Ninth Year of Service

RADIO ENGINEERING

Vol. IX MAY 1929 No. 5

IN THIS ISSUE

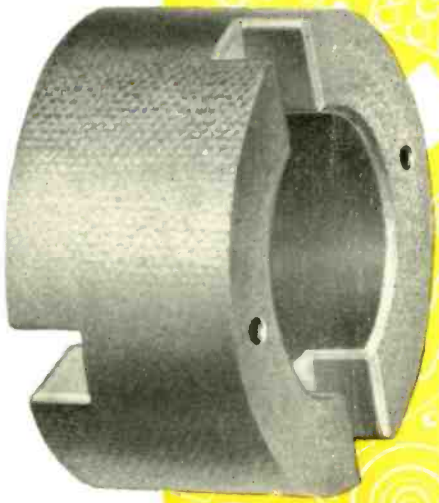
The Journal of the Radio Industry

Your Requirements ✓
Phenolite's Performance ✓
—They Must Check!

—and they can be made to check 100 per cent if our Service Engineering Department knows what part laminated bakelite plays in the performance of your product.

Wastes in fabricating, inaccurate assembling or other inefficiencies are not necessarily the faults of your mechanics. Look to the material itself—or better still, have our Service Engineers study the situation from every angle. Their past experience in problems comparable to your own enables them to determine by actual tests which grade of Phenolite is best suited to the service requirements of your product. And because we exercise full control over every process that goes into the manufacture of Phenolite, your future orders will conform with these specifications to the letter! Correspondence regarding your difficulties or requirements will bring immediate action.

PHENOLITE
Reg. U.S. Pat. Off.
Laminated BAKELITE
SHEETS : RODS : TUBES : SPECIAL SHAPES



To be specific—here is a coupling disc fabricated by "National" from a grade of Phenolite developed in our laboratory for the known requirements of this particular part. It possesses unusual tensile strength and resistance to wear. It is unaffected by oil or moisture, and due to its fabric base, this coupling has valuable shock-absorbing properties.

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FORMICA has large resourses for giving prompt service on high quality laminated phenolic insulating materials.

These resources include the largest and most complete equipment in the industry; the largest organization and one that has specialized for 15 years on just one product; a thoroughly equipped and competently manned laboratory.

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RADIO ENGINEERING

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Contents

Departments

KC. Dial Designation Becoming Standard

MR. H. B. RICHMOND, of Cambridge, Mass., Director of the R.M.A. Engineering Division, states that the "kilocycle" designation on receiving set dials is becoming general and follows the adoption of the kilocycle standard by the Federal Radio Commission and scientific organizations.

"The use of kilocycles as the approved method of designating the location of a broadcast station has become established beyond doubt," said Director Richmond. "This is just the logical development of advances in the refinement of receiver design.

"Radio sets were first marked in numbers only. Sometimes dials used the 0-100 system. At other times the dials were graduated in geometric degrees. Both of these methods served only as reference points. They both made it necessary for the operator to fish for a new station. With the improvement of receiver design, it became practical to calibrate the dials. These dials were marked sometimes in wavelengths, sometimes in kilocycles, and occasionally in both. A few manufacturers went so far as to include not only kilocycles and wavelengths, but also added a reference scale. The use of this multiple system was often as confusing as it was helpful.

"The Federal Radio Commission and scientific organizations have adopted the use of kilocycles only. No cross-reference is being made to wavelengths. The broadcast band has been laid out on the basis of a 10-kilocycle separation between stations. The band extends from 550 to 1500 kilocycles.

"The tendency in new receiver design is decidedly in favor of marking dials with but a single scale, that of kilocycles."

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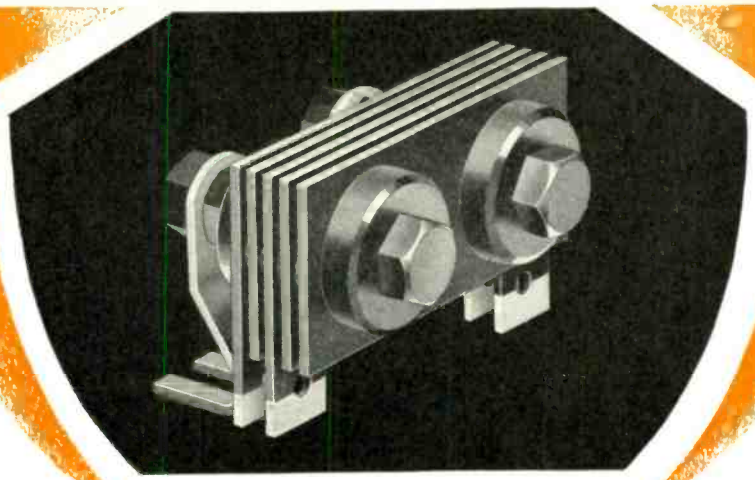


Type B-402 B-L Rectifier Max. D. C. Rating, 3 Amps. 2 Volts.

Dynamic Speaker Rectifier

A New Design of B-L Rectifier for Dynamic Speaker Field Extitaton to Give Low Voltage and High Current Output

This new type B-L Dynamic Speaker Rectifier is designed to provide a maximum low D. C. rating of 2 volts, with a high current output of 3 amperes . . This means a decided saving for dynamic speaker manufacturers because it allows the use of a low voltage type of speaker field winding.

The resulting advantages are many: Relatively few turns of larger size wire may be used in the winding . . . The winding is, therefore, more rugged . . . Winding costs are lowered . . . Wire costs are less, because the per-pound cost of wire is less in larger sizes than in smaller sizes . . . A better space factor is assured.

In addition to these obvious advantages of Type B-402 B-L Rectifiers, complete data and engineering service is offered to all dynamic speaker manufacturers.

Write for prices and further information.

***The* B-L ELECTRIC MFG. CO.**

Formerly Mfg. Div. of Benwood-Linze Co.

19th & Washington Ave. **St. Louis, Mo.**

B-L RECTIFIERS

EDITORIAL

May 1929

FUTURE DESIGN

IT IS not too early to start considering the matter of the design of radio equipment for the years 1930 and 1931. For that matter, present industrial fields are so highly competitive, that it would seem well for radio engineers to work five years ahead of market demands.

Unfortunately, it is impossible to work out complete designs much in advance of the times; engineering progress will not permit it—but it is possible to lay out a tentative groundwork design sufficiently flexible to permit changes, when new developments appear.

Last-minute design does not pay, nor for that matter does it pay to sit tight and purloin the design of another manufacturer. Neither method pays because real engineering effort is not reflected in the completed model.

If one asks, what form of radio equipment *will* be marketed two years from now, one can only reply that the matter depends entirely on engineering developments—and no one can foretell what may be conceived.

If one asks, what form of radio equipment *should* be marketed two years from now, the answer is different. The kind of equipment that *should* be marketed is equipment that most readily fits in with modern trends and consequently more readily meets public demand.

There is really quite a difference between the "will" and the "should." The first suggests force—and it is not always good policy to create greater markets solely through a continual process of public re-education. "Should" suggests acceptance of that which the public would like to have if it were made available on the open market. A combination of both seems most desirable.

A design groundwork can be laid out for the future if present trends are closely studied. It is a matter of determining which way the wind blows.

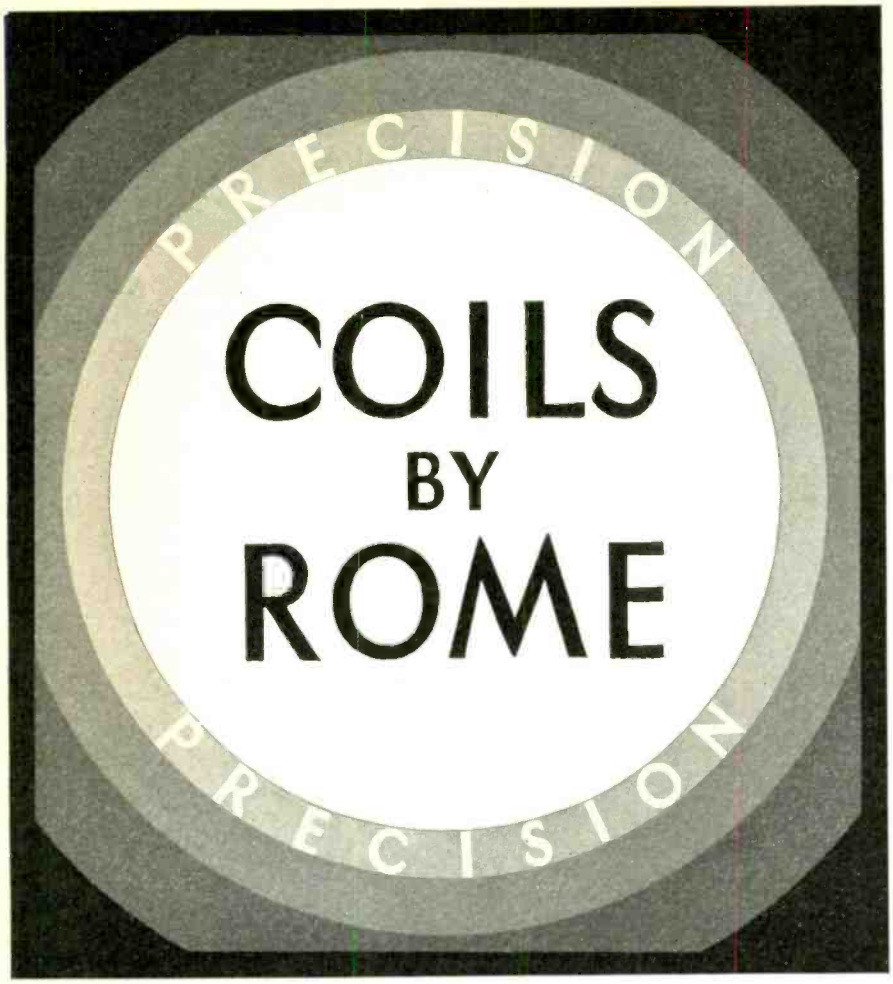
There are a number of important elements to consider in connection with the future design of radio equipment. There is the electric phonograph; which is well taken care of for the present; there is the home talking movie and lastly, there is television. If each of these devices are to be manufactured as separate units, it means a very large duplication of equipment—and a possible total of four machines to place in the home. Obviously, all of these devices can be worked into one outfit and the same equipment used for a number of purposes, but the sales on such an outfit would be restricted somewhat by the size of the machine, and its price. But five years from now there may be no such restrictions; quantity production and engineering developments may well solve the problem.

Of more immediate importance are the numerous "convenience accessories" springing up in the field, such as remote tuning and volume controls, automatic volume control systems, tone control, visual tuning indicators, program recording attachments, and so on. The inclusion in a receiver of devices of this sort assists in stimulating sales.

It is quite possible that, with the steady increase in the number of homes wired for radio and the growing demand for automatic remote tuning and volume control systems, there will arise a good-sized market for a fool-proof receiver chassis designed for permanent installation in an out-of-the-way place. The loudspeakers would be the only units entering into the decorative scheme—and incidentally, they allow a considerable amount of flexibility in cabinet design; more so than a receiver chassis.

One other point: The present and future merging of organizations, directly or indirectly connected with the radio group, will have an effect on what one may well term, "the consolidation of equipment." In this respect, mergers will influence future design trends.

M. L. MUHLEMAN, *Editor.*



COILS BY ROME signifies the establishment of a complete coil winding department,—already busy winding coarse coils, fine coils, magnet coils, paper cell coils. . . .

COILS BY ROME signifies engineering that begins with fundamental coil design and carries through to application. It may well be considered an adjunct to your own design and experimental departments.

COILS BY ROME signifies a new precision process in winding coarse wire coils that achieves an otherwise impracticable factor of space utilization.

COILS BY ROME signifies manufacturing methods and capacity that are eager to match coils and costs with you, whether you wind your own coils or buy them.

COILS BY ROME is both a challenge and an invitation.

. . . We ask an opportunity to prove the significance of COILS BY ROME.

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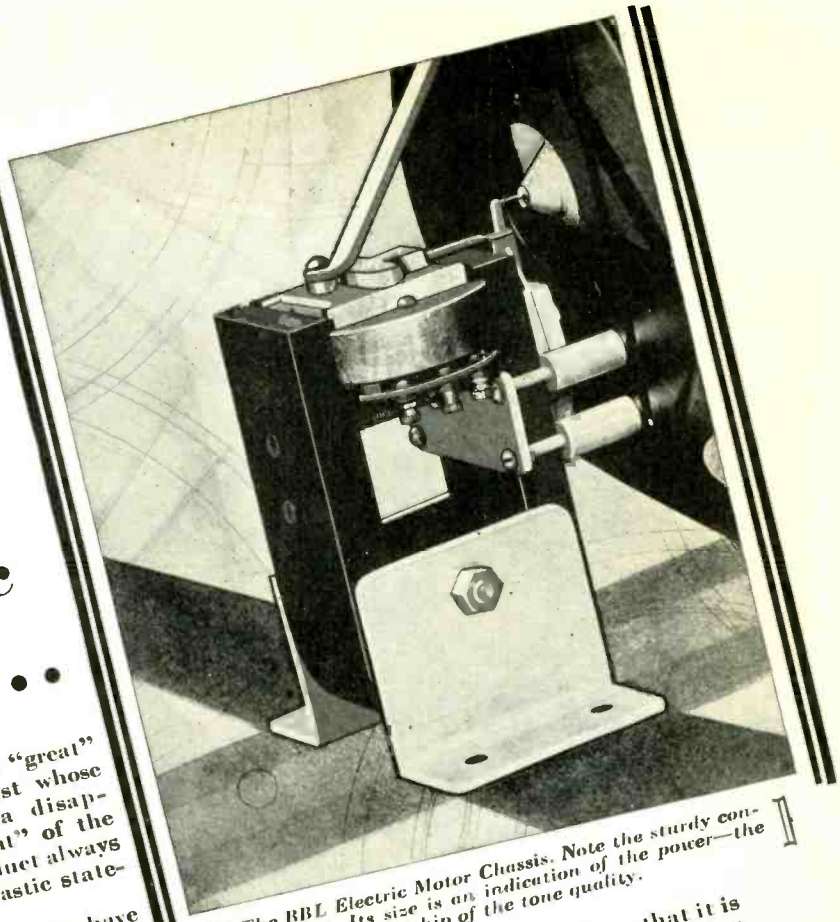
Division of General Cable Corporation
ROME, NEW YORK

ROME PRECISION COILS

. . . the G-R-E-A-T BBL Electric Motor . . .



The BBL Electric Motor Chassis. Note the sturdy construction. Its size is an indication of the power—the careful workmanship of the tone quality.

AND it is great—not the "great" of the Bally-hoo artist whose show always was a disappointment, but the "great" of the true engineer—whose product always exceeds his most enthusiastic statements.

We are engineers primarily, we have your viewpoint. You know what the famous BBL units have been—how our statements have always been more conservative than the performance. And now we announce

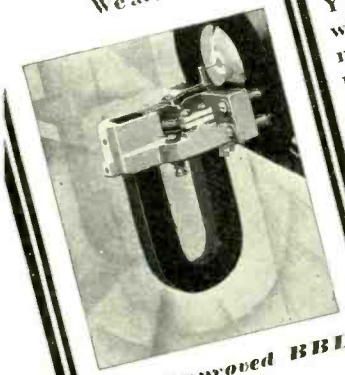
The Sensation of the Year

Every year there is some one development which stands out as the crowning achievement of the engineering brains of the country. This year the BBL Electric Motor bids fair to capture the palm. It is not just another so-called semi-dynamic. Built on an entirely new principle, its action is just what its name implies.

We want you to hear it in your own laboratory, on your own set or speaker. We tell you that it is "great". And we'll wager that you will say that its performance is remarkable.

Remember, no moving coil, no transformer, no rectifier, no condenser, no hum—just perfect satisfaction. Remarkable power (volume without distortion) deep bass notes—and high ones, too—the result of a truly fine engineering job. One and a half times the volume of dynamics and twice as sensitive.

