so as to provide a more suitable and practicable basis for the distribution of broadcasting facilities.

Radio reception, the RMA Board of Directors further recommends, may be improved in the following manner:

(a.) By the deletion of stations not performing a real service to the public.

(b.) By permitting stations on cleared channels to use higher power under adequate regulation.

(c.) By requiring stricter adherence of stations to frequency assignments.

(d.) By permitting the use of such increased power from sunrise to sundown, eastern standard time, as will not cause interference.

Chain Programs

Regarding regulations to avoid undue duplication of chain programs, the RMA Board of Directors further expressed the view that the Federal Radio Commission had approached this matter erroneously by its Order No. 43, suspended until February 1, prohibiting duplications within arbitrary limits of 300 miles. The RMA opinion is that distance standards vary according to physical and other conditions, and that regulations should be based on engineering tests and actual, practical results in station operation.

The RMA also adopted a resolution commending the Federal Radio Commission "for the adoption and enforcement of the rule requiring that programs derived from phonographic records or other mechanical means of reproduction be announced at the beginning and end of each selection."

RMA Broadcasting

The new broadcast feature, the special programs sponsored by the Radio Manufacturers' Association and contributed by various of its members, commenced Wednesday evening, February 6th. It had been hoped to inaugurate the RMA programs sooner, but time required to secure space on various national chains and arrange the schedule of the programs necessitated delay of the first RMA program until February 6th. Others contributed by various manufacturers who are members of the RMA, which comprises virtually all prominent makers of all radio products, will follow thereafter weekly, at different hours and on various chains, as determined by the contributing manufacturer.

In entering broadcasting through the cooperation of its members, the RMA has several objectives. First, it desires to make its contribution to the radio public, by affording new and more broadcast features. Secondly, the RMA desires to support broadcasting and broadcasters, and third, it is hoped to stimulate other radio manufacturers, not now using the air, to contribute to the public through additional broadcast features. Each of the RMA programs, of various types, will contain special features each week not on the usual program of the contributing member. At least eight, and probably more, manufacturers already have agreed to give a special RMA program, assuring a schedule of eight, and probably more, weeks' time.

Officials of the two principal chains, the National Broadcasting Company and the Columbia Broadcasting System, are cooperating with the Radio Manufacturers' Association toward making the new RMA programs a substantial and attractive air feature.

The next meeting of the RMA Board is planned at Pinehurst, N. C., late this month.

RADIO MEN TO FIGHT FOR SERIAL NUMBER BILL IN ALL STATES

Plans for the passage of a law to maintain the radio manufacturer's identity and resulting responsibility for their product during the successive changes in ownership to the final resting place in the home will be mapped out at the forthcoming convention of the Federated Radio Trade Association in Buffalo, N. Y., February 18 and 19, 1929.

"This 'serial number' legislation which will be whipped into shape by the radio dealers and wholesalers, will provide punishment for the persons, who sell or offer to sell any machine or article of merchandise, the serial number or distinguishing number of which has been removed, altered, defaced, covered or destroyed."

In states other than California and Pennsylvania both the radio public and the industry have been without protective legislation.

For the good of the industry, radio is seeking the same protection accorded other valuable products whether radio receivers are considered electrical, musical or me-

chanical devices. Pennsylvania handles the matter by specifically mentioning radio apparatus as coming within the meaning and intent of its act.

According to Harold J. Wrape, president, Federated Radio Trade Association, St. Louis, Mo., Connecticut, Illinois, Missouri and Ohio, "has thus far in advance of the convention given impetus to the plan of securing countrywide passage of the Serial Number Law. Senator Roy C. Woods of Chicago recently introduced the Serial Number Bill into the Illinois Legislature in Springfield.

Peter Sampson, Chicago, president of the Radio Wholesalers Association conducted the survey for the Federated which disclosed the fact that the public was not even partially protected from unscrupulous dealers in most of the states.

RADIO INDUSTRY INFLAMED

A burning question now inflaming some radio dealers and manufacturers is:

"Will fire more quickly damage or destroy radio receiving sets or electrical curling irons, dish washers, or refrigerators?"

This question is the cause of a red-hot controversy between certain fire insurance companies and radio jobbers and dealers. An investigation is being made by the Federated Radio Trade Association, the national organization of radio jobbers and dealers, and the Radio Manufacturers' Association, which are affiliated.

Complaint of radio dealers that their fire insurance rates had been greatly increased caused the inquiry being made by the radio industrial associations. Fire underwriters advised them that insurance rates on radio products were increased because they are more subject to damage from fire and water than electrical products. This also raises the question of whether radio apparatus is an electrical product or not—another burning question within the radio and electrical industries.

Insurance rates fairly adjusted on radio products as compared with electrical and other similar products are being sought by the Federated Radio Trades Association and the Radio Manufacturers' Association.

RADIO SERVICE COURSE IS NEARING COMPLETION

The text of the course for radio servicemen which is being prepared by the Radio Division of the National Electrical Manufacturers' Association in collaboration with the Radio Institute of America is nearing completion. The members of the special committee who are reviewing this text are now reading the last set of galley proofs, the final step preceding make-up and publication.

The course is a complete education for the dealers' and jobbers' servicemen and comprises, in addition to lesson texts, the wiring diagrams of standard radio receivers and power supply equipment. The course covers only the field of broadcast recention in which the large majority of servicemen are engaged. It explains radio phenomena briefly, the function and design of each part of the usual radio receiver, the essential tools and test equipments required by the servicemen and all the necessary information on the subject of aerial devices, such as vacuum tubes, batteries, power supply devices and radio speakers.

Although the course will be distributed to individual subscribers, the larger part of its circulation will be attained through its distribution to dealers in quantities at a substantial discount by leading radio manufacturers who perceive its value in improving the character of service rendered the consumer. The price of the course has not yet been established, awaiting final figures of its cost of production.

JENKINS TELEVISION PLANT NOW IN JERSEY CITY

The Jenkins Television Corporation has acquired a factory at 346–370 Claremont Avenue, Jersey City, N. J.

"We shall have our general offices and factory, as well as our engineering laboratories, at this address," states James W. Garside, President of the company. "In addition," continues Mr. Garside, "we shall have a television broadcasting station for the New York Metropolitan area installed in the annex on the roof of the building, with ideal conditions for satisfactory signal propagation, as soon as license is granted by the Federal Radio Commission.

"Meanwhile, our experimental and research laboratories remain in Washington, D. C., in charge of C. Francis Jenkins, our Vice-President in Charge of Research.

"We are working toward production on standardized television receiving equipment for the home, as well as transmitting equipment for broadcasting stations desirous of engaging in this new art. The first sets of television receivers are now coming through our production department. Following exhaustive tests and satisfactory demonstration, our mass production schedule will follow."

POLYMET PURCHASES COIL PLANT

The Polymet Manufacturing Corporation announces its entrance into the coil field with the acquisition of the Coilton Electric Manufacturing Company of Easton, Pa.

The absorption, under the Polymet name of this large and well-known coil plant will undoubtedly prove of great interest to the radio, speaker, and other coil-using industries. Polymet, through this acquisition, will be even more closely tied to manufacturers and users of radio parts by adding Power Transformer Coils, Audio Transformer Coils, Transformers, Coils for Dynamics, and Power Packs to its present line of Filter Blocks, Condensers and Resistances.

The Coilton Electric Manufacturing Company's windings have been established for over eleven years, and have established a reputation for quality which has warranted their incorporation in leading radio receivers, dynamic speakers, and many other coil-using products. Under Polymet direction it is planned to increase the size of the plant by 25,000 to 30,000 square feet of floor space; fifty to a hundred new multiple-winding machines are to be added to present equipment; and the factory force is to be augmented in proportion, so that production may be kept in line with orders.

STATEMENT ON RCA-VICTOR MERGER

The recently announced unification of the Radio Corporation of America and the Victor Talking Machine Company which was approved by the respective boards of these two companies on January 4th of this year, contemplates, according to a statement just issued by J. L. Ray, Vice-President and General Sales Manager of the Radio Corporation of America, no alteration in RCA's present distributing and merchandising methods and no immediate change in the Radiola line.

Mr. Ray further states that he is very optimistic as to the benefits which will accrue to both the RCA and the Victor line of merchandise through the now unified laboratory and factory facilities of the two companies. The mutuality of interest of these two companies make this step an important milepost in their respective and now mutual progress.

AMRAD TO INCREASE MERSHON PRODUCTION

Basing its calculations upon sales for the past year, the Amrad Corporation, Medford Hillside, Mass., is preparing to more than double its output of Mershon condensers, on which it has exclusive patents. It has recently acquired a plant in Davis Square, Somerville, which will be used exclusively for the manufacture of condensers.

Sales records for the past year showed that the present Mershon condenser plant, which is a part of the Amrad factory, would be insufficient to meet the demands of production. It will, however, continue to operate in 1929, with a capacity of 9,000 condensers a day.