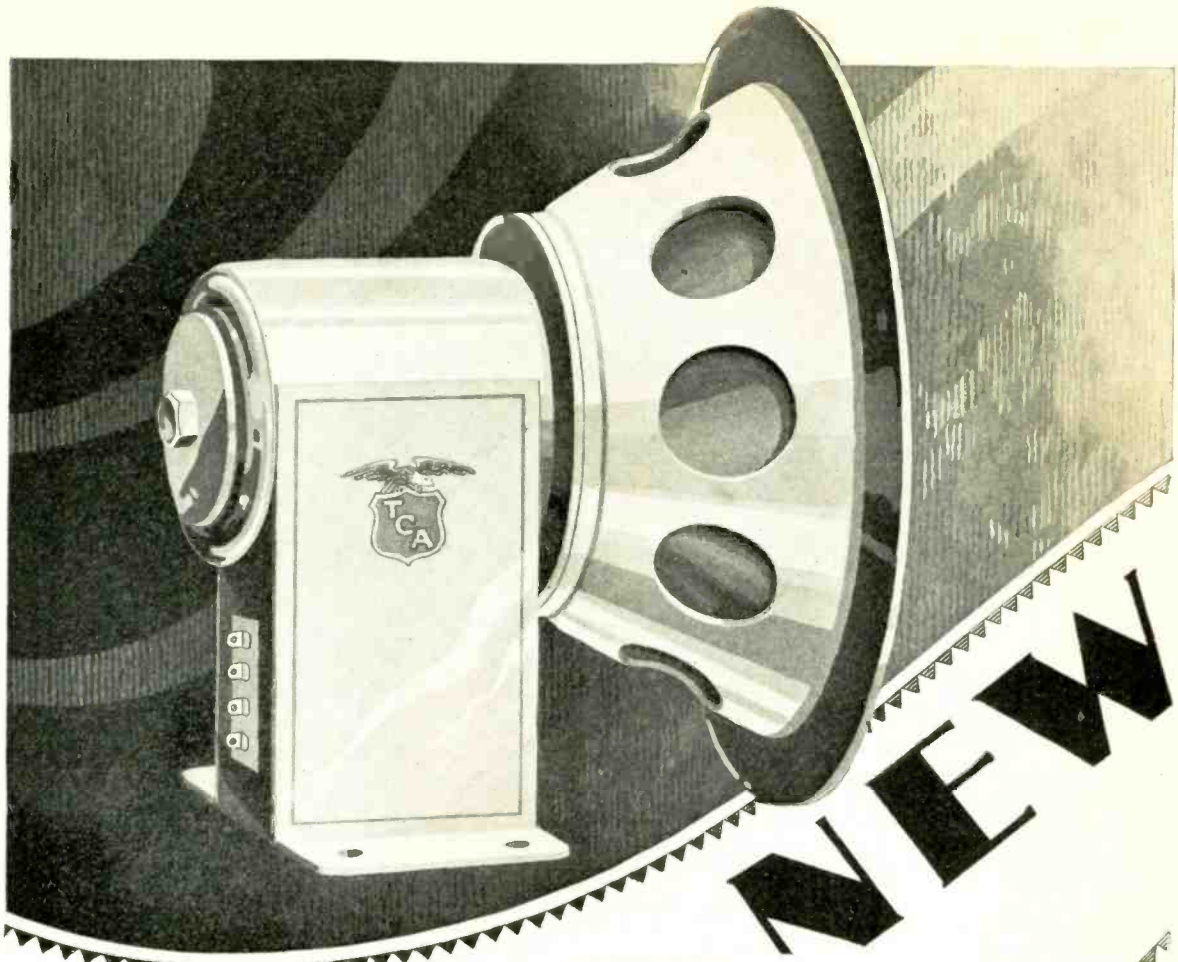
Supplied in chassis form to manufacturers at less than the lowest dynamic prices.



The Improved BBL Motor

The majority of the magnetic cone manufacturers used the BBL this season. Now we have improved it tremendously and have doubled our factory floor space enabling us to take care of a few more manufacturers. Supplied in chassis form to manufacturers.

BEST MANUFACTURING CO.
1200 GROVE STREET
IRVINGTON, N. J.



NEW NEW

NEW heights in Electrodynamic reproduction are reached by this latest development of the T·C·A—a unit that offers a fidelity of tone and a rich full amplification that must be heard to be appreciated.

Intensive research has shown the necessity for several important modifications from common dynamic speaker practice. These improvements are offered to the industry for the first time. Details and data on request.

These refinements are possible without prohibitive cost only in a completely manufactured unit. The T·C·A Dynamic is not assembled from outside parts, but is made complete under one roof.

The finish of the unit is as impressive to the observer, as it is practical and protective in use. All external metal parts are cadmium plated. All terminal lugs are grouped on a rear panel of bakelite, improving appearance and making cabinet installation fast and easy.

The new T·C·A Dynamic is presented with full confidence that it will take its place side by side with T·C·A Transformers and Power Packs in the finest sets the industry offers.

Complete line of types and sizes on dependable quantity delivery.

THE TRANSFORMER CORPORATION OF AMERICA, CHICAGO, ILL.

NEW NEW

NEW products, of which this Electrodynamic speaker is the latest, make the T·C·A line a peculiarly helpful source of supply to the quality set manufacturer.

Concentration upon a group of closely associated products has enabled the development of specialized production methods that make possible a high degree of uniformity and precision.

Dependability in T·C·A power packs and chokes is no accident. Interchangeability in T·C·A Transformers is not a matter of luck or chance.

For every manufacturing operation has been perfected and developed through the production of thousands, and in some cases, millions of identical units.

Controlled quantity production is the key to T·C·A quality.

NEW production facilities made possible by the plant illustrated below will further emphasize T·C·A's claim to leadership.

In this magnificent plant, high-speed, controlled production can be attained to a new degree.

Here basic raw materials, such as wire and sheet steel, will be converted into finished receiver units, ready for installation in the radio set. Much of the manufacturing equipment has of necessity been developed by T·C·A For it is a fixed policy to rely on automatic precision machines rather than on variable or less reliable hand work.

The thoroughness of the T·C·A engineering laboratory has enabled it to render valuable service and assistance to many set manufacturers. Inquiries invited.

2301-2319 South Keeler Avenue

THE TRANSFORMER CORPORATION OF AMERICA, CHICAGO, ILL.

SPEED

1929's OUTSTANDING RADIO TUBE

SPEED with the SPEED Tube Line. It's right—right in quality, right in price. Each sale induces repeat business. ¶SPEED Tubes incorporate new developments—months ahead of competition.

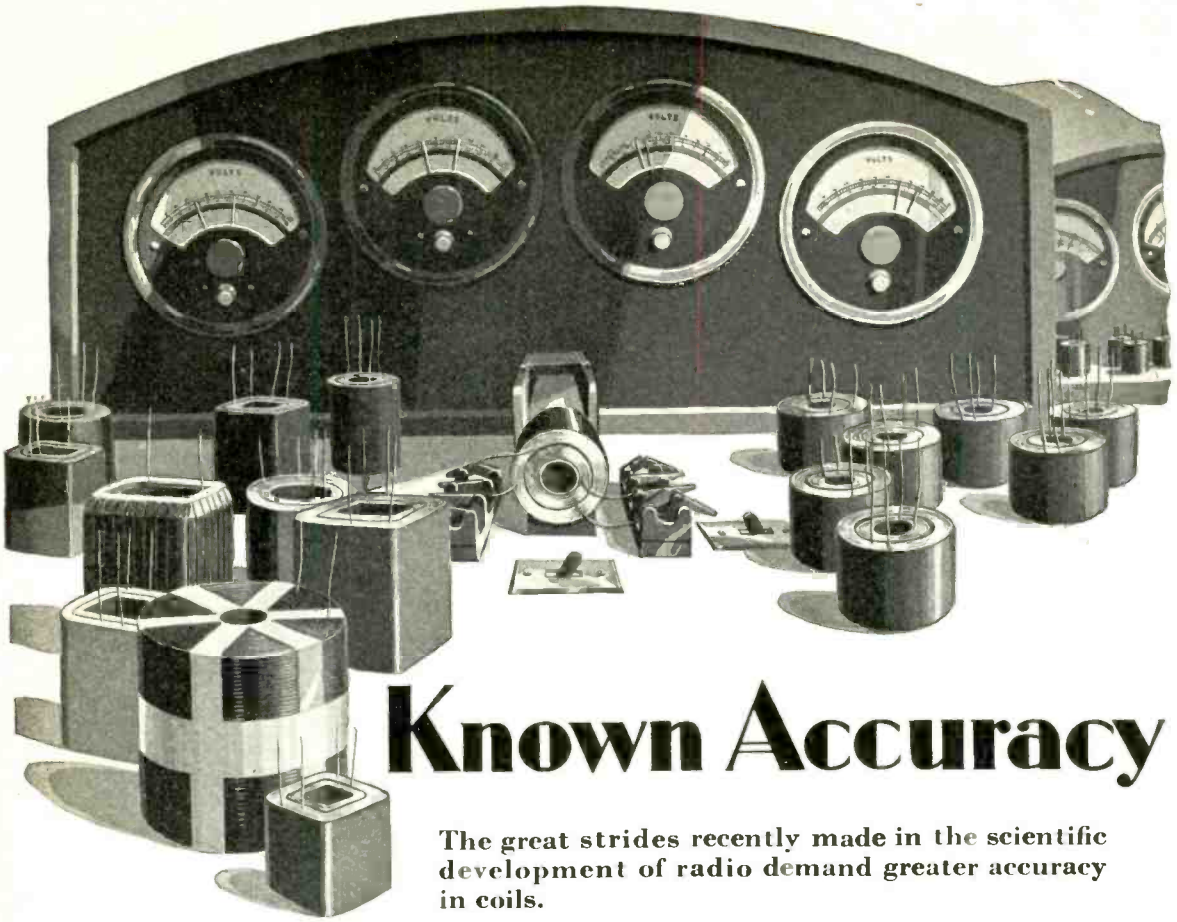
The fastest operating 227 A.C. detector. Newest developments in 224 A.C. shielded grid tube.

A Smashing advertising campaign of full pages in Saturday Evening Post, leading magazines and newspapers throughout the country will Speed SPEED sales. ¶Get all details at once. It's a great proposition and now's the time for the ringside seats!

At the Chicago Show, Speed to Booth No. 11. See us—see the line Speed with SPEED.

CABLE RADIO TUBE CORP.

80-90 NORTH 9th STREET :: :: BROOKLYN, N. Y.



Known Accuracy

The great strides recently made in the scientific development of radio demand greater accuracy in coils.

To insure the utmost accuracy, Dudlo is equipped with every available instrument for their testing and inspection.

The meter panel pictured above . . . only one of the tests to which Dudlo coils are subjected . . . calibrates output voltages, detects short-circuits and breakdowns. Other instruments check many other requirements to insure strict adherence to customers specifications.

This is one of the reasons why Dudlo coils are designed right, built right, and give uniformly good results wherever used.

If you are having coil troubles, send them to us. Dudlo engineering resources are at the service of the radio industry.

DUDLO

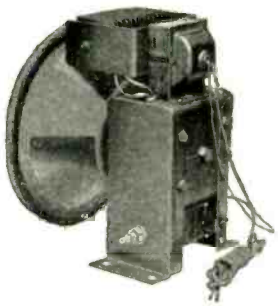
DUDLO MANUFACTURING COMPANY, FORT WAYNE, INDIANA
DIVISION OF GENERAL CABLE CORPORATION

DUDLO

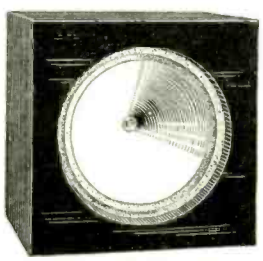
THE COIL'S THE THING IN RADIO

Temple Speaker Units
Speak for Themselves

Especially Adapted for Set and Cabinet Manufacturers



DYNAMIC CHASSIS
Model 10, 110 volt A. C. 60 cycle; Model 12, 110 volt A. C. 25 cycle; Model 14, 110 volt Direct Current; Model 16, 6 volt D. C. Battery Type.



MODEL 5-B MAGNETIC
Built into a baffle box which measures 9¼" sq. x 7⅝" deep.

MODEL 5-C MAGNETIC
This is the bare Magnetic chassis without the box baffle. This measures 9" diameter, depth 5".

All Temple speakers are available in table models—in most attractive cabinets.

Temple Dynamic Speakers

Temple Dynamics are better because of the unequalled engineering which is behind them—because of a more thorough knowledge of speaker manufacturing—because of a reputation for high grade speaker performance which has kept the Temple name among the leaders in the radio industry.

All Line Hum Eliminated

Exclusive with Temple Dynamics is the fact that all semblance of line hum has been eliminated. The Temple System of Hum Elimination is a Temple development and found only in Temple Dynamics. A two-tone switch allows for reception with predominating bass or for reproduction in natural tone values.

Temple Magnetic Speakers

Temple Magnetic Speakers fill the demand for quality reproducers, where tone of the highest order is demanded, but where the matter of insufficient receiver power or taste makes the purchase of a dynamic speaker inadvisable. True response, natural and pleasing tone, and an ability to please the most discriminating from the standpoint of performance makes this model one of the most popular in the radio field.

For Every Type of Installation

Temple Magnetics are designed for new console installations. or for replacements—for bringing the tone of older receivers up to 1929 standards. The two types differ only in the fact that one model is housed in a box baffle, while the other is the bare chassis. Both are complete and ready for installation and are equipped with the famous Temple Double Action Unit.

TEMPLE CORPORATION

Set Division
Clearing Station
5253 W. 65th St.,
Chicago

Address Speaker Inquiries to
Speaker Division
1925 S. Western Ave.,
Chicago

Temple speakers are made by the manufacturers of sensational

TEMPLE
TEMPLETONE Radio

"ROUND ROBIN"

$1.

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FACTORY EXECUTIVES
PRODUCTION MANAGERS

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(T) Technician.
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RADIO MANUFACTURERS ASSOCIATION R-M-A

5th ANNUAL R.M.A. CONVENTION JUNE 3 to 7 INC. STEVENS HOTEL

CHICAGO

Wednesday evening, June 5th, is the date — the place is the Banquet Hall of the Stevens Hotel, Chicago, and the occasion is the Third Annual Radio Manufacturers' Association Banquet. There will be a variety of entertainment by radio's most prominent artists. This outstanding program of the year will be broadcast over a nation-wide chain from Coast to Coast and Gulf to Canada.

Tickets can be had upon application to the Radio Manufacturers' Association offices, 32 West Randolph Street, Chicago, Illinois, or 11 West 42nd Street, New York City. Tables will be reserved for parties of ten persons each. The tickets are $6.50 per person.

Trade Show Exhibitions at Stevens, Blackstone and Congress Hotels

Remember — this year there will be manufacturers' exhibits and demonstration quarters in three hotels — the Stevens, Blackstone and Congress. It will be necessary therefore, for you to visit the exhibitions and demonstrations in each of the official hotels in order to get a comprehensive view of the entire trade show.

Reduced Rates on All Railroads

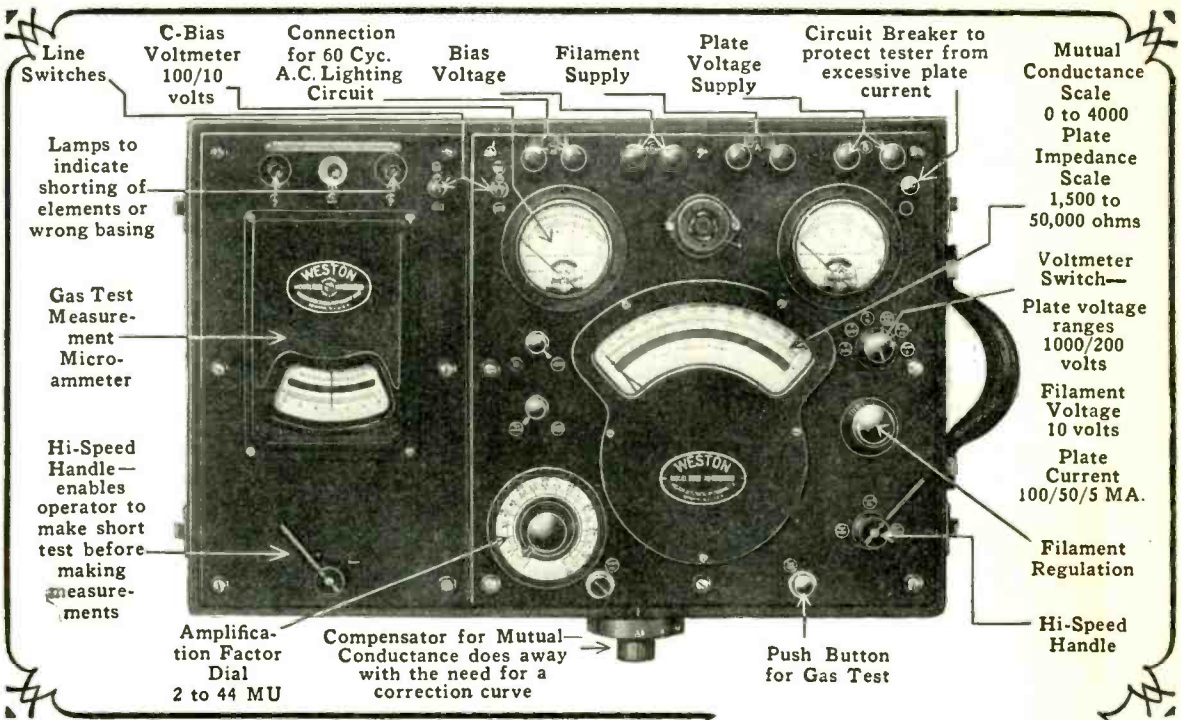
All the railroads are giving special reduced rates to the Radio Trade Show in Chicago, June 3rd to 7th, inclusive. Make your plans to attend. Arrange now for hotel accommodations.