A roomy, well-located factory in Somerville, with distinct source of power, water and gas as well as convenient railroad facilities, will be used by the Amrad Corporation to bear the brunt of Mershon condenser output. The new plant has a capacity of 12,000 condensers a day. The total production of condensers from both plants is guaranteed by the Amrad executives to be more than 5,000,000 a year. There are at present more than three-quarters of a million Mershon condensers in use in United States and Canada.

TEMPLE CORPORATION ABSORBS SLEEPER RADIO

Of considerable importance to the trade comes the announcement that Temple Corporation of Chicago has absorbed the business of the Sleeper Radio & Manufacturing Company, of Long Island City, New York. The Temple Corporation, long prominent in speaker manufacturing, joins forces with one of radio's pioneer set manufacturers. The Sleeper Radio & Manufacturing Company, in existence practically since the beginning of radio, adds their wide experience and knowledge to that of the Temple organization and the new combination promises extensive and far reaching plans for 1929.

Effective at once, Gordon C. Sleeper becomes head of the Temple Corporation sales organization. Mr. Sleeper, for many years prominent as the head of the Sleeper Radio & Manufacturing Coompany.

The announcement of the appointment of Fred W. Piper as assistant sales manager is also released. Mr. Piper is well known in radio circles, particularly in the middle West, for his work in the sales of Peerless reproducers and previous to that time for his activities with the Amplion Corporation.

The new Temple picture will assume tremendous proportion in the year 1929. In a little over twelve months the present Temple factory has been outgrown, a factory which it was believed would be adequate for years to come. The Temple factory is now being moved to the Clearing Industrial District of Chicago, where full facilities are available to take care of enormous production plans for the 1929 season.

UTAH LICENSED TO MANUFACTURE NEW BI-LATERALLY OPERATED CONDENSER SPEAKER

Utah Speaker developments show great promise for 1929–30. Improved standards for this coming year in Magnetic and Dynamic construction are assured from extensive developments made by the Utah Radio Products Company's Engineering Laboratories, it was announced here by E. S. Riedel, General Sales Manager.

Utah has been licensed by the German inventor, Hans Vogt, to manufacture in the United States the new bi-laterally operated condenser speaker. For those who are interested in a condenser type speaker, Utah is in position to offer a greatly improved speaker, over the old type unilateral construction.

Utah has had the most successful year in its history. Popular demand throughout the United States and foreign countries has brought about a 400% increase in sales. Production is now running at full capacity and enough business has been booked by the sales department to justify keeping this pace for four months to come.

FRESHMAN LEASES NEW FACTORY

C. A. Earl, President of the Chas. Freshman Co., and Chairman of the Board of the Freed-Eisemann Radio Corporation, made the following statement recently:

"We have just signed a lease with Cross & Brown, brokers, for a new manufacturing plant which will mean a tremendous saving to the corporation. This factory is located at Clifton, N. J., 12 miles from New York City, right in the heart of the labor market of Newark, Paterson and Passaic. It is an ideal plant for economical manufacturing. There are over six acres of floor space on one floor, with sawtoothed roof construction. It is a fireproof plant, practically new, having been built only seven years ago, and provides ample receiving and shipping facilities directly on the Erie Railroad.

"At the present time we are operating two factories, one in the Bronx and one in Brooklyn, with an assembly plant in Chicago. The Freed-Eisemann Company is also operating a factory in East New York. We are going to consolidate the manufacturing operations of both the Freshman and the Freed-Eisemann companies which will mean a tremendous saving of rental, overhead and efficiency, amounting to several hundred thousand dollars a year under present operating expenses.

"The economical layout of this new factory will enable us to decrease costs and expenses for operation, and will result in a large increase in our volume of business for the year 1929."

HOWARD RADIO EXPANDS

Mr. A. A. Howard, President of the Howard Radio Company, Chicago, Illinois, announces that Messrs. John H. Parnham and James L. Barron, South Haven, Michigan, have acquired substantial stockholdings in the Howard Radio Company and will become directors in this company.

Simultaneously with this announcement, Mr. Howard states that his company has been considering for some time the advisability of moving its plant to some city near Chicago, where it could enjoy good shipping facilities, secure the advantages of a closer and more economical contact with fine cabinet making facilities, and in

response to this desire, the Howard Radio Company will shortly move its plant to South Haven.

Mr. Parnham and Mr. Barron are well known and highly respected members of the piano trade, being President and Vice-President, respectively, of the Everett Piano Company, one of the largest and most successful manufacturers of high grade grand pianos in the piano industry, with valuable dealer connections from Coast to Coast. With their wide acquaintance and experience in the musical field, coupled with the added advantage to the Howard Co. of being able to utilize the Everett's cabinet factory, which is conceded to be one of the most modern and efficient plants in the entire wood-working industry of the country, it is believed that their affiliation with the active management and affairs of the Howard Co., will greatly facilitate the already strong and rapid growth of this company.

Mr. Howard also states that this arrangement makes a factory site of ten acres with more than five and one-half acres of floor space immediately available for the manufacture of a complete unit.

NEW PERRYMAN PLANT GROWING FAST

On Wednesday, January 19, 1929, the corner stone was laid of the new Perryman Electric Tube plant, located on the Hudson Boulevard at 13th Street, in North Bergen, New Jersey.

George Perryman, wielded the trowel with the dexterity of an experienced mason, and within a few minutes the brick layers were well under way with the front and side walls.

Immediately prior to the laying of the corner stone a luncheon was served at the Lincoln restaurant, in Union City, at which time Mr. Joseph Pulvermacher, Vice-President of the Chase National Bank, offered a toast to the continued success of the organization, and sketched the rapid growth of the company, and touched on the personalities of the Perryman executives.

When completed, the factory will comprise two manufacturing floors over 200 feet in length, allowing for the most modern straight-line production methods. It will be completely equipped with the most modern machines and methods known to the tube-making art, and give the company an increased production of five to six times over its present capacity.

The front of the structure will be three stories in height, providing complete facilities for executive and general offices. Provision has been made for large and thoroughly equipped chemical and electrical laboratories which play so important a part in the development of new tubes and improved production processes. It is expected that the new plant will be completed and in actual production by May 1st.

Inasmuch as it is located within half a mile of the present Perryman plant, it will be possible to transfer the entire factory staff without loss of a single day's production.

T. C. A. EXPANDING

Ross D. Siragusa, President of the Transformer Corp. of America, announces that his company is making great plans for 1929. They are getting tooled up for production of 40,000 transformers and choke coils per day. During 1928, their production was four times greater than the previous year.

Just recently the company's stock was listed on the market, and with the money obtained they are carrying on this expansion program, which carries with it removal on February 15th to factory space aggregating eight times their present size. They will have 50,000 square feet.

The officers of T. C. A. are: Ross D. Siragusa, President; Jas. J. McCarthy, Vice-President and Production Manager; E. J. Doyle, Secretary and Chief Engineer; J. J. Kahn, Sales Manager.

FEDERAL AT PEAK OF PRODUCTION

January production at the plant of the Federal Radio Corporation, Buffalo, N. Y., reached its peak during the month just closed, according to W. R. McAllister, sales manager of the company. Ordinarily the first month of the year is somewhat inactive due largeiy to production preparation work on new sets to be introduced later in the season. The company set a precedent this year, however, in introducing its new Ortho-sonic "K" models, which are six tube sets, using a 222-type A.C. tube, at the outset of the new year.

AEROVOX EXPANDS AGAIN

So great has been the demand for Aerovox products during the past few months that the 10,000 square feet of extra space added to the Aerovox plant last July has proved inadequate to meet the demands for increased production.

In spite of the additional space, the installation of special machinery to speed up production and the use of extra shifts, it has been found necessary to add another 15,000 square feet to the plant.

ARCTURUS CHANGES NAME

The name of the Arcturus Radio Company of Newark, N. J. has been changed to the Arcturus Radio Tube Company. The change is merely a matter of policy and the same personnel continues to operate its five New Jersey A.C. tube plants.

NEMA SPRING MEETING

The Spring meeting of the National Electrical Manufacturers Association will be held at The Homestead, Hot Springs, Va., May 20-25, 1929.

NEW SLEEPER EXECUTIVES

Announcement is made of important changes in officials of the Sleeper Radio & Mfg. Corp., of Long Island City, N. Y.

Hal. P. Shearer, formerly general manager of the Splitdorf Radio Corporation, of Newark, N. J., assumes the important post of vice-president and general manager of the reorganized Sleeper company.

Mr. Shearer's right-hand man will be A. N. Clifton, a newcomer in New York who is the new sales manager. Mr. Clifton was formerly sales manager of the Alden Manufacturing Co., of Springfield and Brockton, Mass.

ROBERT GAIR CO. IN MERGER

The Robert Gair Company, of New York, announces a merger with the Warner and Childs Co., Inc., Medford, Mass., manufacturers of corrugated board products. R. M. Taylor, president of the Warner and Childs Co., Inc., will remain with the management and the personnel of the entire concern will remain intact.