Invitations to the trade will be issued about May 1st.

Radio Manufacturers' Association Trade Show, Room 1800 Times Bldg., New York

Under Direction of U. J. Herrmann and G. Clayton Irwin, Jr.

Production Tester—
that insures uniformity of tubes



THE Model 526—Type 6 Radio Tube Tester is made primarily for set and tube manufacturers. It is a triumph in instrument design and embodies features which make it invaluable as a production testing instrument. Its use as a bench test set insures uniformity of tubes, while its design and construction provide for high speed operation.

No calculations or correction factors are necessary, all tube characteristics being quickly obtainable by *direct indication*. It is simple to operate, positive and reliable.

The tube manufacturer will find the Model 526 indispensable in reducing the time element of testing tubes as well as minimizing labor and material losses. It accelerates mass production processes, increases output, protects guarantees — and most essential of all, it insures the uniformity of the product.

The Model 526 is a marvel of simplicity—only a few quick operations being necessary for a complete test. Refer to our nearest sales office for full particulars, or write direct to the factory.

WESTON ELECTRICAL INSTRUMENT CORP.
612 Frelinghuysen Ave. • Newark, N. J.

You can be assured of
UNIFORMITY
by the following tests:

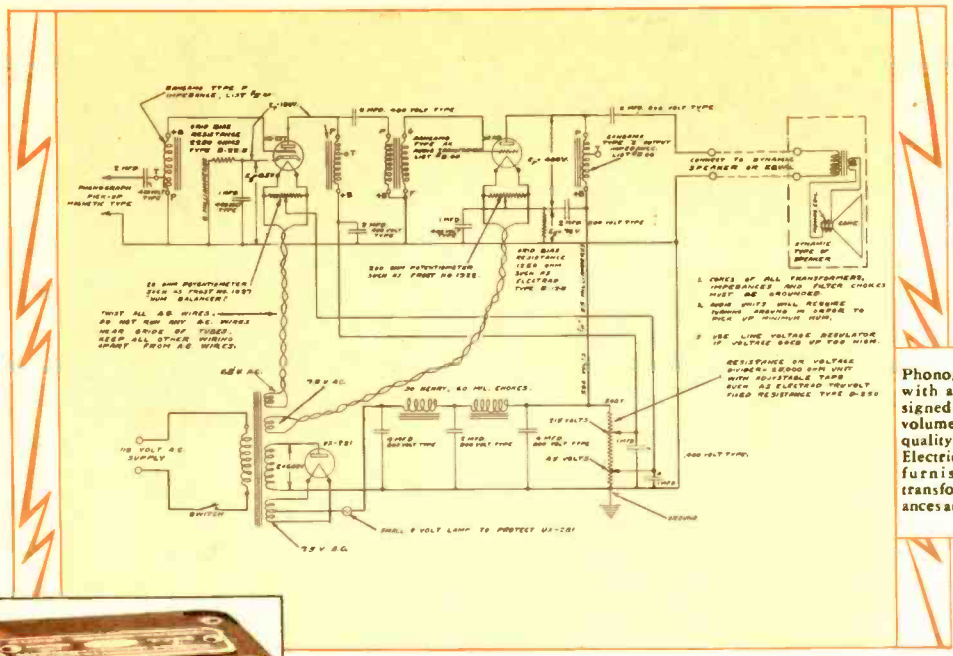
1—*Short Test:* By turning Hi-Speed handle, lamps indicate shorts between elements as well as filament continuity.

2—*Gas Measurement:* Depress button and read value *directly* on micro-ammeter.

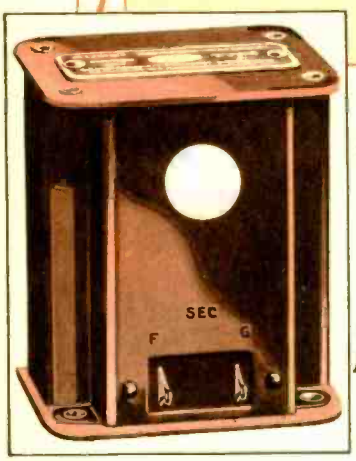
3—Read amplification factor *directly* on amplification dial.

4—Read plate impedance and mutual conductance directly on large instrument scale.

Weston
PIONEERS SINCE 1888
INSTRUMENTS



Phonograph pick-up with amplifier designed to give large volume and high tone quality. The Sangamo Electric Company can furnish the audio transformers, impedances and condensers.



TONE- *sells the phonograph amplifier, too*

The exacting standards to which phonograph amplifiers must measure require manufacturers to exercise increasing care in the design of circuits and the selection of parts of *known accuracy in performance.*

Sangamo Audio Transformers are built to precision standards with electrical characteristics that will give unsurpassed reproduction when used in appropriate circuits.

The proof of transformer excellence lies in a flat performance curve. Due to the fact that the impedance of the windings of all Sangamo Audio Transformers is accurately matched to the impedances of the tubes and speakers with which they work, the Sangamo performance curve is the nearest to a straight line ever achieved by any transformers now available.

When equipped with a good phonograph pick-up and a speaker that will handle the volume output, this amplifier and power supply will give an exceptionally high quality of tone and large volume.

SANGAMO ELECTRIC CO.

SPRINGFIELD, ILLINOIS, U. S. A.

Sangamo Electric Co. of Canada, Ltd., 183 George St., Toronto, Ont.

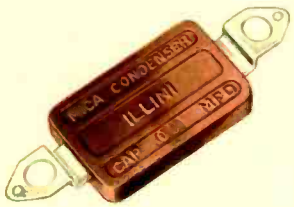
For 30 years preeminent manufacturers of electrical precision instruments

SANGAMO

The quality of fixed condensers affects every note and syllable

Sangamo Fixed Condensers are accurate . . . . *and stay accurate!*

Standard Type "A"
Sangamo Fixed Condenser



The New "Illini" Condenser
For Manufacturer's Use

COSTLY experience has brought home to many manufacturers the realization that no other item costing so little can cause as much trouble as a fixed condenser.

Not all fixed condensers are good condensers even though molded in Bakelite. Sangamo Fixed Condensers are not only rendered immune to thermal changes and mechanical damage by a Bakelite enclosure—but a soundly constructed, *accurately rated* mica condenser within the Bakelite casting assures minimum variations from rated capacities.

Sangamo precision manufacturing traditions and facilities, including one of the country's finest equipped laboratories, are responsible for Sangamo accuracy. Every Sangamo product is subjected to searching tests of the sort possible to make only in a manufacturer's laboratory. The standard line of Sangamo Fixed Condensers is tested within ten per cent of rated capacity.

The Sangamo "Illini" Condenser for manufacturer's use, is a new type of the same quality as the standard Sangamo Fixed Condenser. Its connecting lugs, which may be bent to any position required without damaging the condenser, adapt it more readily to factory production.

Mail the coupon for complete information and prices.

Pin this to your letterhead and mail

SANGAMO ELECTRIC CO., Springfield, Illinois, U.S.A.
Dept. 542

Sangamo Electric Co. of Canada, Ltd., 183 George St., Toronto

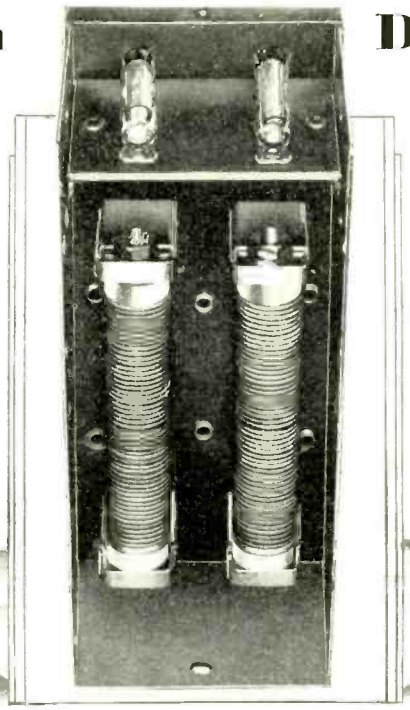
☐ (*For manufacturers*) I am interested in engineering data regarding your transformers and condensers, also the phonograph amplifier hook-up.

☐ (*For dealers*) Please send data on Sangamo Condensers.

☐ (*For set builders*) Please send booklet describing your apparatus and latest audio hook-ups. I enclose 10c to cover cost of mailing.

This New Elkon Rectifier Eliminates the Power Transformer in Dynamic Speakers

This shows the size of one of the rectifier units. Two are required on each speaker.



The rectifier units can be easily replaced when necessary as may be seen here.

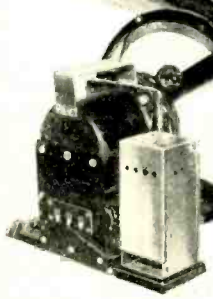
AGAIN Elkon leads the field. The new Elkon D-29 Power Supply is the outstanding development of the year in rectifiers for dynamic speakers.

This remarkable rectifier operates directly from the AC power line eliminating the Power Transformer and reducing the cost of assembly.

Supplied complete, ready to install, or the rectifier units (two required on each speaker) can be sold separately.

Wonderfully efficient, quiet in operation. The units can be replaced when necessary as easily as a tube is changed in a socket.

If you have not already sent us a sample of your new speaker, do so at once. We will equip it with the new Elkon rectifier and return it to you promptly.



The Elkon D-29 Power Supply Installed on a Dynamic Speaker.

ELKON, INC.

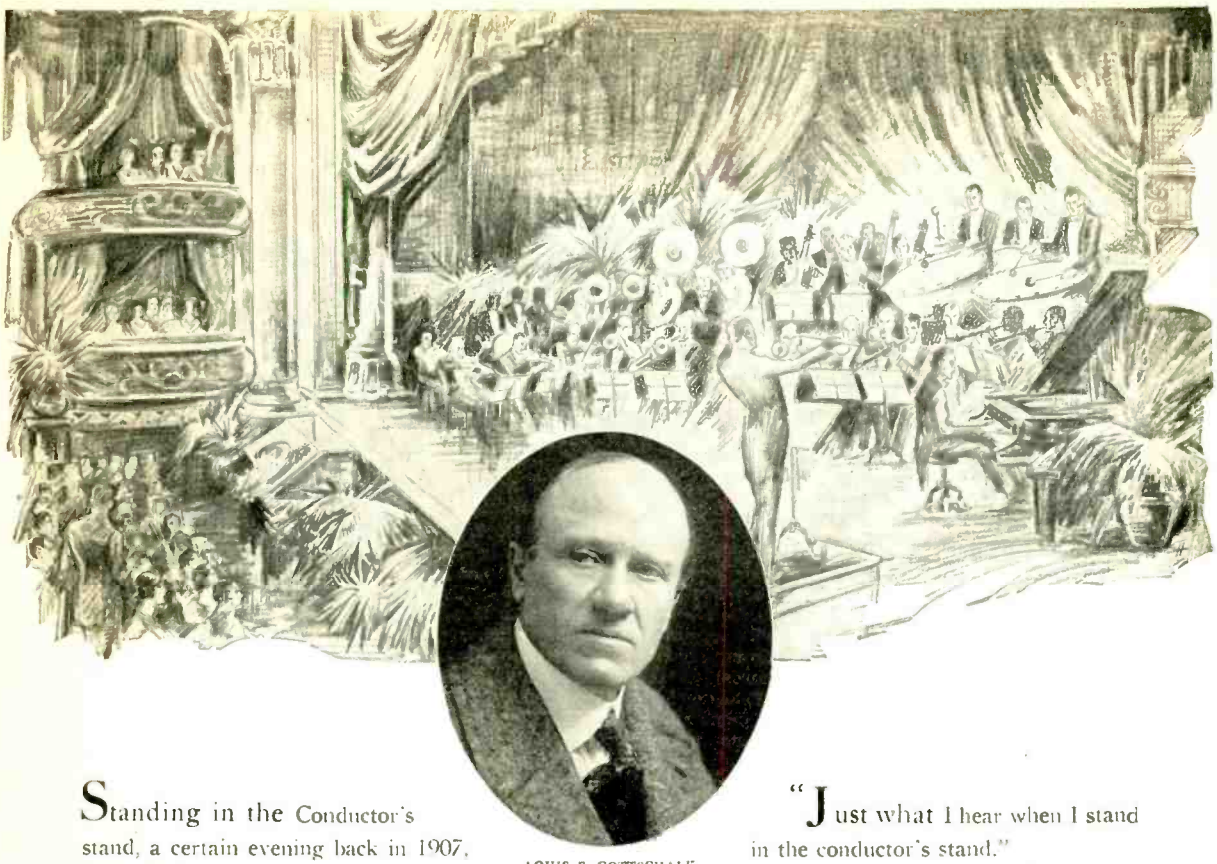
Division of P. R. Mallory & Co., Inc.

350 Madison Avenue
New York City

ELKON, Inc., Radio Dept. E-60
350 Madison Ave., N.Y. City.
Please send me complete information on your new Elkon D-29 Power Supply for Dynamic Speakers.

Name .....

Address .....



LOUIS F. GOTTSCHALK
World Famous Composer and Director

Standing in the Conductor's stand, a certain evening back in 1907, Louis F. Gottschalk created a sensation that theatre goers and music lovers of New York City are never apt to forget. It was the introduction of the "Merry Widow" to the American public.

Louis F. Gottschalk now stands as one of the world's greatest composers and orchestra directors.

The first composer selected by the Griffith Films to write original scores, Louis F. Gottschalk produced many beautiful musical compositions, such as those accompanying "Broken Blossoms," "The Four Horsemen of the Apocalypse," "The Three Musketeers," and the "Prisoner of Zenda."

Orchestration scores for a musical movie "The Rainbow Man," not yet released, have just been completed by Mr. Gottschalk.

"Just what I hear when I stand in the conductor's stand."

I can give no greater praise.

I wanted to write you ever since your remarkable treat of "The Evening of Music."

So you see, if a hard-boiled, distinctly hostile musician like I am can listen to this Wright-DeCoster reproducer with a great thrill, it is uncanny.

Just how on earth any mechanism can transport a full hundred artist orchestra through the air and reproduce it in a distant place with all the richness and clarity of the complete ensemble, with the very "personality" of each instrument perfectly reproduced.—that, to me, is a miracle.

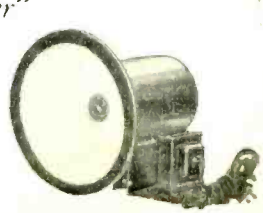
Louis F. Gottschalk

"Your Radio Can Be Only As Good As Its Speaker"

Write for descriptive matter and address of nearest branch office.

Wright DeCoster Inc.
TRADE MARK

WRIGHT DECOSTER, INC.
MAIN OFFICE AND FACTORIES
ST. PAUL, MINN.



THE SPEAKER OF THE YEAR

Cross-Licensing for the Radio Industry

By Le Roi J. Williams
Chairman R. M. A. Patent Committee

THE Patent Interchange Plan of the Radio Manufacturers' Association does not present an entirely new idea. The general scheme is old. Its adoption by the automobile industry was manifestly one of the foremost contributing factors in the conspicuous and unprecedented success of that great industry.