GENERAL AMPLIFIER CO. FORMED

Announcement has been received of the formation of the General Amplifier Company, located at 27 Commericial Ave., Cambridge, Mass.

The company has been incorporated for the purpose of manufacturing power amplifiers of four types for use in homes and for public address work in schools, theatres and out-of-doors.

The General Amplifier Company occupies 2 200 square feet of space in a modern, five-story building.

Mr. A. R. Wilson, formerly of the General Radio Co., is president of the new corporation.

SILVER-MARSHALL TO ENTER RECEIVER MARKET

Silver-Marshall, Inc., of Chicago have plans under way for the manufacture of a complete line of licensed receiving sets, which will probably be introduced in the early Spring.

The indications are that a large quantity of the licensed chasses will be sold under private brand labels.

Silver-Marshall has no intention of discontinuing the manufacture of parts; the manufacture of receivers will be an addition to their present activities.

WESTINGHOUSE ELECTS CHAIRMAN OF BOARD

Andrew Wells Robertson, of Pittsburgh, president of the Philadelphia Company, was unanimously elected chairman of the board of directors of the Westinghouse Electric and Manufacturing Company in a meeting of that board, held in its offices at 150 Broadway, New York City, January 16.

Mr. Robertson will withdraw from his other business activities and devote his entire time to the Westinghouse Company. For the present his official headquarters will be in Pittsburgh.

Henry Bedinger Rust, President of the Koppers Company, and an official and director of many other companies was elected a director of the Westinghouse Electric and Manufacturing Company at the same meeting. Mr. Rust will continue to serve as head of the Koppers Company.

Since the death of Mr. Guy E. Tripp in 1927, the chairmanship of the board has been temporarily held by Paul D. Cravath, General Counsel of the Westinghouse Company. Mr. Cravath will continue in the capacity of General Counsel.

R. M. WISE JOINS GRIGSBY-GRUNOW

R. M. Wise, formerly chief engineer of E. T. Cunningham, Inc., has resigned his position with that company, and will join the Grigsby-Grunow Co., of Chicago, as director of their tube laboratory.

Mr. Schmidt, long connected with E. T. Cunningham, Inc., is to take over Mr. Wise's position.

L. M. CLEMENT ELECTED PRES. OF RADIO CLUB OF AMERICA

Lewis M. Clement, head of the Kolster Radio Corporation research laboratories in Newark, aand a prominent radio engineer, has been elected president of the Radio Club of America for the year 1929.

The Radio Club, a national institution of 500 members with headquarters in New York, has played an important role in the development of radio in America. Founded in 1909, it has among its members most of the leading radio scientists in the country, who have brought before the organization the results of their research. Professor L. A. Hazeltine's announcement of the neutrodyne theory was first made public in a paper read before the Radio Club.

HERTZBERG JOINS PILOT

Robert Hertzberg, for the past two and a half years managing editor of "Radio News" Magazine, announces his resignation from that position, to take effect January 15th. He will join the forces of the Pilot Electric Mfg. Company, of Brooklyn, in the capacity of technical and editorial consultant, and will also devote considerable time to free-lance writing.

W. T. TABER JOINS STEVENS ENGINEERING STAFF

W. T. Taber, well-known radio engineer and specialist in amplification and reproduction, has joined the engineering staff of the Stevens Manufacturing Corporation, New York City, manufacturers of Stevens loud speakers and Burtex acoustic materials. Mr. Taber will be remembered as the former chief engineer of the Daven Radio Corporation, of Newark, N. J., as well as chief engineer of the Tilletson Transformer Company, of Orange, N. J. His engineering experience also includes his previous connections with the Liberty Electric Company, the R. E. Thompson Company, and the old Marconi Company. Mr. Taber is now in charge of loud speaker and transformer research and engineering for the Stevens Manufacturing Corporation.

WESTERLUND GOES TO POLYMET

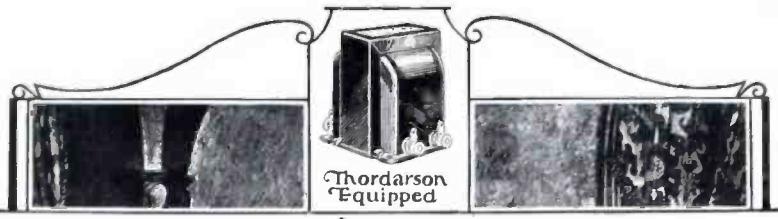
Geo. E. Westerlund, Purchasing Agent of the Charles Freshman Co., Inc., for the past three years has resigned from that company to take over new duties as head of the Purchasing Department of the Polymet Manufacturing Corporation.

Mr. Westerlund's wide experience includes Purchasing and Production activities for the Charles Freshman Company as well as a previous connection with the New York Edison Company in a designing and testing capacity. He has just returned from a four months' tour of Europe where he studied radio development on the continent. Mr. Westerlund will take over his new duties at once, making headquarters in the executive offices of the Polymet Manufacturing Corporation, 599 Broadway, New York City.

RHINOW OF KOLSTER PROMOTED

Announcement has just been made that Mr. A. W. Rhinow has been appointed Assistant Sales Manager of the Kolster Radio Corporation.

Mr. Rhinow has been a member of the Kolster merchandising division for three



Thrilling Tone Purity
"Radio's Richest Voice"

We have now been using Thordarson transformers for some four years, which should be proof conclusive that we think them capable of maintaining the high quality of Sparton Radio Receivers, which we so jealously guard.

President-General Manager
The Sparks-Withington Company

THE manufacturers of the world's finest receivers realize the important relationship between the choice of transformers (power supply and audio) and the performance of their instruments. Almost universally they have turned to Thordarson as the source of their transformers.

In Thordarson Power Supply Transformers they have found an efficiency of design, an abundance of power and a constancy of performance that makes their power unit free from service calls; and in Thordarson Audio Transformers a fidelity of reproduction that renders their receivers musical instruments of the highest caliber.

The purchaser and builder of radio receivers who seeks the ultimate in performance will insist on Thordarson Radio Transformers.

THORDARSON ELECTRIC MFG. CO.
Transformer Specialists Since 1895
Huron, Kingsbury and Larrabee Streets, Chicago, Illinois

THORDARSON
RADIO TRANSFORMERS

SUPREME IN MUSICAL PERFORMANCE

years, closely associated with the work of the Sales Manager. In that time he has become well acquainted with the Kolster distributors, who are congratulating him on his appointment.

Before coming to the Kolster organization in 1925, Mr. Rhinow was active in the radio and phonograph field for 12 years. He was assistant general manager of a distributor's organization in Philadelphia for four years and for eight years he was connected with the Thomas A. Edison Laboratories in the phonograph industry, in the sales department and as promotion manager. Through this experience he has become familiar with dealer and distributor problems and is well qualified for his new position.

R. H. CANNING HANDLING FEDERAL WEST COAST SALES

R. H. Canning, more familiarly known in the trade as "Dick Canning," has been made Pacific Coast Supervisor for the Federal Radio Corporation, confining his efforts entirely to the supervision of sales and service for Federal Ortho-sonic wholesalers and retailers west of the Rockies. Mr. Canning will make Los Angeles his headquarters.

Arrangements for distribution of Federal Ortho-sonic radio in the Duluth, Minnesota, territory, have just been completed with the Duluth Paper and Specialties Company of that city, according to an announcement from the Federal Radio Corporation of Buffalo, N. Y., manufacturers of the receiver.

A. N. FRENCH WITH ARCTURUS

It is announced that A. N. French has joined the sales staff of the Arcturus Radio Tube Co.

Mr. French was formerly associated with the miniature lamp department of the American Eveready Co. of Long Island City, as sales representative and assistant to the sales manager.

Mr. French will cover New York State and part of New England for Arcturus.

NEW SALES REPRESENTATIVE FOR ARCTURUS

John L. King, formerly of the Air Reduction Sales Corporation, has joined the sales department of the Arcturus Radio Company as a sales representative covering southwestern territory.

Previous to his association with the Air Reduction Company, Mr. King was instructor in electrical welding at the Detroit Institute of Technology.

MADE SALES MANAGER OF CECO

Edward T. Maharin has been made sales and field manager of the CeCo Manufacturing Company, Providence R. I. He previously had been special representative of that company.

GOLENPAUL INCREASES LATITUDE OF WORK

Charles Golenpaul, sales manager of the Clarostat Manufacturing Co., Inc., has rearranged the entire sales and publicity program for that company that it may coincide with the increased production program laid out by the factory and with the announcement of the new series of wirewound resistors.

Mr. Golenpaul states that foreign and domestic reports have indicated the beginning of a large demand for the new products.

Charles Golenpaul
Sales Manager, Clarostat Manufacturing Co., Inc.

NORMAN F. DAW NOW DE FOREST ASSISTANT SALES MANAGER

At this time H. C. Holmes, general sales manager of the DeForest Radio Company, announces the appointment of Norman F. Daw as assistant sales manager.