Prior to the year 1914 there were many threats and counter-threats of patent litigation between automobile companies. There were differences of opinion as to how patents should be best used. There were those who felt that patents should be taken out only to prevent others not entitled to them from holding up the legitimate owners of inventions. Such patents were obtained merely for protection against aggressors—not for the levying of tribute or the collection of royalties.

There were those who felt they possessed a legal patent monopoly on the manufacture of modern automobiles. Pools for aggressive use of patents against the industry were formed. Other pools were threatened.

Then the natural thing happened. The National Automobile Chamber of Commerce, comprising almost all of the representative automobile manufacturers of America, submitted to its membership a cross-licensing agreement under which all signers granted patent licenses to each other without payment of royalties except where payments were required to third parties. This interchange of patent rights was complete except with respect to patents involving inventions of a high order or a radical departure from previous accomplishments. However, in almost fifteen years of operation, no patent has been found by the automobile industry to merit the latter classification. Practically, therefore, there has been a complete cross-licensing under all of the patents of the signers.

Of course, when the plan was presented to the automobile industry there were those who said that it would be adopted only by those who had no patents; that those who had valuable patents would not sign the agreement, and that it would, therefore, be an empty arrangement. As a matter of fact all except two of the representative automobile manufacturers entered into the cross-licensing agreement.

The reasons which sold the agreement were many. There were a large number of companies in the industry. A few of them owned many patents. Many of them had a few patents. When the large owners of the more important patents considered the agreement they were confronted with the question: "Are my patents more valuable than all of the patents owned by the rest of the industry?" The answer was obvious. The value to be given by each was less than that received from the rest.

LE ROI J. WILLIAMS

It was also recognized that with a pooling of patent rights there could be free interchange of patent information for defensive purposes. It was also understood that such information could be collected by the association and used by it, not only in taking over defenses of suits of general interest to the industry, but also in preventing threatened suits. This feature proved to be a valuable aid to the industry in its defense against invalid patents and unjustified suits. It is a matter of general knowledge that the automobile industry has been particularly free from patent litigation from outside as well as inside sources. I am of the opinion that this defensive feature which naturally ties up so closely with a cross-licensing agreement was the most valuable step to the industry.

With the adoption of the cross-licensing agreement, it was expected that each company would be free to build the best possible product by the best possible methods and could devote all of its energies to the constructive problems of organization, manufacturing and distribution—and not be harassed and hampered by threats, patent litigation and injunctions. Each company would have the benefit of the developments of the rest of the industry. The results anticipated in this respect have far exceeded expectations. Every company in the industry, of necessity, has been stimulated to keep pace with the most modern developments in design and methods of manufacture. To do otherwise, meant that a company would slip out of the picture. The result of this stimulus was greatly improved products at startling reductions in cost. Volume was increased; great profits were earned—and the buyers obtained more for their dollars in the purchase of an automobile than was obtainable in any other mechanism. Everyone was benefited.

Patent cross-licensing has been a great, if not the paramount factor in obtaining these results.

The situation in the radio industry today is a close parallel to that of the automobile industry when it considered the cross-licensing agreement in the year 1914. The challenge and the opportunity are the same.

In general the Radio Manufacturers' Association plan follows that of the automobile industry. It seems to follow that successful plan so far as practicable to do so. However, some of the radio manufacturers are engaged in electrical activities unrelated to radio. Some of the manufacturers build complete radio sets. Others manufacture special radio parts. Therefore, the Radio Manufacturers' Association plan cross-licenses only so far as it effects their so-called "radio" activities, namely, the manufacture of radio devices, electrical phonographs and group address systems, including parts and accessories for such devices. As in the case of the automobile cross-licensing agreement, the Radio Manufacturers' Association plan provides for an exclusion from the cross-licensing agreement, by action of the Board of Direc-

tors, of patents covering inventions "of an outstanding character, or the result of an inventive effort of a high order; rather than a mere improvement, variation, modification, or natural development of the existing art, resulting from an ordinary effort of the inventive faculty." The standard set up in the radio plan in order to provide for exclusion of a patent from the operation of the agreement is not quite as high as that of the automobile plan which required that in order for an invention to be so excluded, it must involve a "radical departure" from what had been done before. This modification was recommended by high officials of the automobile association. It should be observed that in the radio plan in order to have a subsequently acquired invention classified as excluded from the cross-licensing agreement, the invention must have been "devised and worked out by one or more agents or servants" while employed in or about the business of the signer of the agreement. So far as subsequently acquired inventions are concerned, this provision was adopted from the automobile plan.

In so far as inventions owned by signers of the agreement at the time they entered into it are concerned, according to the radio plan, it makes no difference whether the invention was developed in the organization of the signer or was acquired from others. According to the automobile plan no patent could be classified as being excluded from the operation of the agreement if it were acquired from outside of the signer's organization.

It was provided in the automobile cross-licensing agreement and it is provided in the radio plan, that all signers release each other from all claims for damages or profits on account of the infringement of any patent covered by the agreement by reason of the manufacture of any radio devices, electrical phonographs, group address systems and/or parts and accessories therefor. The far-reaching effect of this clause in wiping out cases of litigation is obvious.

The period of the radio plan extends until December 31, 1933, and will be extended beyond that time, not exceeding five years, unless 51% of the signers then in good standing terminate the agreement. After December 31, 1933, any signer of the agreement may terminate the license as to himself upon six months prior notice to the association of his desire so to do.

Agreement Covers Only Radio Activities of Members

It was the intention that the cross-licensing agreement of the Radio Manufacturers' Association should cover only the manufacture and sale of radio devices and parts therefor, and to have no effect on the other activities of those adopting the agreement. Therefore, the agreement opens with a statement of the purpose of the document, which is to avoid "the possibility of patent litigation between them over patents on or relating to radio devices, electric phonographs, group address systems and/or to parts and accessories therefor."

Definitions of Field of License

Then follows a group of definitions. On Page 2 appears a definition of "radio devices" as follows:

(a) devices useful only for "radio purposes" and

(b) devices especially adapted for "radio purposes" but capable of other uses except where the same are sold, licensed only for uses other than "radio purposes" in which cases the same are not to be regarded as radio devices hereunder.

On Page 1, paragraph, 3, there appears the following definition of "radio purposes":

(a) The transmission and/or reception by radio and/or by wire of news, music, pictures, speeches, sermons, advertising, entertainment, educational and/or similar matter and/or any of them and/or combinations of any of them only for the purposes of exhibition, entertainment and/or general instruction or education.

(b) The electrical amplification of electrical energy for use in group address systems, phonographs, and/or for the purposes set forth in sub-division (a) of paragraph (3) of this Article.

(c) The adaptation of electric energy from electric light, heat, power, or traction lines and thereby supplying local energy to the elements, or any of them, of electron discharge tubes and similar devices for the purposes set forth in paragraphs 3, 4, 5, 6 and 7 of this Article.

Analysis of What Are Radio Devices

It will be observed from the foregoing definitions that a "radio device," which is the subject of the cross-licensing agreement, is one (including amplifiers and socket power devices for use with radio devices) that is especially adapted or useful for transmission or reception, either by radio or wire, of program or news material which is seen or heard "but only for the purposes of exhibition, entertainment and/or general instruction or education." It will be observed that the definition of radio devices does not include transmission and reception of power, nor commercial communication either by wire or radio. Radio devices as defined, are limited to what is generally recognized as the program or entertainment field by wire or radio.

Group Address Systems and Phonographs Covered by License

As has been observed, there has been included within the scope of the cross-licensing agreement, group address systems and phonographs because of their similarity in character to radio devices. These are defined as follows in paragraphs 5 and 6 on Page 2:

(5.) Group address systems means the combination of

(a) Means for receiving and translating sound energy into electrical energy,

(b) Means for the electrical amplification of electrical energy and

(c) Means for converting electrical energy into sound energy.

(6.) Phonographs means all apparatus for the reproduction of intelligence from records in motion.

Cross-Licensing Only Covers Class B Radio Patents

The patents which are the subject of the agreement are so-called radio patents, which according to the definition in paragraph 8 on page 2 means:

"all Letters Patent (or claims thereof) of the United States, covering inventions used in, or in connection with radio devices, electrical phonographs and group address systems, except (a) design patents and (b) patents on raw materials and/or (c) any patents so far as the claims thereof cover inventions not applicable to, nor relating to radio devices, electrical phonographs and group address systems."

Then follows paragraphs 9 and 10 on the same page, with definitions of what are referred to as Class A Radio Patents and Class B Radio Patents, respectively.

Class B Radio Patents which are the only patents under which cross-licenses are granted, are briefly defined as all radio patents not included within the definition of Class A Radio Patents. Therefore, it is of interest to observe the following definitions of what constitute the radio patents which are excluded from the operation of a cross-license agreement, namely: What are Class A Radio Patents? The contract defines them as follows:

"A Class A Radio Patent means any of the 'Radio Patents' (or claims thereof) now or hereafter issued, of or under which the 'Subscriber' may now have, or hereafter acquire, ownership or control, or the right to grant licenses or shop rights, to the extent of any claim or claims thereof, covering an invention which, in the opinion of the Board of Directors of the 'Association,' expressed in a resolution duly adopted at a regular or special meeting duly called, at which a quorum thereof

was present and participated, or in case of appeal as hereinafter provided, in the opinion of the arbitrators appointed hereunder, is of an outstanding character, or the result of an inventive effort to a high order; rather than a mere improvement, variation, modification, or natural development of the existing art, resulting from an ordinary effort of the inventive faculty: provided (1) that such patent is duly reported to the 'Association' within the time and in the manner hereinafter provided, with a written request for the classification thereof as a Class A patent, accompanied by the affidavits hereinafter provided for; but any delay in the fulfillment of this last proviso may be expressly waived in writing by the 'Association,' provided such waiver is given with full knowledge of the material facts; and provided, (2) as to patents in which the 'Subscriber' may acquire ownership or control or the right to grant licenses or shop rights thereunder after March 1, 1928, that such invention is developed within the 'Subscriber's' organization, that is to say, is devised and worked out by one or more agents or servants (including officers) of the 'Subscriber,' while employed in or about the 'Subscriber's' business."

Class A Radio Patent Idea Adopted from Successful Automobile Agreement

The idea of excluding from the operation of the cross-licensing agreement a group of patents (known in this agreement as Class A radio patents) covering inventions

> "of an outstanding character, or the result of an inventive effort of a high order; rather than a mere improvement, variation, modification, or natural development of the existing art, resulting from an ordinary effort of the inventive faculty";

is closely patterned after, but is more liberal than a similar provision of the automobile cross-licensing agreement.

During almost fifteen years of operation under the automobile cross-licensing agreement, so far as is known, no patent in the automobile industry has been so classified as to be excluded from the operation of the agreement. It should be observed, however, that the automobile cross-licensing agreement provided that in order for a patent to be so classified, it must cover an invention involving a *radical departure* from the existing art. This is a higher standard than in the radio agreement. Another substantial difference between the automobile provision and the radio provision is, that the former has a requirement that in order for patents to be excluded from the operation of the agreement they must cover inventions developed within or by a subscriber's organization. The radio provision requirement of this character applies only to inventions acquired or controlled after March 1, 1928.

It will be observed that the radio provision covering Class A Radio Patents is more liberal in favor of so classifying unusual inventions than is the automobile cross-licensing agreement. This is in accordance with the recommendation of one of the high officers of the National Automobile Chamber of Commerce.

Method of Determination of Class A Radio Patents

Radio patents will be classified as Class A by the Board of Directors of the Association after proper hearings. In case of a decision unfavorable to the owner of the patent, an appeal is provided for to an arbitration board consisting of one appointed by the Association, one by the Subscriber, and the third to be chosen by the Subscriber from a list of not less than three disinterested persons submitted by the Association.

Cross-License Does Not Affect Obligations to Third Persons

Paragraph B of Article II, page 3 of the contract, provides that no subscriber will be required to grant a free license when it would violate "the legal or equitable rights of any other person, firm or corporation." In other words, when a subscriber is required to pay royalties to others under any of his patents, such a patent would not be the subject or a royalty free grant under this agreement.

No License Granted on Parts and Accessories for Devices Unrelated to Radio

Paragraph D1 of Article II provides that the cross-license applies only for use

> "in radio devices, electrical phonographs and/or group address systems, and/or parts and accessories therefor, and that when licensed parts and accessories which are manufactured thereunder are adapted for uses other than in radio devices or for use in electrical phonographs and/or group address systems, the license to sell shall be limited to sale for use only in radio devices, electrical phonographs and/or group address systems, and for sale only to manufacturers of radio devices, electrical phonographs and/or group address systems, and likewise to jobbers, dealers and the retail trade."

The foregoing provision means that when parts or accessories which might be used in radio devices, phonographs and group address systems are also adapted for use in devices unrelated to radio, they do not carry a license when sold for employment in such other devices. It also provides that when parts, as such, are sold for use in radio devices, electrical phonographs and/or group address systems, that such *parts* are licensed only when sold to cross-licensed manufacturers of radio devices, electrical phonographs and/or group address systems, or to jobbers, dealers and the retail trade. The purpose of this provision, of course, is to protect subscribers in their respective patent rights in activities unrelated to radio.

Licenses Are Personal Shop-Rights

As appears in Sections 2 and 4 of Paragraph D of Article II, the licenses are personal, indivisible, non-assignible and irrevocable shop-rights for manufacture only in regular manufacturing establishments of the subscribers.

Licenses Are Under United States Patents Only

It is also provided in Section 5 of Paragraph D of Article II that no rights are granted under foreign patents.

Term and Termination

The following Section 6 provides that licenses shall be granted

> "only for so long as the licensee named therein shall remain a member of the 'Association' in good standing and shall not be in default under this agreement, and for six months thereafter, but in no event beyond the 31st day of December, 1933, except as hereinafter prescribed in Article X of this agreement."

Article X provides that the agreement may be extended after December 31, 1933, not exceeding five years, unless at least fifty-one per cent. of the Subscribers then in good standing as members of the Association, and not in default under the agreement, shall revoke the same. After December 31, 1933, any signer of the agreement may terminate the license as to himself upon six months' prior notice to the Association of his desire so to do.

Agreement Effective Upon Adoption by Majority of Members

The cross-licensing agreement as provided in Paragraph 2 of Article IV will not become operative "until at least 51% of the members of the 'Association' have adopted the cross-licensing agreement." After the contract becomes operative as provided in Paragraph 2 just discussed, the other members of the Association who have not adopted the agreement, will be given six months' notice that they also may become subscribers by adopting it.

Release of Damages and Profits

Article 8 provides that subscribers to the cross-licensing agreement waive all claims for damages or profits against all of the subscribers arising out of the manufacture or sale of licensed devices or parts or accessories therefor, unless the damages or profits were in litigation by suit or proceedings actually commenced before March 1, 1928.

Analysis of Papers Employed in Radio Manufacturing

II. The Use of the Microscope and Accessories in Fibre Analysis— Characteristics of Fibres

By I. L. Gartland

PAPER manufacturers have a great many problems with which to contend. Their water supply, raw materials, machinery, and, in addition, the everlasting changes in the elements, floods, droughts, ice, etc. One can readily imagine, therefore, the constant vigilance necessary to maintain system and order. Considering the vast amount of capital invested in a paper mill it is easy to realize the necessity for this

FIG. 22

Details of mounting glass, with black and white paper pasted on one side.

vigilance in order to maintain efficiency: hence, control must be as perfect as possible. Laxity cannot be allowed. Digesters, beaters, screens, wires, felts, dryers, calenders and rewinders are all part of this process and a lack of coordination in any of them often results in the destruction of an excellent product.

Many paper mills therefore, have instituted a department of technical control, where the function of the machinery is not so much concerned, as the results of the condition of the fibres which are checked, physically, chemically and microscopically. It is this constant hourly check that enables the mills to produce a uniform and reliable product and for this they depend greatly on the microscope.

There are three major places where cellulose receives its most severe treatment; in the digester, the beater and the Jordan Engine. Raw material prepared in the digester and passing through the successive stages of refining produces cellulose of an entirely different appearance when in the beater or Jordan Engine, than at the beginning of the process.

Since this article has to do mostly with fibres after treatment, it is well to remember that consideration must be given not only to the character of the fibre viewed, but the action of the reagents as well, so that no false interpretations may arise through confusing one cellulose with another. This is possible in some cases, and should be carefully guarded against.

A good microscopist in a paper mill can tell some remarkable things about the history of a fibre by just viewing it under the microscope. Cooking characteristics and beating (the two most important factors that constitute a desirable product) are vividly portrayed. We are, however, concerning ourselves mostly with papers used in the Radio Industry and laying stress on the more important cellulose used in the manufacture of products for this industry. To cover the entire field of paper fibre analysis would be impossible in such a limited space.