"Mr. Daw is an experienced salesman and a close student of merchandising," states Mr. Holmes. "He studied salesmanship at Boston University. He sold electrical supplies for a Boston jobber, covering the New England territory. For the past few years he has represented the Chase-Shawmut Company of Newburyport, Mass., in the territory east of Chicago and south to New Orleans."

The appointment of H. A. Hutchins, Jr., as New York district sales manager is also announced.

Mr. Hutchins comes direct from the Kolster Radio Corporation, where he was assistant general manager of the Merchandising Division. He is a graduate of Annapolis and a post graduate of Massachusetts Institute of Technology. He served in the corps of construction of the Navy. During the past six years, Mr. Hutchins has been engaged in selling, and his experience covers the electrical, automotive and radio fields. Three years ago he joined the Kolster organization as assistant sales manager.

RADIO AND ASSOCIATED STOCK QUOTATIONS

Company	Dec. 3	Jan. 3	Feb. 4
Acoustic Products	24	18½	14
All-Am. Mohawk	40	35½	35
American Bosch	41⅝	42	41⅜
Bruns - Balke Collen (Com.)	54¼	52⅜	52⅜
CeCo Mfg.	68	60½	83
Crosley "A"	87½	117	185
Davega	38⅜	36	34¾
De Forest	22¾	25½	23⅝
Dubilier	10	9	11
Erla	22	14⅜	19½
Fansteel	15⅛	12½	17
Formica	24	30	34¾
Freed-Eisemann	5⅛	5	3⅞
Freshman	13⅛	11⅞	9¾
General Elec. (Com.)	197	245¼	251
Gold Seal	19⅛	25	38
Grigsby-Grunow (new)	143	148⅜	168½
Hazeltine	50	48	46½

Company	Dec. 3	Jan. 3	Feb. 4
Kellogg	19¼	17¾	17½
Kodel "A"	24¾	17	24
Kolster	91¼	75½	68½
Magnavox	15	11½	9
Polymet	52	....	....
Radio (Com.)	407	394¾	393
Raytheon	69	59	60
Sangamo	35	37¼	42¾
Sonatron	157½	....	n. 43½
Sparks-Withington	170	180	175
Stromberg Carlson	30	31	30⅞
Stewart-Warner	116¼	123⅝	141
Utah	56	46	52½
Tower	9	8¾	16¼
Union Carbide (Com.)	199¾	206¾	220
Victor (Com.)	138½	152¼	155¼
Westinghouse	135	143	164¼
Weston (Com.)	23½	22⅞	22
Zenith (new)	57	54	59¾

PRECISE APPOINT NEW METROPOLITAN AGENTS

The Precise Products, Inc., of Rochester, N. Y., have appointed the Gotham Engineering and Sales Co., of 50 Church Street, New York City, to handle the sales of their complete line of variable condensers, friction drives, and dials in the New York Metropolitan District and the State of New Jersey.

Bert Smith and Al Daniels, of the Gotham organization, are well known to most of the trade through their previous connections. They are also Metropolitan Agents for The Potter Co., of North Chicago, Ill.

RESISTOR PATENT GRANTED ELECTRAD

Letters patent No. 1,607,406 has been granted to Electrad, Inc., on a new type of resistor, developed two years ago, by Henry G. Richter, Chief Engineer of the company.

The resistor unit, due to its unique construction, provides a high resistance element which can be located within a small available area, and being flexible, can, if necessary, be bent upon itself after assembly and compacted to a size that will allow it to fit in a very small space. In addition, a relatively high value of resistance can be obtained within a short unit of length.

Another very practical advantage gained by the use of this invention is that the unit itself can serve practically as an attachment by means of electrical terminals at opposite ends of the resistor.

J. F. BICHL JOINS GLOBE WERNECKE

Mr. J. F. Bichl, vice-president and general sales manager of the Kodel Electric & Manufacturing Co., of Cincinnati for the past ten years has joined the Globe Wernecke Co., of Cincinnati as sales manager of the Radio Furniture Division.

B. S. HILL JOINS S-M

Mr. B. S. Hill, formerly with the Chicago office of Herbert H. Frost Co., has joined the forces of Silver-Marshall and is in charge of sales to the radio manufactuers.

LOVETT, OF FROST, TO CHICAGO

Jack Lovett, for several months in charge of the New York office of Herbert H. Frost, Inc., has been put in charge of the Chicago office, located at 160 N. La Salle St.

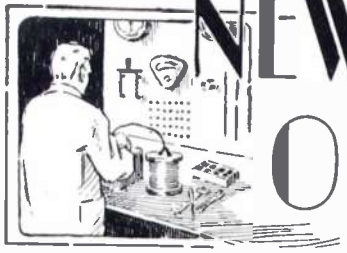
COMPENDIUM OF RADIO RECEIVERS

The third edition of the compendium of Radio Receivers and Manufacturers prepared by General Contract Purchase Corporation is now being distributed to the various offices and subsidiaries of the company throughout the country. This is the only complete list available which gives all the licensed sets, together with their prices, and the number and types of tubes used.

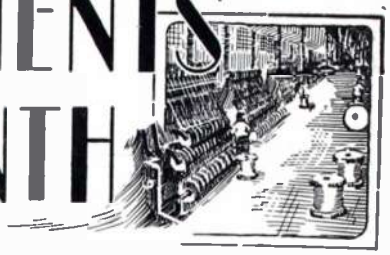
NEW BOOK FOR SERVICE MEN

The Radio Treatise Co., of 1440 Broadway, New York City, publishers of books written by John F. Rider, announced a revised edition of the Treatise on Testing Units for Service Men. This new issue is printed and bound, contains approximately 18,000 words describing the most modern testing units.

Constructional details inclusive of parts used are given for each tester and among the numerous portable and stationary testing units are full details, including the wiring diagram of the Weston 537 AC-DC set and tube tester. The table of contents includes such items as tube reactivator; calibrated vacuum tube bridge, Weston model 537 AC set tester, B Eliminator tester, signal generator for receiver testing, radio frequency oscillator, capacity tester, resonance indicator, multi-range meters, complete test bench panel for service station, resume of meter design, etc. The book is 48 pages, 6 in. x 9 in. and lists at $1.00.

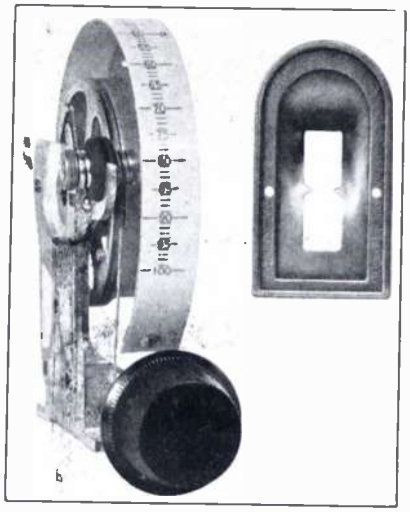


NEW DEVELOPMENTS OF THE MONTH



S-M TYPE 810 DRUM DIAL

The new S-M type 810 drum dial illustrated herewith presents a number of interesting features. In construction it is of the strictly all-metal die-cast type, the only exceptions being the translucent celluloid scale, the rubber bumper stop, rubber insulating bushing for the miniature lamp socket used to illuminate the dial scale, and the bakelite control knob. This new illuminated dial is of the positive, so-called "string drive" type, with no backlash. As a matter of fact, no string is employed in the dial, the connecting link between shaft and drum being a substantial bronze cable. This cable, being anchored both to drum and drive shaft, absolutely prevents backlash or slippage, no matter how stiff the dial "load" may be. Three takeups are provided, one a service "screw adjustment" on the drum, and the other two collars located on the drive shaft—though stretching of the bronze cable is an improbability.



The new Silver-Marshall drum dial and escutcheon.

The drum itself has an outside diameter of 3⅞", which provides a useful scale length of about 6" for the 100 point scale. Each division is a full 1-16" in width, so that exact readings to ½ division or less can easily be made. The illuminating lamp placed directly behind the dial scale enables readings to be made even upon a set located in the dark.

The dial drum itself rotates in a die-cast bracket which carries the illuminating lamp socket and the ¼" drive shaft. This bracket is arranged so that when fastened to a chassis it is sufficiently rigid to provide all necessary mounting for one, two, or three gang condensers. Any standard condenser may be easily attached by virtue of five mounting holes provided in the bracket. On the other hand, if the dial is to be used in a receiver in which the condenser is firmly mounted upon a chassis, there is no need to anchor the dial itself permanently. It is necessary only to slip the drum over the condenser shaft, tighten the set screws, and allow the bracket and drive shaft to "float." This assembly cannot turn, once the drive shaft has been inserted through a ¼" hole in the front panel or escutcheon.