Fibre Analysis

Fibre analysis is in itself an art and a microscopist should give serious consideration to the accessories he is to use in order to become proficient. The more important of these for general analysis are the following:

1. Abbe condenser
2. Mechanical stage
3. 6x and 10x ocular
4. 24 mm.— 16 mm.— 4 mm. objectives
5. Lamp for proper illumination
6. Teasing needles
7. Reagents and stain
8. Slides and cover glasses
9. Balsam (for permanent mounting)
10. Test tubes, beakers, glass tubes and glass rods.
11. A "mounting glass"

The last item must be constructed by one's self, and is indispensable in mounting slides. It is made by taking a piece of plain glass 5" by 7" or 8" by 10" that has been thoroughly cleaned, and pasting on one side a piece of black and a piece of white paper (see Fig. 22). The black is used for detecting fibre particles unstained and dried, while the white part is used for detecting stained particles and their location on the slide. Once this simple method is tried, cover glass mounting troubles will be greatly reduced.

In addition to the eleven important items mentioned, a spirit lamp, small sieve or screen, 2% solution of caustic soda, tweezers, slide holder, hand microtome and also a dark field stop are required. For more elaborate experiments, a polarizer and analyzer may be added to good advantage.

Method of Procedure

Before attempting to analyze the more intricate papers, take an ordinary piece of newspaper with which to experiment. (It might be well to remember that in principle the ensuing method will apply to all paper analysis.) Tear from it a strip, (where printing is absent) from one to three inches wide and seven or eight inches long. Cut, or tear this into fine pieces, from ⅛ to ¼ inch square and place in a test tube. Add to this a solution of 2% caustic soda, filling the test tube about half full and gently heat over the spirit lamp or bunson burner. Bring gradually to a boil and allow to boil for several minutes. This is done to dissolve the "loading" matter and aid in the disintegration of the fibres. Pour off the mass through the screen and take the remaining paper (after washing away any residue caustic) and place in a clean test tube; half fill with water, and shake vigorously. Continue shaking until the entire mass becomes a "pulp." It is now ready for analysis. Take a small pipette or a glass tube and with the finger pressed to the upper aperture insert into this "pulpy" mass and at a point where the fibres seem well disintegrated, release the finger and allow the mass to enter the tube, replacing the finger so that the transfer to the slide will be made without the loss of a drop.

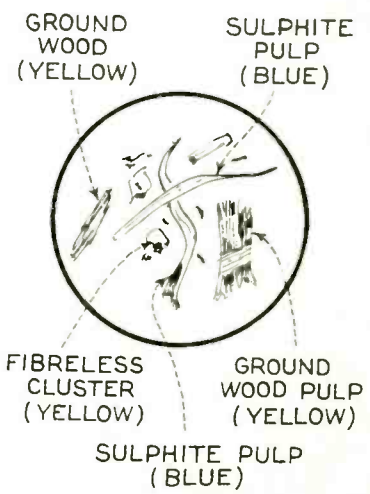
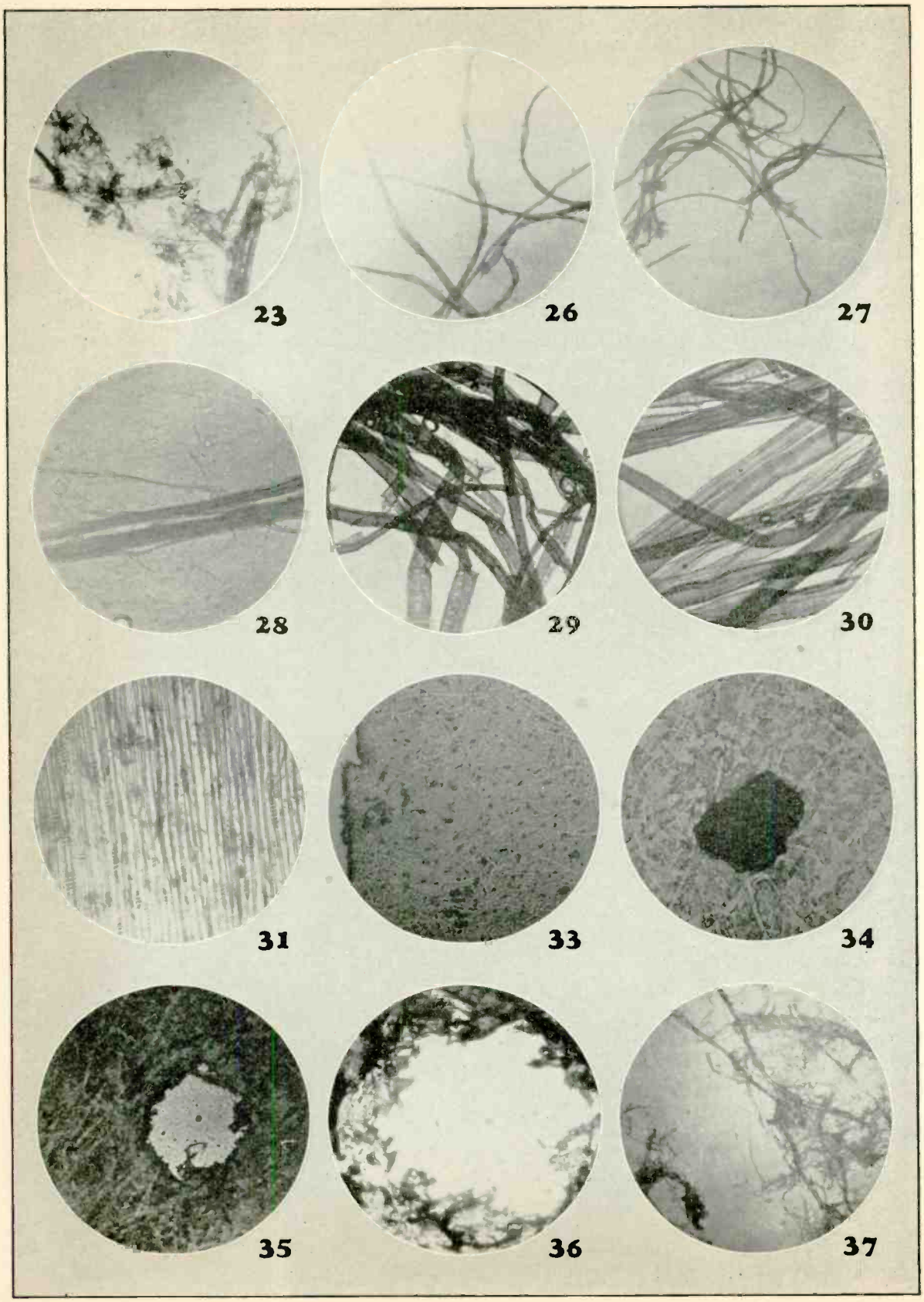


FIG. 24

"Newsprint" fibre content. Sketch drawn with the aid of a Camera Lucida.



With the slide now on the black side of the mounting glass, lay the glass tube in the center of slide and gently release the finger to allow enough of the aqueous solution of fibre to flow on to the slide, covering an area of about ¼ inch in diameter (if using a 3" x 1" slide, which is standard). Take the slide clippers, clip the slide and holding over a spirit lamp, fully evaporate the water from the fibres, making sure always that they do not boil or run off or down the slide. After this process is finished, again place the slide on the black side of the mounting glass to cool.

Preparing the Microscope

While the slide is cooling, prepare the microscope for the examination. In the first series of this article we referred to sources of illumination (page 28, 3rd column) and the necessity for care in the choice of a light source. A failure to recognize this important feature and the proper diameter of the iris diaphragm will not only result in loss of detail, but will tire the eyes quickly.

Swing into place a low power objective and with the aid of a standard slide (Fig. 5, first series; page 29) focus the objective. A word about focusing: many excellent slides have been permanently damaged by improper methods of focusing. When the operator does not know the working distance of an objective or, in fact, whether he does or does not, he should always work from the lowest distance up (focus up from the slide, not down to the slide). In this way there is little chance of damage occurring to the mounted slide.

The standard slide focused, a recheck made of illumination, flatness of field, etc., he can now take the cooled slide containing the fibres, locate the field and focus.

Microscopic Observations of Fibres

After careful examination two distinct characteristics of fibres will be found. (See Fig. 23). Study the unstained specimen, note formations, fibre lengths and so called "bundles" of cellulose of the "mechanical" or ground wood type; also the general appearance of the "sulphite" fibres and compare them with the mechanical fibres.

Remove the slide from the stage of the microscope and place it on the white side of the mounting glass. Place a cover glass over the fibres and then proceed to stain these with a reagent, known as the Herzberg Stain (See Fig. 7, page 30, April issue, for irrigation methods of staining).

The Herzberg Stain is the most commonly used in the Paper Industry and is prepared as follows:

Sol. "A"
20 Grams Zinc Chloride
10 C. C. Distilled Water

Sol. "B"
2.1 Grams Potassium Iodide
0.1 Gram Iodine Crystals
5 C. C. Distilled Water

Dissolve solutions "A" and "B" separately, then mix and allow to stand several hours. After they have settled, decant. Be sure your reagent is correct and fresh. All iodine solutions deteriorate rapidly in light, hence it is necessary to keep them in a dark colored bottle and away from constant sunlight.

This reagent acts upon the various specie of fibres as follows:

Cotton, linen, hemp—wine red
Chemical wood fibres, bleached jute and straw—blue to violet
Mechanical wood fibres, unbleached jute and straw (ligneous fibres)—yellow

Replace the slide under the microscope and there will be found, as a result of the staining, two color reactions (Fig. 24). The blue represents the sulphite or chemical wood content and the yellow the mechanical (ground wood) content.

The purpose of this is to determine the number or per cent. of different

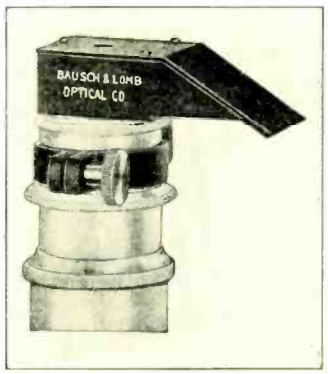


Fig. 25. Illustration of a Camera Lucida.

kinds of fibres that go to make up a specific piece of paper. This is commonly called "fibre count."

It cannot be expected to obtain an accurate count of fibres by just one estimation; the process must be repeated at least ten times and the mean taken:

	Mechanical Pulp Per Cent.	Sulphite Pulp Per Cent.
1	19	81
2	21	79
3	18	82
4	20	80
5	20	80
6	19	81
7	20	80
8	21	79
9	18	82
10	19	81
	195=19½%	805=80½%

To depend entirely on reagents is rather hazardous and one must become familiar with the characteristics of fibres whether stained or not. Staining often gives greater detail and hence as a check on the reagent or vice versa the author always makes it a practice to examine carefully his specimens, both stained and unstained.

Characteristics of Fibres

We have submitted for study microphotographs and drawings (drawings were made through the use of the Camera Lucida, Fig. 25) of the principal fibres and their characteristics. In addition to the explanation of each group it might be well to examine these drawings and photo-micrographs carefully.

Cotton fibres (Fig. 26) appear ribbon-like, with numerous twists and are very transparent; hence the necessity of staining for detail. Let us make mention that frequently a stain, other than a reagent is far more desirable. Eosine or Mythelene Blue is preferred by the author when the classification of the fibre is known and only the details are sought.

Linen (Fig. 27) are polygons and possess a lumen of uniform length. Always check and recheck both linen and cotton with and without reagents as mistakes are liable to occur in trying to distinguish between these fibres, as the action of the reagent is almost alike with iodine solutions.

Jute (Fig. 28) is a thick-walled fibre and varies greatly in appearance, but resembles hemp and flax. Striations are parallel to the fibre knots.

The characteristics of wood fibres can be put into two groups; cellulose, from coniferous trees and cellulose from deciduous trees. Of the coniferous group we have pine, fir, spruce, hemlock, etc., and of the deciduous group poplar, aspen, birch, etc. The conifers are mostly composed of tracheids (cells) as illustrated in Fig. 29, while the deciduous trees give us our libriform cells (Fig. 30). Fig. 31 shows a tangential longitudinal section of pine with tracheids and medullary rays.

Fig. 32 represents a cross-section of tracheids and shows how these cells are formed. By comparing this drawing with Fig. 29 and 31 their position in a fibre or group of fibres can be readily understood.

Cellulose

Cellulose chemically is designated by $C_6H_{10}O_5$ and has been divided into several groups. There are Alpha Cellulose called Oxycellulose; Ligno Cellulose called Beta Cellulose, evidenced chemically by the presence of Methoxyl groups.

Cotton is considered the prototype of celluloses because of its purity, hence its use in the manufacture of gun-cotton for high explosives. It is the impurities of wood cellulose that have caused the paper manufacturer most of his troubles, but at the present time, with the development of new machinery and methods, most of these have disappeared in contrast to those of fifteen years ago.

Cellulose is incapable of crystallization, is insoluble in simple solvents and is comparatively inert to most

reagents and by reason of this inertness it is possible to remove foreign matter without much possibility of affecting the cellulose.

Of the solvents of cellulose, hot zinc chloride will produce a viscous compound, as for instance, in the production of incandescent lamp filaments and fibre vulcanization where this is utilized.

Another soluble of cellulose is Schweitzer's Reagent (Ammoniacal Cupric Oxide). This reagent and modifications of it are employed in the manufacture of artificial silk.

Different Methods of Making Pulp

There are two ways in which materials, such as linen, cotton, hemp, wood, etc., are reduced to cellulose: First, by cooking, using either the acid method or the alkali method. Second, by means of mechanical grinders.

The acid method (known as the sulphite method) is applied to wood, which is reduced to pulp by means of digesting with the aid of bisulphites of alkaline earth metals (as calcium or magnesium).

The alkali method also applied to wood (known as the sulphate method) employs sodium sulphate as the "cooking" medium by which wood is reduced to cellulose.

In the reduction of rags to pulp an alkaline lye is employed to convert chemical and other impurities into a removable soap. Caustic soda is most

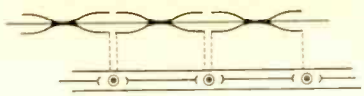


FIG. 32

Tracheids of coniferous group.

commonly used, though, sometimes, as in the case of jute, lime may be employed. The difference is that lime converts dirt into insoluble soaps, while soda converts dirt into soaps that are soluble.

Mechanical wood pulp is produced by grinding logs under pressure and in contact with water.

Condenser Paper

The surface of a typical condenser paper is illustrated in Fig. 33. Note the homogeneousness of this mass of cellulose, the length of the fibres and the general appearance of compactness. The dark splotches are not holes, but translucent spaces completely closed. In photographing the amount of light necessary to get the detail of the surface (which was transmirted) was so intense that it caused this appearance. Compare this with the appearance of the fibres in Fig. 27.

Minute holes and carbon particles cause as much damage to condensers as most any known imperfection. Fig. 34 is a microphoto of a piece of carbon imbedded in a condenser tissue. An analysis of this carbon after photographing showed that it was probably "flue carbon." Fig. 35 is a microphoto of a hole in a condenser tissue. This is a paper machine hole and must not be confused with the hole represented in Fig. 36, which is a "blow out" (Section taken from a 1 mf. condenser, breakdown at 3000 volts).

Fig. 37 is a microphoto of fibres of a condenser paper, disintegrated after the method employed in the beginning of this article and is merely to illustrate the results of the same method employed in the extraction of "newsprint" fibres. These fibres were stained with the Herzberg Stain and photographed.

Conclusions to be drawn will indicate, not only the varieties of cellulose employed in the manufacture of paper, but also the fact that each has its classification and definite purpose in the construction of a given paper.

In the next and concluding article on this subject, more will be illustrated regarding the combinations of these classes of cellulose and fibre analysis. A bibliography will also be given for aid in more exhaustive researches.

(To be continued)

Note.—In the previous article, the caption of Fig. 19 should have read; Sulphite fibres illustrating photograph with Graphlex Camera.

The Horizontal Checkerboard Antenna

New Horizontally Polarized Transmitting System at W2XAF Increases Ten-Fold the Effective Radiation

AN antenna that increases the directional power of W2XAF, the short-wave station of WGY, ten times, making a 20 kilowatt station the equivalent of 200 kilowatts in effectiveness in one direction, has been erected at the South Schenectady transmitter laboratory of the General Electric Company. This antenna faces the south and it is used for one program only and then but once every other week. The engineers call it the "Byrd" antenna because when this particular radiator is in use, the message is directed to Commander Richard Byrd and his men at Little America, Bay of Whales, Antarctica.

This particular antenna was used for the first time Saturday night, March 23, and within fifteen minutes after the conclusion of the program, WFA, the Byrd transmitter, reported in code that the entire program had been received through loudspeaker.

Twelve Antennas in One

The Byrd antenna is of the horizontal checkerboard type and it is similar to the radiator constructed for program transmission to Germany and for facsimile developmental work with the Pacific Coast. It is one of a dozen or more antennas which sway above the 54-acre transmitter laboratory at South Schenectady. These antennas hang from steel masts from 150 to 300 feet high, from plain wooden masts and from masts with cross bars, not unlike scaffolds in appearance. Ordinarily, W2XAF, the 31.48 meter transmitter of WGY, uses a vertical antenna about 50 feet in length. The new antenna is actually twelve antennas in one, consisting of two sections of a checkerboard, each section made up of three squares. One section is known as a reflector. Only the horizontal wires of the system function as antennas, the vertical wires being for support or power transmission to radiating wires.

The horizontal antenna was developed following years of research along lines suggested by Dr. Alexanderson, consulting engineer of the General Electric Company. The effectiveness and carrying power of horizontally polarized radiation were discovered by Dr. Alexanderson in 1924. When transmitting with horizontally polarized waves the so-called ground wave is quickly absorbed, leaving only the high-angle radiation which in its carrying power appears superior to the vertically polarized wave. With the horizontally polarized system it is possible to shoot most of the energy into the air and, with the antenna now in use, to direct the greater part of this energy in any desired direction instead of dissipating it in every direction over a comparatively small area.

Consistent Results Obtained

The use of horizontal antennas in facsimile work has assisted immeasurably in assuring transmission to the Pacific Coast. Both German and English radio observers have reported a great increase in signal strength of short-wave broadcast signals when the horizontal antenna system is used.

All future Byrd programs of WGY will be broadcast on the special antenna, and while it is unlikely that even this system will penetrate the heavy static of severe snow storms, there is assurance that the explorers will get a much better signal than has heretofore been possible.

Light-Sensitive Cells

III. Amplification, Measurement, and Utilisation of Photoelectric Currents

By John Patton Arnold

THE original intention of the writer was to treat rather fully the various applications of photoelectric cells. But in view of the fact that RADIO ENGINEERING has kept its readers thoroughly up-to-date in this respect, that purpose is now abandoned, and the reader is referred to the files of the magazine for a great deal of information which is omitted here to avoid duplication. Therefore, only a summary of the previously published data and the presentation of a few supplementary facts which help to round out the picture will be considered in this article.

Amplification

Photoelectric cells of the alkali metal type are used in circuits which either do or do not require amplification of their exceedingly small current output. Without amplification, extremely sensitive electrical apparatus must be employed. Such circuits are more often applicable to delicate physical measurements than any other purpose, for the cost of accessories—for instance, a relay which will operate on 30 or 40 microamperes—is out of proportion to their usefulness in engineering practice. However, in such cases, the cell acts as a variable resistance, the magnitude of the current being determined by the intensity of the acting light.

Although there are a number of applications of the foregoing sort, cells are more often used in conjunction with the thermionic vacuum tube in order to obtain currents of effective magnitude. When employed in this way, the cell is operated as a variable source of potential. Only a charge current flows through the cell, and the potential acquired by one of the electrodes is proportional to the light intensity.

Kunz[1] first suggested that a vacuum tube might be used for amplifying photoelectric currents. Since that time, many circuits have been devised and published with the result that today we have what is commonly known as a "parent situation." A patent situation arises when a number of gentlemen all want the same thing, and failing to get it, condescend to call each other thieves and liars. Sometimes they go to court. There they are more polite but twice as greedy. Beyond this point the writer has not investigated. When the high priests fall out, the laity might just as well stay away from the temple. Still it does seem that, given the photoelectric cell and a vacuum tube, and the idea of coupling the output of one to the input of the other, any screw-driver electrician could discover a number of effective ways of doing the deed. There are, of course, many refinements in so doing.

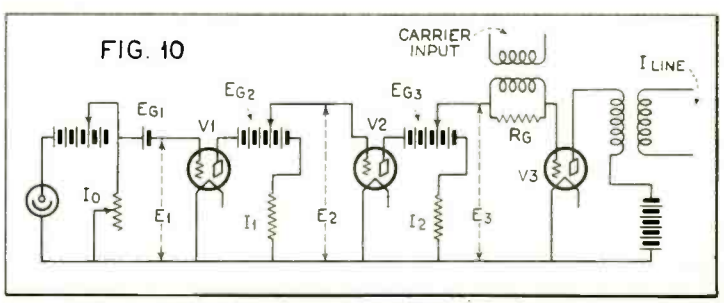
The "Daylight Integrator"—a set-up for measuring light over long intervals of time, by means of electrolysis.
(*Courtesy of General Electric Co.*)

The point which the foregoing digression was intended to illustrate is that, in the absence of other ideas, even a dabbler in the art might be expected to think of the advantages of the ordinary methods of transformer, resistance, or inductance coupling. That such ideas are patentable is granted, but no one need seriously believe that a competent radio engineer would be stumped for one moment by the proposition or would have to resort to his badge of courage—the slide-rule.

Among the refinements to such circuit arrangements are the adaption to a-c. and d-c. supply from lighting mains the use of common batteries to supply both the cell and the plate of the tubes, etc. In the following paragraphs, some of these frills will be indicated.

The usual forms of vacuum tube amplifiers are not suitable for continuous or direct-current amplification. In photoelectric engineering it is often necessary to amplify continuous or slowly changing currents and hence an amplifying circuit similar to the one shown in Fig. 10 is necessary since it is clear that transformer or resistance-condenser systems are inapplicable. Morecroft[2] and Loftin and White[3] describe such systems at length.

A carefully designed amplifier of this type for the electric transmission of pictures over telephone lines is described by Ives[4] *et al* as follows: "Starting at the extreme left (Fig. 10) is the photoelectric cell, the current from which passes through a high resistance. The potential tapped off this resistance (of the order of 30 or 40 millivolts) is applied to the grid of the first vacuum tube amplifier. The second tube amplifier is similarly coupled with the first, and the vacuum tube modulator in turn to it. The relationship between illumination and current in the photoelectric cell is linear from the lowest to the highest values of illumination. The voltage current (E versus I) characteristics of the amplifying tubes and the modulating tube circuits are not linear over their whole extent. It becomes necessary, therefore, in order to preserve the linear characteristic, which is essential for faithful picture transmission to locate the range of variation of current in each of the latter tubes on a linear portion of their characteristics. This is accomplished by appropriate biasing voltages (Eg), as



Direct-current amplifier for photo-telegraphy.
(*Courtesy Bell Systems Technical Journal*)

[1] *Phys. Rev. Vol.* 10, *p.* 205; 1917.

[2] "*Principals of Radio Communication*," *p.* 970.

[3] *Proc. I. R.E., Vol.* 16, *p.* 281; 1928.

[4] *Bell Sys. Tech. Jour., Vol.* 4, *pp.* 198—200, 1925.

shown. As a consequence of this method of utilizing the straight line portions of the tube characteristics, the current received at the far end of the line does not vary between zero and finite value, but between two finite values."

The design of amplifiers for the transmission of television signals demands considerable care, since the photoelectric currents are extremely weak due to the necessity of collecting the reflected and diffused light from the object to be transmitted. Troublesome sources of interference in a particular instance[5] were found to be due to electromagnetic and electrostatic induction and to mechanical and acoustic vibration where tremendous amplification was necessary. Special amplifiers, designed according to well-known electrical engineering practice, has overcome the early objection to the use of photoelectric cells of the alkali metal type for such experimental work. The cell is usually connected to the input of the vacuum tube as shown in Fig. 11.

The engineers of the Bell System Laboratories were the first to use large potassium hydride, gas-filled cells for the production of television signals. Such cells present forty square inches of light-sensitive cathode and have an aperture, or "window" of 120 square inches. A commercial cell, similar to this, having a bulb diameter of twelve inches costs about $335. In the Bell television system three large cells are used in parallel.

Considering the Ives cell, as described in the foregoing paragraph, the problem of amplification may be understood from the following quotations: "Starting with the photoelectric cell in which the initial luminous signal wave is converted to an electric signal wave, we are interested in the magnitude of various pertinent constants. The cell may be considered for our purposes as an impedance, the value of which is determined by the quantity of light reaching it. With no illumination at all this impedance is almost entirely a capacitance of the order of 10 mmf. When the cell is illuminated this capacitance becomes effectively shunted by a very small conductance which is roughly proportional to the square of the voltage between the electrodes. For a fixed potential the magnitude of this conductance is nearly a linear function of the illumination. With a suitable potential in series with the cell, then, there is obtained a current the amplitude of which is proportional to the quantity of light reaching the cell."

"In order to connect the photoelectric cell to the amplifier, there is introduced in series with the cell and its polarizing battery a pure resistance the voltage drop across which is used to control the grid potential of the first tube. It is desirable, of course, to make this resistance high in order to have available as much voltage as possible. Its value is, however, limited by two considerations. The added series conductance must not be so low that it appreciably disturbs the linear relation between the illumination and the total conductance of the circuit. The voltage drop must also be so small, in comparison with the total potential in the circuit, that the photoelectric cell operates at an approximately constant polarizing potential." (See Fig. 11 and the reference immediately above, pp. 587-588.)

The talking moving picture has opened up a highly interesting field of usefulness for the photoelectric cell. The problems of amplification are less severe than in the case of television. The resistance-condenser method of coupling is also employed (Fig. 11). Scriven[6] discusses the sound projector system using this type of amplifier.

Fox, Rood and Marburger[7] describe an amplifier which takes its supply from the ordinary 110-volt alternating current sources. The circuit is given in Fig. 12 and was used specifically for the control of a laboratory clock by means of photoelectric signals. The circuit includes a full-wave gaseous rectifier, a power amplifying tube, photoelectric cell and relay. This is an economical means of operating a photoelectric cell in continuous service.

Coblentz[8] in his study of instruments used in radiometry, refers to the following methods of measuring photoelectric currents:

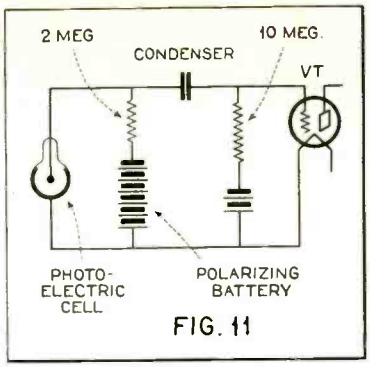


FIG. 11

Method of connecting cell to vacuum tube; circuit commonly employed in television and talking motion pictures.

1. The current may be measured directly by noting the deflection of a sensitive galvanometer. (a high resistance ironclad Thomson type is recommended) provided the question of proportionality is considered and the light intensities are fairly high.

2. An electrometer or a sensitive galvanometer may be used as a detector or indicator and "to balance the photoelectric current with a current which can be verified in a known manner." (Refer to Griffith, Phil. Mag., 14, p. 297, 1907; Richtmyer, Phys. Rev., 29, pp. 71 & 204, 1909.)

3. Measurements can also be made by observing the rate of drift of an electrometer needle. (Ives, Astrophys. Jour., 39, p. 432, 1914.) This investigator found that the needle did not "move at a uniform rate."

4. "A fourth method (which experimenters seem to prefer to the one just described) is the 'ballistic throw method.' In this method the photoelectric cell is exposed to light for a convenient length of time, say 10 seconds, and the charge acquired by the electrometer needle is noted. The 'natural drift' of the needle is determined by noting the drift in 10 seconds when the cell is not exposed to light, and this is subtracted from the observed deflection." (Hubert, Astrophys. Jour., 42, p. 210, 1915.)

5. Nichols and Meritt (Phys. Rev., 34, p. 475, 1912) describe a method of using the photoelectric cell whereby the deflection rather than the rate of change of deflection is read.

6. Richtmyer (Phys. Rev., 6, p. 66, 1915) employs the null method of measuring photoelectric currents with an electrometer. This avoids the question of proportionality in the cell.

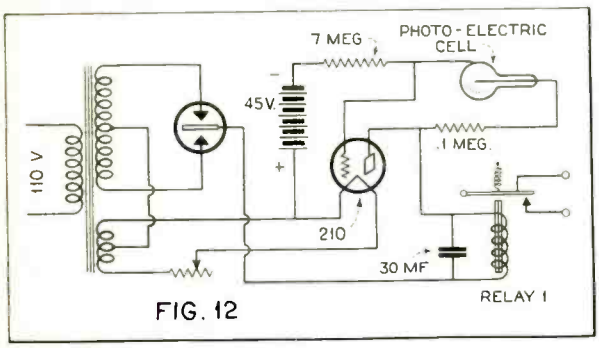


FIG. 12

Schematic diagram of power amplifier for photoelectric cell operation. *(Courtesy Journal, Optical Society of America)*

*Uses of Cells**

A fire and burglar alarm, invented by Dr. R. C. Burt, of Pasadena, Calif., is shown in Fig. 13. The light from the lamp L after successive reflections from a number of mirrors (M_1, M_2, and M_3), ultimately falls on the ca-

[5] *Bell Sys. Tech. Jour., Vol. 6, p. 560; 1927*

[6] *Bell Sys. Tech. Jour., Vol. 8, p. 197; 1929.*

[7] *Jour. Opt. Soc. Am., Vol. 15, p. 364; 1927.*

[8] *Bur. Stand. Sci. Paper No. 319, pp. 522-526; 1918.*

* *Refer also to* RADIO ENGINEERING, *p. 40, August, 1928; p. 28, September, 1928; p. 980, October, 1927; p. 1038, November, 1927.*

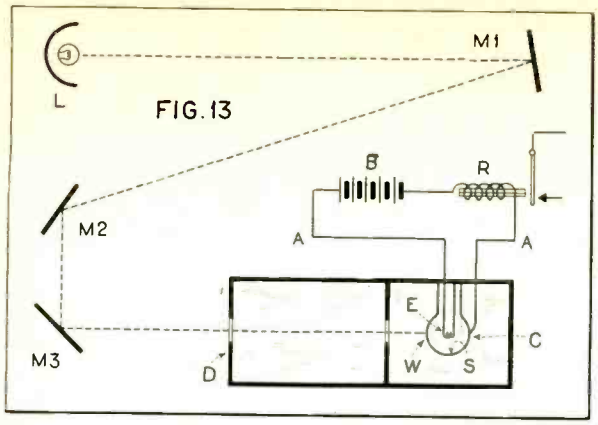


FIG. 13

Circuit and details of a fire and burglar alarm system. Any obstruction in the light path trips the relay, R, which sets off the alarm.

thode of a cell, in the circuit of which is a sensitive relay. The relay controls an alarm system of any sort. The relay is of a sensitive and carefully balanced type in order that a slight increase or decrease in the light will set off the alarm. This is to prevent, when used as a burglar alarm, an intruder in the room from holding the relay inoperative by flashing a light into the box (D). As the room is barred by light, if a person or any opaque object crosses the path of the beam, the relay trips and the alarm goes off. The sensitivity of the device can be adjusted as desired, and can also be made to respond to fire or smoke.

One of the useful applications of photoelectric cells is for automatic temperature regulation. A practical circuit for this purpose is shown in Fig. 14. In connection with a subject of which we will have more to say later, i. e., the construction of light-sensitive cells which require careful annealing processes, this circuit would be very satisfactory as a temperature control. The thermocouple controls the movement of a mirror galvanometer, M, from which a beam of light (represented by the star) is reflected upon the cathode of the photoelectric cell. The current of the latter is amplified in order to actuate the relay which controls the power circuit operating, let us say, an electric heater. Thus the thermocouple can be made to control this heater in the manner of an automatic switch, turning the current on or off when any particular temperature is reached.