The whole assembly is extremely compact, being only 1 1/16" wide exclusive of knob and lamp socket, and 2" from front or back of dial to shaft center. The dial is manufactured in two types — 810L (bracket at left of drum), and 810R (bracket at right of drum). Both types rotate in the same direction for increase or decrease. Both types are priced at $3.75 each, list, complete with knob and lamp socket, but no lamp, and may be used with the S-M 807 single window escutcheons (illustrated) at 50c list, or with the new 811 and 812 single window escutcheons shortly to be released.

This dial is manufactured by Silver-Marshall, Inc., 846 West Jackson Boulevard, Chicago, Ill.

WEBSTER "FIDELITONE" AMPLIFIERS

The Webster Company, 850 Blackhawk St., Chicago, are producing, under the trade name of "Fidelitone," a complete line of amplifiers for use with either phonograph, microphone or radio.

The small amplifier uses a single 250 tube with a 281 rectifier. Current is supplied for a dynamic field. The speaker mounts on the amplifier. The combination will fit the majority of console cabinets.

The intermediate amplifier has two stages using a 226 tube followed by a 250 and the large amplifier has three stages using a 227 followed by a pair of 226 tubes in push-pull followed again by a pair of 250's in push-pull.

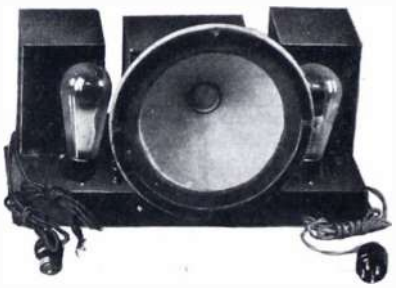
The input audio transformer is provided with windings for the average magnetic phonograph pickup and a double button microphone. These windings are so arranged to obtain the maximum transfer of energy between the two windings in use. The intermediate transformer placed between the 226 and 250 tubes on the intermediate amplifier has its winding so arranged to minimize secondary capacity effects. The windings are so arranged also to counteract any reaction prone to occur in amplifiers giving extremely high amplification.

The output choke has the optimum air gap for the number of turns, length and cross section of the core. All the cores used are high silicon content scaleless steel. Although no oxide film is present, a special process through which the metal is placed prevents actual magnetic contact between adjacent laminations, it is claimed.

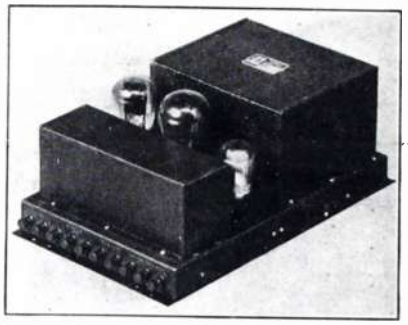
As a matter of standard of measure, it might be said that the larger amplifier requires as a minimum, two dynamic speakers which it can drive to absolutely their full limit.

Both sizes of amplifiers supply voltage for the dynamic field coils. By connecting two posts provided, the field connection can be eliminated and a group of magnetic speakers used.

As in the amplifier transformers, the power transformer and choke are assembled on shell type laminations to eliminate extraneous fields and consequent interaction.



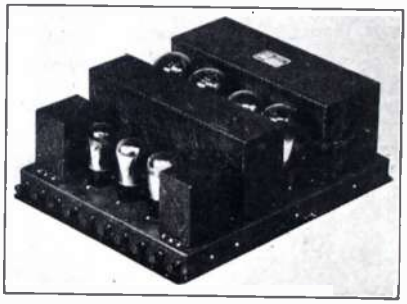
Webster power amplifier and dynamic speaker.



Webster power amplifier using a single 250 tube.

On the smaller amplifier, it was found that the mode of arranging and connecting the windings is important. The primary was placed next to the core with a shield winding over it. This completely shields the primary because the core is grounded. Thus line pickup is eliminated.

The rectifier filament is placed next, after which comes the high tension secondary, the outer end of which is its low potential end. The remaining filaments then follow. This new arrangement causes the outer layer of the high tension winding to act



Webster double push-pull power amplifier.

as a shield effectively shielding it together with its rectifier filament between the regular shield and the outer layer of the high tension winding acting as a shield because it is connected to the lowest potential point of the amplifier. Thus the entire high tension section is isolated from the rest of the coil preventing any undesirable interaction between it and the filaments.

Another feature of this arrangement is that the minimum potential difference exists between any two adjacent windings reducing the danger of insulation puncture and consequent failure of the unit.

This high tension winding shielding arrangement is accomplished in the full-wave rectifier transformer used in the large amplifier by winding this secondary in two sections, connecting the outer leads of the two coils to the lowest potential end of the amplifier system.

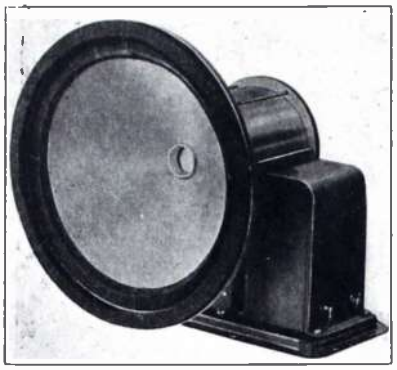
No gummed paper of any sort is used to eliminate the presence of any moisture within the coil. The coils are thoroughly preheated before impregnation. Thus, every precaution is taken to absolutely prevent leakage of any sort. It is said that one thousand volt megger tests show infinity between any windings or any windings and

core. This condition also exists in all other windings in the amplifiers.

The power supply transformer is designed without a primary tap. The voltages are such that the amplifiers operate efficiently at 95 v. line. At 135 v. line, the maximum permissible voltages are applied to the tubes, therefore, at usual line voltage, the amplifier tubes are being operated at a conservative rating. At no time can the tubes be overloaded.

NEW MUTER DYNAMIC SPEAKERS

The Leslie F. Muter Co., Inc., of 8444 South Chicago Ave., Chicago, have announced a complete line of dynamic type speakers of improved construction, to meet practically every requirement.



New Muter dynamic speaker chassis.

The dynamic speaker unit comes in three types: 6 volts D. C., 90 volts D. C. and 110 volts A.C. These three primary types are obtainable in both cabinet and console. The prices range from $29.50 to $74.50.

THE CLAROSTAT "HUM-DINGER"

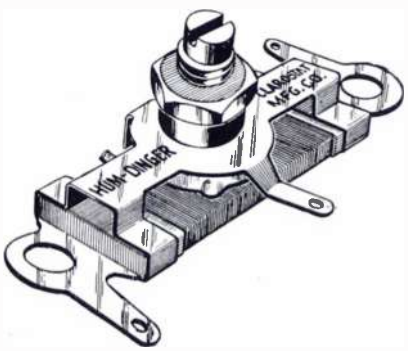
The Clarostat Manufacturing Co., Inc., of 285 N. 6th St., Brooklyn, N. Y., have introduced an improved form of center-tap resistor, for hum control in A. C. tube circuits, under the trade name of "Hum-Dinger."

The "Hum-Dinger" is exceedingly small and foolproof and is essentially a Clarostat strip resistor. It is provided with a contact arm which swings over the center half of the winding, since the ends are never utilized in practice. Adjustments are made with a screwdriver blade engaging with the recessed slotted head of the shaft.

The "Hum-Dinger" is available as a one-hole mounting job in the usual panel or sub-panel applications, and for baseboard mounting, by means of its end lugs which are provided with screw-holes. Connections are made to these soldering tabs.

No screws or nuts are used in its assembly. There is nothing to get loose or wear out.

The range of the standard "Hum-Dinger" is 30 ohms. Can also be made up in any desired range from 10 to 200 ohms.



The Clarostat "Hum-Dinger."

CLAROSTAT WIRE-WOUND RESISTORS

The Clarostat Manufacturing Co., Inc., of 285 N. 6th St., Brooklyn, N. Y., announces at this time a complete line of

Clarostat wire-wound resistor.

flat wire-wound resistors for all applications in which fixed resistors can be employed.

The fibre support, upon which the wire is wound, is threaded in order that the wire may be partly embedded. This prevents slippage and short-circuiting of the turns. The sides of the fibre support are rounded, for less strain on the wire.

The metal ends are firmly clamped on the winding, for positive contact and mechanical strength.

The accurate resistance value is stamped on one end of each unit, so that there can be no errors.

Also furnished in adjustable types, with a sliding clamp for varying the resistance value, when desired.

Made in all necessary resistance ranges and sizes, from 1 to 2,000 ohms, fixed or adjustable.

AMPERITE LIN-A-TROL

The Amperite voltage regulator operates on the thermo-electric principle. That is, its resistance varies very rapidly with small variations from any pre-determined current. The voltage across the Amperite Lin-A-trol varies from 20 to 40 volts or 100% with a 10% increase in current.

The Amperite Lin-A-trol consists of an Amperite voltage regulator and an auto-transformer. This combination permits the use of Amperite without any changes in the receiver. When a receiver is built to include Amperite no auto-transformer is

The Amperite Lin-A-Trol, which consists of a special type Amperite and an auto-transformer.

necessary. Amperite not only cuts the voltage down when it is high, but raises the voltage when it is low.