Dr. L. B. Koller, of the General Electric research laboratories, devised a method of measuring the amount of daylight received over any desired intervals of time, using a photoelectric cell, a microammeter, and an electrolytic cell for this purpose. The electrolytic cell was a glass beaker containing a weak acid solution in which a carbon rod was immersed to serve as an anode. A long glass tube, inverted in the beaker with a copper rod extending up through it, was used for the other electrode. When the photoelectric cell is exposed to light and the current passes through the electrolytic cell, hydrogen is liberated within the tube, which was sealed at the top to trap the gas. The hydrogen forces down the electrolyte in the tube in accordance with the amount of light falling on the light-sensitive cell in a given period of time. This device is called a "daylight integrator."

Byrnes[9] indicates another interesting application. "The problem of measuring the output of high-frequency transmitters by means of a dummy load has been given considerable thought. If an attempt is made to use the conventional dummy antenna resistors, it is found that their inductance has an appreciable effect on the load circuit, and accurate measurements are difficult. One method which has been successfully used to measure high-frequency power consists of a bank of incandescent tungsten lamps which are used to load the transmitter. These lamps are mounted in a compartment with a photoelectric cell and their brilliancy controls the internal resistance of the cell. Such a device may be calibrated on direct or low-frequency alternating current and tests have shown that accurate measurements can be made with such a system. In other words, the brilliancy of the lamp when heated by high frequency is the same as when heated by an equivalent power at low-frequency or by direct current."

[9] *Proc. I. R. E., Vol. 16, p. 651; 1928.*

Robbins[10] employs a cell in apparatus for automatic machine gauging in the quantity production of various articles of manufacture. The particular instance in which the cell was used was testing heat coils used to protect telephone exchange equipment from excessive electrical currents that might accidentally come over the lines. The photoelectric cell is a part of the apparatus which selects or rejects a coil which is either above or below the standard required for the purpose. There are many applications of this type which open up a wide field for an engineer in industries which are making the word "manufacture" an anachronism.

P. P. Cioffi (reported by F. C. Jones in *The Iron Trade Review;* reprinted in part by *The Literary Digest* for Feb. 18, 1928) devised photoelectric apparatus said to be capable of measuring lengths of the order of a billionth of an inch for certain studies of magnetic materials.

In the various possible applications of photoelectric cells, a common error is to use the light-sensitive device where other electrical or mechanical methods are much more suitable. Generally speaking, it is not advisable to employ a cell for a purpose which may be accomplished by other means, chiefly because cells and their accessories are more expensive, less rugged, and require greater care. This statement refers more specifically to applications based on the use of relays.

Sources of Light

The usual sources of light for photoelectric works are (1) the spark, (2) the electric arc, and (3) the mercury vapor lamp, since these are rich in ultra-violet rays. The light of burning magnesium may also be used for some experiments, but for practical work with the more electro-positive metals and with the photo-conduc-

(*Continued on page 46*)

[10] *Bell Sys. Tech. Jour. Vol. 7, pp. 712–718; 1928.*

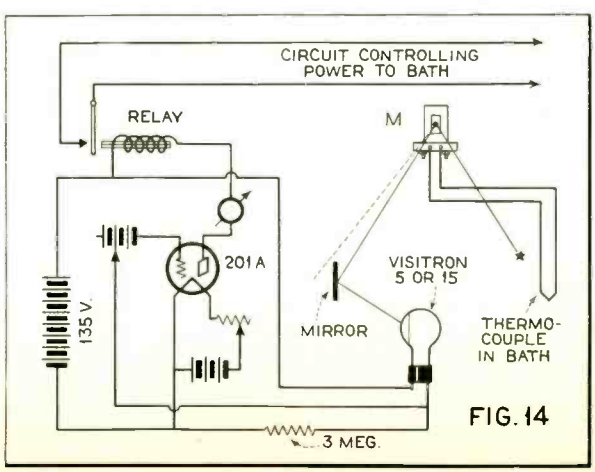


FIG. 14

Circuit diagram and details of a temperature control system. A thermocouple and mirror galvanometer are employed. (*Courtesy of G-M Laboratories, Inc.*)

The Engineering Rise in Radio

By Donald McNicol

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

Part XII

Theory of Action of the Audion

THE events of 1913 were somewhat bewildering to the radio worker. Commercial radio telegraphy and shipshore service were making some headway. In 1912, the Marconi Wireless Telegraph Company of America acquired the stations and other assets of the opposition company, the United Wireless Telegraph Company. In that year the disastrous loss of the S. S. Titanic (April 15) attracted wide attention to the great value of wireless telegraphy on shipboard as a means of saving life in case of accident. An International Radio Telegraph Conference was held in London, in 1912, which approved important regulations looking to uniformity of practice in wireless operations throughout the world.

The commercial stagnation which prevailed from the early days of the art until the arrival of the oscillating audion and its regenerative uses, was at an end. And, in August 1914, the Great War in Europe was begun, which was to have as a by-product, not considered in the calculations, a greatly accelerated development of radio telegraph and radio telephone signaling.

In 1914, then, there was a pressing need for a clearing up of the situation with regard to the audion. What was its theory of operation? What its characteristics? What its possibilities? These and other questions awaited answers in terms understandable to the host of workers, professional and amateur, engaged in radio undertakings.

It was Armstrong who gave the answer, and the fact that he was first to give a popular explanation of the properties of the audion and its associated circuits in radio receivers, brought to him quickly the approbation both of the expert and the tinkerer the world over.

In the *Electrical World*, New York, of December 12, 1914, Armstrong published a paper entitled "Operating Features of the Audion," and at the March 3, 1915, meeting of the Institute of Radio Engineers, New York, he read a paper entitled "Some Recent Developments in the Audion Receiver."

These papers reported oscillographic examinations of tube characteristics, in which investigation Armstrong was aided by Professor J. H. Morecroft, of Columbia University. Digests and reprints of these papers appeared in many technical and semi-technical periodicals in the United States and other countries, the explanations being so clear that experimenters were at once enabled to set up radio receiving circuits far superior in performance to those previously available. The "regenerative" or "feed-back" circuit became known popularly as the Armstrong circuit, and has so continued until the present time.

Armstrong's paper of December, 1914, set forth that the fundamental principle of the audion as a detector and amplifier is that, starting with the grid and filament at zero potential-difference (no terminal e. m. f. applied to the grid) then when a negative charge is imparted to the grid the current flowing in the plate circuit is decreased; and, when a positive e. m. f. is applied to the grid an increase in current strength takes place in the plate circuit.

The audions examined in the oscillographic study disclosed that the tube is essentially an electron relay; that is, the gas present is exceedingly small, the current in the direction from filament to plate being thermionic. And, distinguishing between the action of the tube as a detector and as an amplifier, Armstrong accounted for the detector action as follows:

> "Since the incoming oscillations are of too high a frequency to affect directly the telephone receiver, the audion must be so connected and adjusted that the cumulative effect of a group of oscillations in the grid circuit is translated into a single low-frequency pulse or variation in the telephone (plate circuit) current. This may be done in two ways, one depending on the non-linear form of the operating characteristic of the audion and the other depending on the so-called valve action between hot and cold electrodes at low pressures. . . . The main part of the discharge through the telephone is in the same direction as the current due to the 'B' battery, constituting an increase in the current actuating the telephone. As this action is repeated for each group of incoming oscillations, a series of wavetrains causes what might be regarded (in its action on the telephone) as an alternating current in the telephone superposed on the continuous current and having a fundamental frequency equal to the number of wavetrains per second."

As an emplifier, assuming that the filament is incandescent and the positive terminal of the local 'B' battery is attached to the plate, "an alternating e. m. f. impressed between grid and filament causes variations in the plate current; the positive alternation producing an increase, and the negative alternation a decrease in the plate current."

In Armstrong's paper of September, 1915, the oscillating property of the audion is described thus:

> "Any repeater, which is also an energy amplifier, may be used to produce continuous oscillations by transferring part of the energy of the circuit containing the battery back to the controlling circuit to keep the latter continuously excited. By providing a close enough coupling between the grid and the plate circuits, sufficient energy is supplied to the grid to keep it in continuous oscillation, and as a consequence thereof oscillations of similar frequency exist in all parts of the system. . . ."

The term "feed-back" which came into popular use soon after Armstrong's papers were published, may perhaps be clear in its significance by considering a receiving circuit in which an audion serves as a detector and as an amplifier. With the incoming oscillations from the receiving antenna affecting the grid element of the tube the desire is that the current in the grid circuit may obtain reinforcement from the energy in the plate circuit supplied from the "B" battery. If then, the plate circuit is extended and coupled magnetically to the antenna circuit, the oscillations in the plate circuit are "fed back" to the grid by way of the antenna coupling unit, in effect producing regeneration of signal energy.

The Audion as an Oscillator

The full significance of the fact that the audion could be associated with other circuit elements so as to produce useful electric oscillations did not at once occur to those who first employed the tube to amplify received signals. The discovery of the amplifying property was a step forward of such length that the discoverers had amply reason for pausing to look backward, rather

An Invitation to our Readers

As usual, RADIO ENGINEERING *will be well represented at the Annual R. M. A. Convention and Annual Trade Show, in Chicago, from June 3rd to 7th.*

We would be very happy indeed to have you drop in and pay us a visit, if for no other reason than to get acquainted. However, we trust that you will take advantage of this opportunity to let us have your impressions of RADIO ENGINEERING *— what, in your estimation should be done to increase its value to you, as a reader; the features you are particularly interested in — and so on.*

The editorial staff wishes to have it understood that they are striving, in every way possible, to cooperate with all factors in the industry and gauge the general requirements of the field — and to this extent would appreciate comments from all readers.

To those of you who will be present at the Trade Show: —we will be happy to receive you in Room 532, the Stevens Hotel.

than for viewing the ground ahead with the thought of selecting footing for still another leap forward.

The audion was invented as a receiver of electric waves. The discovery later that it had amplifying properties might well have seemed to be the ultimate of what should be expected from it. In the course of time excellent receiver circuits were designed and used which do not depend upon regeneration. But, as a transmitting and voice-modulating device the tube was destined to meet the requirements so satisfactorily that for a long time it is likely to have no close rival either for radio telegraph or radio telephone purposes.

For the human mind to at once recognize the full significance of the Ultra-audion receiving assembly and the regenerative, feed-back receiver, it would have been aid had there been in the history of mechanics some such anomaly as a chain serving as a flagpole, or an anchor serving as a parachute. A receiver is the opposite of a transmitter. In the early days it would have been an absurd spectacle had a coherer essayed to play the role of an induction coil.

However, deForest, Logwood, Armstrong and Round have what might be termed *source* minds; minds in which ideas originate, and it was not long before the tube was put to work at both ends of radio systems—serving both as a transmitter and as a receiver. It was an astounding discovery, once the full import of the thing became clear. The brief period between the discovery of the amplifying use of the tube, and the promise of transmitting properties is reminiscent of Henry's discovery in 1842 of the oscillating properties of the condenser discharge. Presumably other scientists of that time said: "Well, what of it?" And it was not until forty-five years later that Hertz gave the answer.

It is interesting now to recall the wording of the early descriptions of the reaction principle in receivers: that "The ratio of transformation of the transformers should be so adjusted to get the maximum signals without causing the audion to generate oscillations."

It is to be remembered that the audion oscillator was discovered to have the property of generating oscillations of the same nature as those generated by high-frequency machine generators, the arc generator, and of the previously employed transformer, condenser and spark-gap transmitters.

The tubes available in 1913, and the transmitting circuits in which they were employed permitted of generating signaling currents of limited energy, but improvements made later by H. D. Arnold, W. D. Coolidge, A. W. Hull, W. G. Housekeeper, H. J. van der Bijl, W. C. White, H. J. Round and others made practicable the production of tubes rivalling in output the massive alternators employed in transocean radio telegraphy. And, for radio telephone purposes the tube oscillator supplied the element previously missing if transmitters were to be set up anywhere other than in locations where huge power plants might be erected.

Notably among the later developments in tube design and construction were the dynatron, pliotron, plio-dynatron and magnetron, brought out by engineers of the General Electric Company. The kenotron and pliotron were described by Langmuir in April, 1915, and the pliotron by A. W. Hull in February, 1918. The kenotron rectifier utilizes the uni-directional property of the current between a hot and a cold electrode in vacuum, while the pliotron utilizes the space charge property of this current, which allows the current to be controlled by the electrostatic effect of a grid element. The dynatron utilizes the secondary emission of electrons by a plate element upon which the primary electrons fall. The dynatron is, as its name implies, a generator of electric power, and feeds energy into any circuit to which it is connected.

References to some of the important literature of the subject which followed the pioneer discoveries of Armstrong, deForest, Logwood, Round, Meissner, and others, are given in a foot note[12].

CHAPTER II

Early Company Organizations

THE financial promoters of the early "wireless" companies were quite aware of the advertising value of wonder, of mystery. There was little in the electrical makeup of the early wireless telegraph apparatus, which even remotely suggested the possibility of wireless telephony. The technical workers were fully occupied in endeavoring to set up dependable telegraph service. They were agreeable to leaving the subject of telephony alone until the serious problems of telegraphy had been solved, and while this was quite proper, and inescapable, on the part of the engineer, no such limitation guided or controlled the deliberations of the promoter.

The early wireless companies organized in America were not handicapped at the start by being given corporate names which implied restriction of field of service. With a commendable buoyancy of outlook and an abiding faith in what the engineer could accomplish, the promoter blithely added the word "telephone" into the name of his company, so that his appeals for financial support might meet with more favor. A company organized simply as a telegraph service organization, and so labeled, could not reasonably (so the promoter reasoned) hope to attract the attention of "long pull" investors, while at the same time a rival company seeking funds, promised earnings from both wireless telegraph and wireless telephone services.

Indeed, even while the promoter's ardent desire was that his technical staff should be able to demonstrate practical telegraph working; in naming his company[1] he placed the word "telephone" ahead of the word "telegraph." The first company, in America organized in 1901, was named the American Wireless Telephone and Telegraph Company, followed later by the Continental Wireless Telephone and Telegraph Company, The Pacific Wireless Telephone and Telegraph Company, and so on until it was realized that the promoter was, in aspiration at least, altogether too far ahead of the engineer.

The scientist, the inventor and the engineer are not much given to capitalizing the future. They are explorers who label and card index only that which they know has been discovered, and that which they know has been accomplished, and it was in this manner of proceeding that the engineer developed radio telephony out of radio telegraphy.

Speech Transmission

In considering the possibility of radio telephony it was apparent that the early damped-wave transmitters used for telegraph signaling, would not be suitable for telephony. For telephone transmission a plain requirement was that between transmitter and receiver it would be necessary to set up a continuous stream of radiation, normally constant in wavelength or amplitude, or both. If there were interruptions these would have to be very rapid if speech was to be transmitted intelligibly. Further, on the stream of radiation it would be necessary to impress, or superimpose, quantitative changes in accordance with the acoustic vibrations to be transmitted. A receiver would be required which would give quantitatively, audible indications of these changes in the character of the incoming waves, a function later called "modulation."

In the course of time the Poulsen arc, and the Fessenden-Alexanderson alternator methods of producing continuous high-frequency oscillations were to prove useful in wireless telephone experiments, but the lure of "talking without wires" was too great to per-

[12] *Langmuir, Proc. Inst. Radio Engineers, New York, Vol. 3, p. 261 (1915).*
W. C. White, General Electric Review, September, (1916).
C. V. Logwood, Electrical World, New York, April 21, (1917).
Alfred N. Goldsmith, Wireless Age, New York, June and July, (1917).
A. W. Hull, Proc. Inst. of Radio Engineers, February, 1918.

[1] An exception to this practice was that of the Thomas E. Clark Wireless Telegraph-Telephone Company, in which the word "telegraph" was placed ahead. This company was organized in 1901, by Thomas E. Clark, of Detroit, Mich. The company produced some of the best of the early wireless telegraph apparatus experimented with in America, and is the only one of the original American wireless organizations which has continued until the present time without amalgamation with other organizations.

mit delay in getting on with the problem. The liquid barretter, due to Fessenden, was available in 1903, and had possibilities as a receiver of modulated continuous waves. The crystal detectors, brought out a few years later, also were fairly suitable for this purpose, but it was not until 1906-1907 that the arc and the alternator methods of producing sustained oscillations were available.

Fessenden was the most industrious of the scientists who directed thought to the problem of space telephony. In November, 1899, Fessenden noted that a telephone receiver connected with a radio receiving system reproduced faithfully the tone of a Wehnelt interrupter actuating the induction coil of the distant transmitter, and it at once occurred to him that by employing a transmitting source with a frequency above audibility radio telephony should be possible.