The auto-transformer is designed as follows — A typical receiver using 4 UX226, 1 UX171A and 1 UX227 and 1 UX280 tube ordinarily requires 0.45 amperes in the primary of the receiver at 110 volts. When the line voltage is 95 volts the Amperite will have a 20 volt drop across it. The transformer will therefore be required to have a 95 minus 20, or 75 volt primary. An auto-transformer of this type has an efficiency greater than 95%. In order to have the same wattage in the primary as at 110 volts, the current in the 75 volt primary will have to be 0.45 x 110-75 or approximately 0.6 amperes. The Amperite for this receiver will pass 0.6 amperes and vary from 20 to 40 volts. This Amperite is number 6-20. An Amperite that will pass 0.7 amperes and has a drop of 20 volts when the line voltage is 95 is called 7-20, etc.

The second requirement of an efficient regulator is that it should not consume too much power. Amperite 6-20 consumes on the average 0.6 amperes x 30 volts or 118 watts which is extremely low.

The third requirement is that the regulator should be compact. When the Amperite is used in a set which is especially built for it, all that is necessary is the Amperite itself. The size of the latter is 1¾" diameter and 3" high, which is smaller than a standard A.C. tube. When it is necessary to use the Amperite in conjunction with an auto-transformer, as in the Amperite Lin-A-trol, the space necessary is approximately 4 x 4 x 6 inches.

The Amperite Lin-A-trol, therefore, consists of an auto-transformer and Amperite which controls the voltage in the receiver to within plus or minus 5%, consumes approximately 20 watts and is extremely compact.

The Amperite Lin-A-trol is manufactured by Radiall Co., 50 Franklin St., New York City.

WESTON MINIATURE CURRENT TRANSFORMER

The Weston Electrical Instrument Corporation, of Newark, N. J., recently placed on the market a miniature current transformer, styled Model 539, for use in connection with a 1-ampere A. C. instrument. When so used, current measurements can be made all the way from 0.2 to 200 amperes.

Model 539 is an exceptionally useful transformer for both industrial and educational purposes because of its exceedingly

The Weston miniature current transformer, permitting current readings from 0.2 to 200 ampers.

small size, light weight, ready portability, speed of operation and wide range of measurement.

It has a 1-ampere secondary. The advantages of this transformer over those with 5-ampere secondaries is that it permits the measurement of currents below 1 ampere.

Model 539 has four self-contained primary ranges of 2, 5, 10, 20 amperes which are changed by means of a unique range changing switch on the top of the transformer. Ranges of 200, 100 and 50 amperes are also available by simply passing the conductor, one, two or four times through the hole in the transformer provided for that purpose. This is known as an inserted primary.

The Model 538 Transformer is primarily designed as a companion instrument to the Model 528 Ammeter and is completely inclosed in a mottled red and black bakelite case to match. It has a guaranteed accuracy of 1% from 25 to 150 cycles. The maximum working range is 750 volts.

While it is primarily intended for use with ammeters, it can be used, however, with wattmeters with somewhat impaired accuracy.

The price of the Model 539 Transformer is $28.00. The price of the Model 528 Ammeter is $13.50.

NEW TWO-BUTTON MICROPHONE

With the advent of the generalized use of public address systems for Auditoriums, Stadiums, Churches, Schools, etc., there has recently been a demand for a high grade microphone, one that will repeat accurately the sound waves of voice or music. The Electric-Acoustic Products Company, of 55-57 East Wacker Drive, Chicago, have developed a microphone which fulfills all requirements of a high grade microphone for radio broadcasting, public address systems, and sound recording.

The microphone is of the double button, stretched diaphram type. Each button has a resistance of one hundred ohms, designed to work into the standard 200 ohm microphone transformer primary. Because

The new Electric - Acoustic Products Co. two - button microphone.

of the uniform response to all audible frequencies, voice and music can be reproduced or recorded with exceptional fidelity. The microphone is remarkably sensitive despite the absence of diaphram resonance, and with a very low "microphone hiss." Along with these merits, the microphone is very rugged and not susceptible to the more common injuries. The precise mechanical construction and bright finish makes it a beautiful instrument as well as a highly efficient one.

Detailed information may be obtained by writing the manufacturers.

THE NEW BELDENTENNA

The Belden Manufacturing Company, 2300 South Western Ave., Chicago, Ill., announce the Beldentenna, a new addition to their line of radio accessories. The Beldentenna is a unique combination of radio antenna and extension cord, that provides a self-contained antenna and also serves as an extension cord to connect electric radio sets or power units to the light socket.

The new Beldentenna.

The Beldentenna consists of a seven-foot extension cord, one end of which is fitted with a Belden Soft Rubber Plug for inserting into the light socket. The opposite end is provided with a Belden Bakelite Floor Type Receptacle for the radio receiver plug, and also a lead to attach to the antenna binding post of the set. The antenna is very selective, gives satisfactory volume in most installations, and eliminates the need of an outdoor or indoor antenna, lightning arrester, lead-in strips and other antenna accessories.

DUBILIER PL-1120 CONDENSER BLOCK

The Dubilier PL1120 condenser block is announced at this time by the Dubilier Condenser Corporation of New York City. This block is intended primarily for the Thordarson R-180 power compact, but may be employed in any equivalent power supply circuit. It contains the following condenser sections: 2 mfd., 600 volts; 4 mfd., 400 volts; 4 mfd., 400 volts; and four 1 mfd., 200 volts. The terminals, in the form of soldering tabs, are arranged on top and on the sides of the metal case, for simplified wiring.

WODACK PORTABLE ELECTRIC DRILL

The Wodack Electric Tool Corp., of 4627 West Huron St., Chicago, are now producing a new ⅜-inch portable electric drill. This new tool is well powered with a General Electric universal motor of the variable speed type, controlled by a trigger switch.

Besides drilling, it can be used for odd jobs of grinding and buffing, which further increases its utility. A stand can be furnished for holding the drill vertically or horizontally.

NEW SHORT WAVE "AERO-CALL"

A new short-wave converter is now in the market and already in the hands of leading jobbers and dealers, that fits all makes of present radio receivers, both A. C. and D. C. This new product, the Aero-Call, is a complete factory-built short-wave radio adapter set that plugs right into the detector socket of any make of radio and transforms the radio set into a modern short-wave receiver.

This new device now makes it both easy and practical to utilize one's radio set for short-wave reception, as the Aero-Call utilizes the power and hook-up of the regular receiver, and all that is required is to pull the detector tube out of the set and plug in the Aero-Call socket whenever short-wave reception is desired.

Being equipped with a special filter control, the annoyance or motor-boating is entirely eliminated.

The Aero-Call, measuring only 9 x 5½ x 2½ inches, is made in both A. C. and D. C. models, each of which retails for $25.00, including three types of plug-in coils and everything necessary to receive short-wave programs, and is manufactured by the Aero Products, Inc., 4611 E. Ravenswood Ave., Chicago, a long established manufacturer of professional short-wave apparatus and the well-known Aero Coils.

MASTER VOLTAGE CONTROL

The Master Engineering Co., of 122 South Michigan Ave., Chicago, have introduced a Standard and a Heavy Duty type voltage control, to be used in connection with any electric radio set.

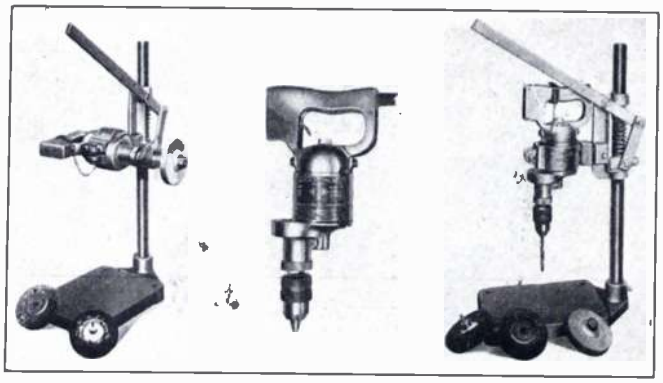
The Master Voltage Control is so designed that it can be plugged directly into a wall socket or any light receptacle.

The Master voltage control, designed to be inserted in the line between the radio set and the light socket. Four voltage adjustments are available.

There are four separate outlet receptacles on the side of the unit, to accommodate the plug from the radio set. The set plug is inserted into the outlet on the unit whose voltage marking corresponds with the light voltage in the home.

The Standard Master Voltage Control has a capacity of 60 watts. The price is $2.50.

The Heavy Duty Master Voltage Control has a capacity of 100 watts. The price is $3.00.



The Wodack portable electric drill and the special stand which allows the drill to be operated in a vertical or a horizontal position.

A Radio Jobberwocky

"Full of sound and fury signifying nothing."

'Twas kolster, and the freshman set
Did haugh and pacent to and fro.
All console were the cabinet
And grebe fada low.

Be-Ware the music master, Son,
The tone that's true, the cone that's free;
But harkness to the priess and shun
The straight line frequency.

He took his garod shield to lynch,
Longine the crosley foe he sought.
Then macnamee beneath the kellogg tree
And ballantined his thought.

But as in balkite thought he stood,
The cunningham with tubes half lit
Came heising through de Forest wood
Freed eisemann as it hit.

A. C., D. C., tobe, acme,
The gang condensers wouldn't track.
He left the dead end loss and said
Zeh bouck! morecroft I lack.

They erla took a willard a,
And splitdorf for a gould,
I hope you get your philco grimes
O bosch, my patents pooled.

And canst thou tune a superhet
Come to my armstrong, sarnoff boy.
El kay! El kay! Oh cockaday!
We must have permalloy.

'Twas kolster, and the freshman set
Did haugh and pacent to and fro.
All console were the cabinet
And grebe fada low.

By Charles Berrien, in the N. Y. Herald-Tribune.

INTERESTING STATISTICS ON TUBE MANUFACTURE

The vacuum tube is essentially an electrical device, and is made almost entirely by electrical machinery. It consumes a considerable amount of electricity in the making, according to interesting figures computed by the Arcturus Radio Company, manufacturers of A.C. tubes. The following electrical processes are involved in the manufacture of the average Arcturus tube—filament plating, seam welding attaching collar and cap to cathode, coating cathode, baking in electric ovens, welding grid wires, making stem and bead, assembly welding, sealing-in, filament bombarding, plate and grid bombarding, ageing, pumping, testing and basing. These processes require the expenditure of 113 watt hours of electrical work.

The work accomplished in operating the average Arcturus tube is about five watt hours per hour. The average A.C. receiver in the course of two evenings entertainment consumes enough electricity to make a complete set of tubes for the same receiver.

The entire day's production of a large tube factory requires about 2,000 kilowatt hours as far as work actually expended on the tubes is concerned. This is enough electricity to run the 20th Century Limited from Grand Central Station to 125th Street, to electrocute 3,000 men in the Sing Sing death chair, to supply the average home with electricity for five years and to Marcel wave the entire feminine population of the City of Newark!

Buyers Directory of Equipment and Apparatus

Readers interested in products not listed in these columns are invited to tell us of their wants, and we will inform the proper manufacturers. Address Readers' Information Bureau.

Addresses of companies listed below, can be found in their advertisements—see index on page 78.

ADAPTERS:
Carter Radio Co
Lynch, Arthur H., Inc.

ALUMINUM:
Aluminum Co. of America

ALUMINUM FOIL:
Aluminum Co. of America
Reynolds Metals Co., Inc.

AMMETERS:
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Corp.

AMPLIFIERS, POWER:
General Amplifier Co.
General Radio Co.
Skidmore, W. K., & Co.

ANTENNAE, LAMP SOCKET:
Dubilier Condenser Mfg. Co.

ARRESTERS, LIGHTNING:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

BASES, VACUUM TUBE:
Formica Insulation Co.
General Electric Co.
National Vulcanized Fibre Co.

BINDING POSTS:
Eby, H. H. Co
General Radio Co.

BRACKETS, ANGLE:
Scovill Mfg. Co.

BRASS:
Copper and Brass Research Assn.
Scovill Mfg. Co.

BROADCAST STATION EQUIP'T:
Cardwell, Allen D., Mfg. Co.
General Radio Co.

BUTTS:
Scovill Mfg. Co.

CABINETS, METAL:
Aluminum Co. of America.
Copper and Brass Research Assn.

CELLS, PHOTOELECTRIC:
Burt, Robert C.
Raytheon Mfg. Co.

CERIUM:
Independent Labs.

CHARGERS:
Benwood-Linze Co.
Elkon Co.

CHASSES
Aluminum Co. of America.
Copper and Brass Research Assn.
United Scientific Laboratories, Inc.

CHOKES, AUDIO FREQUENCY:
American Transformer Co.
General Radio Co.
Silver-Marshall, Inc.
Thordarson Elec. Mfg. Co.

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.
Silver-Marshall, Inc.

CHOKES, B ELIMINATOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Silver-Marshall, Inc.

CLAMPS, GROUND:
Scovill Mfg. Co.

CLIPS, SPRING:
Scovill Mfg. Co.

COIL FORMS:
General Radio Co.
Silver-Marshall, Inc.

COILS, CHOKE:
Acme Wire Co.
Dudlo Mfg. Co.
Westinghouse Elec. & Mfg. Co.

COILS, IMPEDANCE:
Acme Wire Co.
Dudlo Mfg. Co.

COILS, INDUCTANCE:
Acme Wire Co.
Aero Products Corp.
Cardwell, Allen, D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Silver-Marshall, Inc.

COILS, MAGNET:
Acme Wire Co.
Dudlo Mfg. Co.

COILS, RETARD:
Hammarlund Mfg. Co.

COILS, SHORT WAVE:
Aero Products Corp.
General Radio Co.
Hammarlund Mfg. Co.
Radio Engineering Laboratories
Silver-Marshall, Inc.

COILS, TRANSFORMER:
Acme Wire Co.
Dudlo Mfg. Co.

CONDENSER PARTS:
Aluminum Co. of America
Scovill Mfg. Co.

CONDENSERS, BY-PASS:
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Brown & Caine, Inc.
Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E. & Co.
Frost, Herbert H., Inc.
Muter, Leslie Co., Inc.
Polymet Mfg. Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

CONDENSERS, FILTER:
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Brown & Caine, Inc.
Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E. & Co.
Muter, Leslie Co., Inc.
Polymet Mfg. Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

CONDENSERS, FIXED:
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Brown & Caine, Inc.
Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E., & Co.
Muter, Leslie Co., Inc.
Polymet Mfg. Co.
Radio Engineering Laboratories
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
Frost, Herbert H., Inc.
General Radio Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

CONDENSERS, MULTIPLE:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories.

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.

CONDENSERS, VARIABLE:
Cardwell, Allen D. Mfg. Co.
DeJur-Amsco Co.
Frost, Herbert H., Inc.
General Radio Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

CONNECTORS:
Carter Radio Co.
Scovill Mfg. Co.

CONTROLS, ILLUMINATED:
Hammarlund Mfg. Co.
Silver-Marshall, Inc.

CONTROLS, VOLUME:
Carter Radio Co.
Central Radio Laboratories
Clarostat Co.

CONVERTERS:
Cardwell, Allen D., Co.
Electric Specialty Co.

CONVERTERS, ROTARY:
Electric Specialty Co.

COPPER:
Copper & Brass Research Assn.
Scovill Mfg. Co.

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

DIALS:
Hammarlund Mfg. Co.
Scovill Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

DIALS, DRUM:
Hammarlund Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

DYNAMOTORS:
Electric Specialty Co.

ESCUTCHEONS:
Crowe Nameplate & Mfg. Co.
Scovill Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FILAMENTS:
Cohn, Sigmund.
Gilby Wire Co.

FILAMENT, OXIDE COATED:
Independent Laboratories, Inc.

FILAMENT CONTROLS, AUTOMATIC:
Lynch, Arthur H., Inc.
Radiall Co.

FOIL:
Aluminum Co. of America
Reynolds Metals Co., Inc.

GALVANOMETERS:
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

GEARS:
Chicago Stock Gear Wks.

GENERATORS:
Electric Specialty Co.

GETTER MATERIAL:
Independent Laboratories, Inc

GRID LEAKS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
DeJur-Amsco Co.
Frost, Herbert H., Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Lynch, Arthur H., Inc.
Polymet Mfg. Co.

HARNESSES, A-C.:
Carter Radio Co.

HEADPHONES:
Amplion Co. of Amer.

HINGES:
Scovill Mfg. Co.

HORNS:
Amplion Co. of Amer.
Racon Elec. Co., Inc.

HORNS, MOLDED:
Racon Elec. Co., Inc.

INDUCTANCES, TRANSMITTING:
Aero Products, Inc.
General Radio Co.
Radio Engineering Laboratories.
Silver-Marshall, Inc.

INSTRUMENTS, ELECTRICAL:
General Electric Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

INSULATION LAMINATED
Formica Insulation Co.
National Vulcanized Fibre Co.

INSULATION, MOULDED:
Bakelite Corp.
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Westinghouse Elec. Mfg. Co.

INSULATION, VARNISHED:
Acme Wire Co.

IRON, MAGNETIC:
Reid, David, Jr.

JACKS:
Carter Radio Co.
Eby, H. H., Co.
General Radio Co.

JACKS, TIP:
Carter Radio Co.
Eby, H. H., Co.

KITS, SHORT WAVE:
Aero Products, Inc.
Lynch, Arthur H., Inc.
Radio Engineering Labs.
Silver-Marshall, Inc.

KITS, TELEVISION:
Insuline Co.
Lynch, Arthur H., Inc.

KITS, TESTING:
General Radio Co.
Jewell Elec. Inst. Co.
Supreme Instruments Corp.

KITS, TRANSMITTING:
Aero Products, Inc.
Radio Engineering Labs.

LACQUERS:
Zapon Co., The

LABORATORIES:
Electrical Testing Labs.

LAMINATIONS:
Lamination Stamping Co.
Willor Mfg. Co.

LEAD-INS:
Muter, Leslie F., Co.

LOCK WASHERS:
Shakeproof Lock Washer Co.

LUGS:
Muter, Leslie F., Co.
Scovill Mfg. Co.
Shakeproof Lock Washer Co.

MAGNESIUM:
Aluminum Co. of America.

MAGNETS:
Reid, David, Jr.

METERS:
General Electric Co.
Jewell Elec. Inst. Co.
Supreme Instruments Corp.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instr. Co.

MICROPHONES:
Amplion Co. of America
Westinghouse Elec. & Mfg. Co.

MOLDING MATERIALS
Bakelite Corp.
Formica Insulation Co.
General Plastics Co.
National Vulcanized Fibre Co.
Westinghouse Elec. & Mfg. Co.

MOTORS:
Electric Specialty Co.

MOTORS, ELECTRIC PHONOGRAPH:
Gordon, L. S., Co.

MOTOR-GENERATORS:
Electric Specialty Co.

MOUNTINGS, RESISTANCE:
DeJur-Amsco Co.
Lynch, Arthur H., Inc.

NAMEPLATES:
Crowe Nameplate & Mfg. Co.
Scovill Mfg. Co.

NICKEL:
Cohn, Sigmund

NUTS:
Shakeproof Lock Washer Co.

OSCILLOGRAPH:
Burt, Dr. Rob't C.
Geueral Radio Co.

OSCILLOSCOPE:
Burt, Dr. Rob't C.
Westinghouse Elec. & Mfg. Co.

PANELS, COMPOSITION:
Formica Insulation Co.
Westinghouse Elec. & Mfg. Co

PANELS, METAL:
Aluminum Co. of America
Scovill Mfg. Co.

PAPER, CONDENSER:
Dexter, C. H. & Sons, Inc.
Lehmaier, Schwartz & Co.

PAPER, CONE SPEAKER:
Seymour Co.

PHONOGRAPH MOTORS:
(See Motors)

PHOTOELECTRIC CELLS:
(See Cells)

PLATES, OUTLET:
Carter Radio Co.

PLATINUM:
Cohn, Sigmund

PLUGS:
Carter Radio Co.
General Radio Co.
Muter, Leslie F., Co.

POWER PACKS, UNITS FOR
Acme Wire Co.
Lynch, Arthur H., Inc.

POWER UNITS, A-:
Kodel Elec. & Mfg. Co.

POWER UNITS, B-:
Dongan Elec. Mfg. Co.
General Radio Co.
Kodel Elec. & Mfg. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.

POWER UNITS, A-B-C:
Dongan Elec. Mfg. Co.
General Radio Co.
Kodel Elec. & Mfg. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.

POWER UNITS, PARTS FOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Kodel Elec. & Mfg. Co.
Thordarson Electric Mfg. Co.

POTENTIOMETERS:
Allen-Bradley Co.
Carter Radio Co.
Central Radio Laboratories
DeJur-Amsco Co.
General Radio Co.
United Scientific Laboratories

RECEIVERS, ELECTRIC:
United Scientific Laboratories.

RECTIFIERS, DRY:
Benwood-Linze, Inc.
Elkon, Inc.
Kodel Elec. & Mfg. Co.

REGULATORS, VOLTAGE:
DeJur-Amsco Co.
Muter, Leslie Co., Inc.
Radiall Co.

RELAYS:
Cardwell, Allen D., Mfg. Co.

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Allen-Bradley Co.
Carter Radio Co.
Central Radio Laboratories.
DeJur-Amsco Co.
Frost, Herbert H., Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Lynch, Arthur H., Inc.
Polymet Mfg. Co.

RESISTANCES, VARIABLE:
Allen-Bradley Co.
American Mechanical Labs.
Carter Radio Co.
Central Radio Laboratories.
Frost, Herbert H., Inc.
Hardwick, Field, Inc
International Resistance Co.
Lynch, Arthur H., Inc.
Polymet Mfg. Co.

RHEOSTATS:
Carter Radio Co.
Central Radio Laboratories.
DeJur-Amsco Co.
Frost, Herbert H., Inc.
General Radio Co.
United Scientific Laboratories.
Westinghouse Elec. & Mfg. Co.

SCHOOLS, RADIO:
National Radio Institute.
Radio Institute of America

SCREW MACHINE PRODUCTS:
Aluminum Co. of America
National Vulcanized Fibre Co.
Scovill Mfg. Co.

SHIELDING, METAL:
Aluminum Co. of America.
Copper and Brass Research Assn.

SHIELDS, TUBE:
Carter Radio Co

SHORT WAVE APPARATUS:
Cardwell, Allen D., Co.
Frost, Herbert H., Inc.
General Radio Co.
Lynch, Arthur H., Inc.
Radio Engineering Laboratories.
Silver-Marshall, Inc.

SOCKETS, TUBE:
Eby, H. H., Co.
General Radio Co.
Lynch, Arthur H., Inc.
Silver-Marshall, Inc.

SOLDER:
Chicago Solder Co.
Westinghouse Elec. & Mfg. Co.

SOUND CHAMBERS:
Amplion Co. of Amer.
Jensen Radio Mfg. Co.
Rola Co., The

SPAGHETTI:
(See Wire, Spaghetti).

SPEAKERS:
Amplion Co. of Amer.
Jensen Radio Mfg. Co.
Rola Co., The

STAMPINGS, METAL:
Aluminum Co. of America
Scovill Mfg. Co.

STEEL, MAGNETIC:
See (*Iron Magnetic.*)

SUBPANELS:
Formica Ins. Co.
Westinghouse Elec. & Mfg. Co.

SWITCHES:
Carter Radio Co.
General Radio Co.
National Vulcanized Fibre Co.
Westinghouse Elec. & Mfg. Co.

TAPPERS
Eastern Tube and Tool Co.

TELEVISION PARTS:
Allen-Bradley Co.
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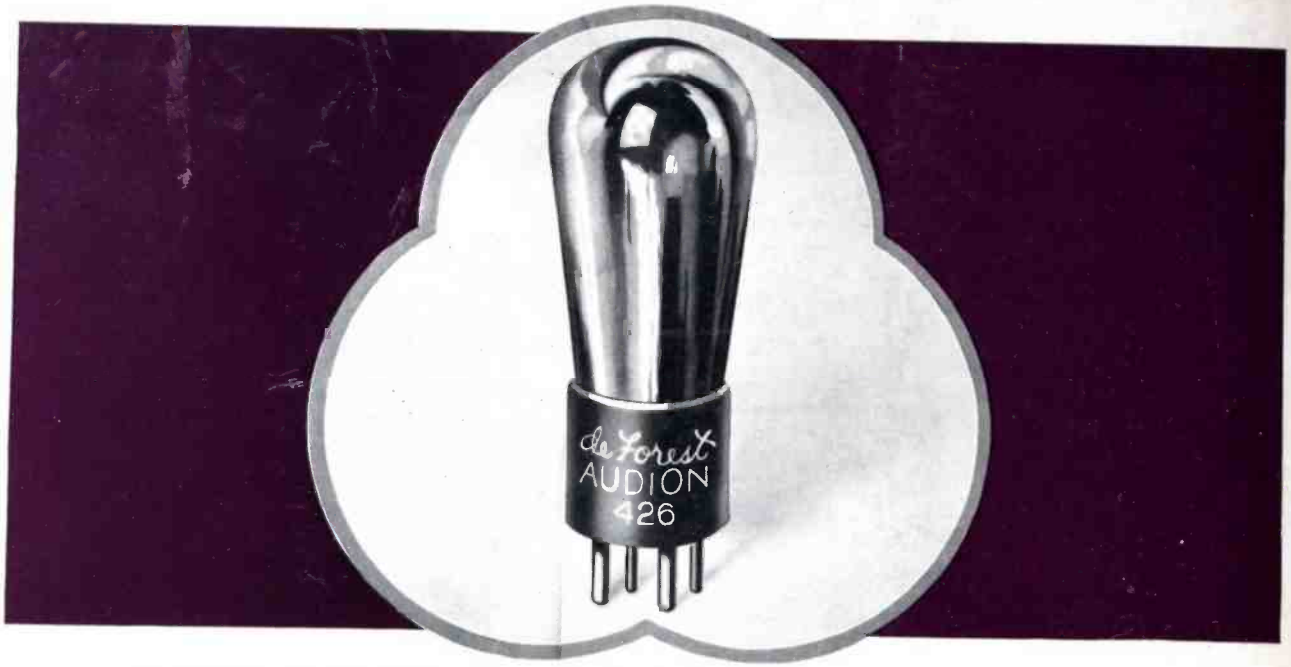

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