For Fessenden's use, S. M. Kintner designed an interrupter which was to have a spark frequency of 10,000 per second, and although the frequency was somewhat less than this in the actual apparatus, telephone experiments were made in the fall of 1900. Naturally, the first demonstrations were what first demonstrations usually are: at best, disclosures of improvements necessary to attain success.

Speech was, however, transmitted and received, although of a poor quality, and as a matter of historical record it may be said that the first speech transmitted and received by radio telephone was that carried on by Fessenden, during Christmas week, 1900, between two stations at Cob Point, Maryland, situated about one mile apart. As Fessenden relates: "poor in quality, but intelligible."

During the succeeding three or four years Fessenden spent considerable time developing ways of producing high-frequency, sustained oscillations. Compressed nitrogen and compressed neon gas oscillators were tried out, also quenched gap and flywheel types of spark dischargers. In 1904, with a nitrogen gap and a spark frequency of 20,000 per second, it was reported that Fessenden had demonstrated radiophone transmission over a range of twenty-five miles, the articulation being considered good enough for commercial service.

In the meantime the alternators described in Chapter 4 were becoming available. In 1906, an alternator was employed in telephone tests between Brant Rock and Plymouth, Massachusetts, a distance of eleven miles. In July, 1907, the range of operation was extended to nearly 200 miles: between Brant Rock, Mass., and Jamaica, Long Island, New York.

DeForest, also, had been at work on wireless telephony and had worked out a system employing arc transmission and the audion receiver. In July, 1907, deForest radiophone equipment was employed to report the progress of yacht races on Lake Erie, the range of operation extending up to twenty miles, and a few months later twenty-six vessels of the Pacific squadron of the U. S. Navy, were equipped with deForest apparatus.

In Germany those engaged in wireless telegraph developments employed the arc in December, 1907 to transmit speech from Berlin to Nauen. The water-cooled flame-arc arrangement was used; twelve arcs in series.

In the early work it was found that the usual carbon type of telephone transmitter was unsuited for radio working owing to its inability to handle the necessarily large actuating current volume. A type of transmitter was designed for the purpose which Fessenden called the "trough" transmitter. It consisted of a soapstone annulus to which were clamped two plates with platinum iridium electrodes. Through a hole in the center of one plate a rod passed, attached at one end to a diaphragm and at the other to a platinum iridium spade. The two outside electrodes were water-jacketed. With a teaspoonful of carbon granules in the central space this transmitter was said to carry a current of fifteen amperes continuously without the articulation falling off appreciably.

In 1907, Fessenden radio telephone operation was carried on between Brant Rock, Mass., and Brooklyn, New York, and between Brant Rock and Washington, D. C., in December, 1907. In the latter month, also, it was reported that the Fessenden station at Brant Rock had on two occasions, succeeded in transmitting speech to a station located at Machrihanish, Scotland, a distance of about 3,000 miles. Experience with wireless telephony and wireless telegraphy at the Brant Rock station showed that with the apparatus available at that time, the power required for telephony was from five to fifteen times as great as that required for telegraph signaling, and that for given power telegraphy could be carried on from two to four times as far.

The Microphone Problem

Naturally, the main problems of the pioneers were to devise suitable telephone transmitters, determine the best location for the transmitter in the circuit assembly, and to provide satisfactory means for modulating the transmitted waves.

For applying acoustic control several inventors employed microphone transmitters in association with either the sending antenna, or the oscillation generator circuit. A microphone could be employed in shunt with a portion of the antenna inductance or capacity or in a separate circuit coupled inductively to the antenna. There was the possibility that the microphone might be used to modify the supply current to the arc oscillator, or to affect any variable associated element controlling the amplitude of the waves produced. By inserting the microphone in the antenna circuit the alterations of microphone resistance produced by voice effects on the diaphragm caused corresponding variations in the antenna current, and consequently of the amplitude of the radiated waves.

There was the possibility, also, that the microphone might be employed to vary the wavelength. John Stone Stone, in America, connected the microphone in a circuit coupled to the main inductance unit of the oscillation generating circuit. In the coupled circuit the currents were varied by the varying resistance of the microphone, the effective inductance of the coil being thereby varied accordingly. Obviously, by this arrangement the frequency was altered, and also the amplitude.

A suggestion made as early as 1907, or 1908, was to employ a condenser telephone of the Dolbear type for varying the wavelength by altering the capacity of the generating circuits or of the antenna.

In this arrangement the approach and recession of a conducting diaphragm to and from a fixed conducting plate varied the capacity, and so affected the potential difference of a conductor in connection with one of the plates and a source of e.m.f., and thus was made to affect the resonance of the antenna circuit.

E. Ruhmer, in Germany, in 1907, put forth an interesting proposal which in principle was somewhat similar to the application of the "B" battery to the plate circuit of the audion, a year or so earlier. Ruhmer stated that if the circuit from a local battery is connected to the microphone, thence to the supply circuit of the arc oscillator, then the arc may be caused to pass to-and-fro between the oscillatory and non-oscillatory states in response to changes in resistance of the microphone: the movements of the diaphragm then being translated into periods of radiation and no-radiation. In this arrangement a difficulty experienced was that the suddenness of transit from oscillatory to non-oscillatory state was not quick enough for good results.

The German radio operating orzanization in a patent application[2] proposed a method of operation by means of which alterations in the resistance of the microphone were to produce large fluctuation of the amplitude of the radiated waves. To accomplish this there was proposed a strongly excited arc circuit very loosely coupled to the antenna, and a closed microphone circuit also coupled to the antenna.

Priority of Invention

If each engineer who has claimed to be the inventor of the radio telephone had a resourceful biographer, and such biographies were published,

[2] *Br. Pat.* 26,530 (1907)

there is no doubt that a historian undertaking to write a history of the development of the art would have no choice but to considerably discount all such writings. When the historian's aim is to select for treatment and description each essential contribution to advancement which survived for a time, or which in turn opened a door beyond which further knowledge of value was waiting, he cannot, while conserving continuity, avoid omitting reference to some of the simultaneous or "independent" work done by experimenters in various parts of the world working along the same line.

Collins' Radiophone Experiments

The reason for referring at this point in our story to A. Frederick Collins, in America, is that the early experimental work done by Collins qualified him to write knowingly and interestingly about his work, and that of contempory investigators. As early as 1902, Collins carried on experiments with crude arc oscillators, and in the years following kept in close touch with what was being accomplished in America and abroad. In his laboratory he set up apparatus with which he demonstrated improvements as such were made from time to time. Early in 1903[3], he experimented with wireless telephone operation between ferry boats plying across the Hudson river.

Collins' illustrated articles in the technical periodicals beginning in 1900, contained detailed information of the sort awaited by American telegraphers. He seemed less concerned with the idea of inventing and patenting than with the urge to write about his own experiments and those of others, a direct and worthwhile result of which was that numerous amateur experimenters were at this early date provided with descriptive matter enabling them to set up equipment for the duplication of experiments performed by the scientific leaders. Undoubtedly, Collins' articles on "wireless" started many of the pioneer radio engineers and amateurs along the road to whatever success they achieved.

Various Radiophone Demonstrations

In 1908-09, an ambitious attempt was made to exploit radio telephony by a company of which William Dubilier, then twenty years of age, was the technical head. Demonstrations were made between Seattle and Tacoma, Washington, a distance of thirty miles. The water-cooled arc oscillator was employed. A tower 320 feet in height was used to support the antenna, which was of the umbrella type. The earth connection was made by means of an elaborate system of wire netting buried several feet in the earth.

In France, Lieutenants Colin and Jeance, of the French navy, in 1908 or 1909, carried out a series of radiophone experiments between a shore station at Toulon and a station on board a war vessel, and it was reported that they had succeeded in conversing with a fair degree of clearness over a range of 120 miles. In these tests the microphone was placed in shunt with a section of the antenna coil of an open-core transformer, the primary of which was connected in the oscillation circuit, fed from an arc generator. The voice transmitter consisted of several microphones in multiple mounted compactly on a hollow base. It was thought that in this way the difficulties of carbon "packing" might be overcome, and at the same time the heat due to the rather large current flowing in the microphone circuit would be distributed throughout the series of carbon chambers. One mouthpiece served to convey the air waves of sound to the several microphones.

V. Poulsen, in Denmark, who had, as described in Chapter 4, developed to a high degree the usefulness of the arc oscillator, employing a multiple microphone, succeeded in telephoning by radio from Copenhagen, Denmark, to Berlin, Germany, a distance of 290 miles.

In Italy, in 1907, Professors Majorana and Vanni brought out a type of telephone transmitter for radio purposes based upon the capillary properties of fluid jets. A stream of liquid flowing from a suitably constructed opening divided itself into drops which followed each other at practically constant intervals. The frequency could be observed acoustically by allowing the drops to fall on an elastic membrane which then gave out a sound of corresponding frequency. When mechanical oscillations were superimposed on the fluid jet periodical constrictions could be observed which were of very nearly the same frequency as the superimposed oscillations. The drops thus forced the membrane on which they impinged to give out sounds of a corresponding frequency. Drops falling on a level surface at right angles to their direction formed a layer varying in depth with the frequency of the drops. The microphone consisted of the usual mouthpiece and of a membrane fixed to a glass tube which moved freely under the vibrations of the membrane and through which slightly acidulated water flowed. The liquid passed out of an opening in the glass tube, striking the upper surface of a "collector" consisting of two cylindrical pieces of platinum insulated from each other. On striking the center of the collector the fluid spread over the surface, connecting the two halves electrically. A battery connected in circuit with a telephone and the collector sent a constant current through it so long as the membrane was not affected by sound waves. When the membrane vibrated, the aperture began to oscillate, varying the flow of the drops so that the fluid on the collector was continually altered in thickness. With this arrangement suitably connected to a spark-gap oscillator, the intensity of the spark corresponded with the sound vibrations, thus modulating the outgoing radiation from the antenna. Although Majorana devised an excellent form of rotating spark-gap he found later that better results were had with the Poulsen arc oscillator.

A similar microphone was devised by Marzi, and was used in some of the experiments of Colin and Jeance, referred to in the foregoing. In this instrument a stream of carbon particles fell between two surfaces, one of which was vibrated by voice waves, so that the carbon stream was correspondingly compressed as required in speech transmission. Owing to the fact that the carbon particles were continuously renewed, no disturbing heat was developed.

Additional Sources of Sustained Waves

Remembering that the oscillating property of the audion was not discovered until 1912-1913, the reader will understand that the engineers working on the problems of radio telephony throughout the years 1906-1914 had available as oscillation generators the high-frequency machine generators and the arc oscillator.

Rudolph Goldschmidt[4], at one time chief engineer of the British Westinghouse Company, and professor at the technical college of Darmstadt, in 1911 invented an ingenious type of machine generator, which was at once a generator and a frequency transformer. Used in radio telephone experiments this generator was found to be quite efficient. In its use it was sufficient to control the exciting current by means of one or more microphones, and as the exciting current was a direct current of low voltage, equivalent to only four per cent. of the total high-frequency power of the machine, its suitability was obvious.

The rather high cost of machine alternators, and the rather special and complicated nature of arc generators, were in those pre-audion oscillator days, at all times incentives to the development of simpler means of supplying high-frequency, continuous oscillations.

A particularly efficient and practical system was brought out by the Clapp-Eastham Company[5], in America, shortly before the development of the audion oscillator was begun. The method used was to charge a condenser by low-frequency alternating voltage about 30,000 times per second; the discharges being divided, by means of a rotary sectored gap, into definite groups recurring at a rate of about 1,200 per second, the group frequency determin-

(*Continued on page* 46)

[3]*Electrical World and Engineer, New York, June* 20, *page* 1046 (1903)

[4]*Proc. Inst. Radio Engineers, New York, March* (1914)

[5]*Proc. Inst. Radio Engineers, New York, December* (1914) The "Hytone" Radio Transmitter, by Melville Eastham.

Making the 1929 Dynamic Speaker Better and Cheaper

Improved Designs of Field Coil and Supply System Develops Better Operation

By J. George Uzmann

THE object of this paper is to describe the results of recent research work completed in connection with electrodynamic loudspeakers. The problem was to find a solution to the following:

(1) To further improve the quality of reproduction.

(2) To eliminate, or further reduce background hum.

(3) To simplify construction, and

(4) To reduce the manufacturing costs.

Admittedly, at first thought, it might appear as though our present-day designs of dynamic speakers are rather nicely developed, and that there is but little room for improvement.

However, modern theory, coupled with scientific design, proves conclusively that radical changes can be made over existing types. The above problems were solved, meaning that next season's electrodynamic speakers are not only going to give more perfect reproduction, but that simplified designs also bring about an appreciable cost reduction.

This article shall deal with recent developments completed in the engineering laboratories of Elkon, Inc., under the direction of Dr. Harry Shoemaker, on the magnetic field coil power supply system; filter mechanism, as well as methods of hum elimination.

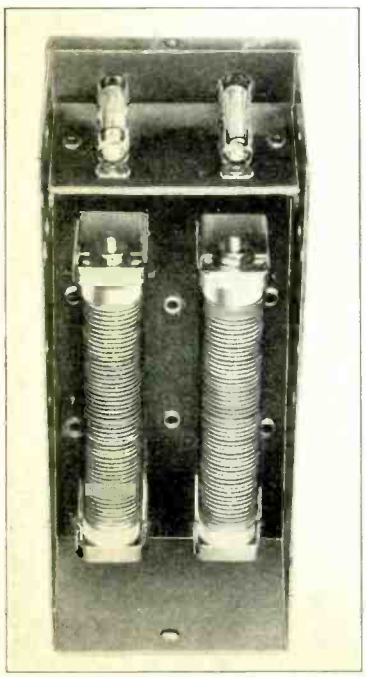


Fig. 2. The high voltage rectifier unit with the outer case removed. Two fuses are mounted on the shelf.

Early Electrodynamic Speakers

Dating back to the first electrodynamic loudspeakers placed on the market some eight years ago by the Magnovox Company, it was then appreciated that the field coil required reasonably large energy for ample excitation. A direct-current source supplied by the filament lighting battery was usually resorted to.

With the advent of factory built receivers, and the coming of a-c. operated (or batteryless) sets, manufacturers, in quest of more perfect loudspeakers, readily accepted the electrodynamic cone drive principle, although it was realized that that method proved much more costly than electromagnetic varieties.

Many novel circuit arrangements were devised in order that the required d-c. field energizing source would be free from batteries—a requirement in all a-c. sets. The R.C.A., in their early 104-type loudspeaker equipments and receivers, employed a field coil made up of a very large number of turns, which in turn was connected up in place of the second filter choke coil in the high voltage rectifier system. Here was one way to eliminate the old style battery, but unfortunately the method produced a hum.

Manufacturers then looked towards a different direction. Metallic or dry disc rectifiers of the cupric sulphide-magnesium types were readily adopted. These units operate practically free from trouble and possess many excellent features for this class of work. Unfortunately, the rectifier, plus its step-down transformer, added materially to the cost of production.

The standard practice, until recently, was to feed the rectified low voltage output directly into the field coil. While it was realized that the inductance of the average low voltage "pot magnet" is something in the order of .5 to 3. henrys maximum, and will give certain filter action to the rectifier output; nevertheless, the resulting ripple component, plus that produced through the a-c. tube amplifier system, reaches such a high order in properly designed sets as to develop an excessive amount of hum, or signal

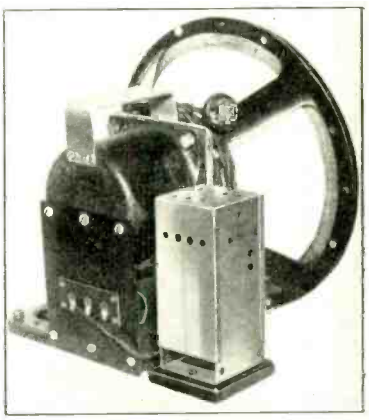


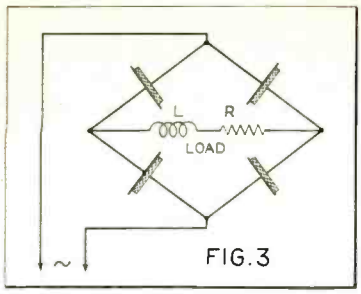
Fig. 1. A dynamic speaker equipped with the high voltage, dry disc rectifier unit.

background noise. Therefore, set makers of late were compelled to further increase their dynamic speaker costs by adding an additional high capacity electro-chemical condenser, connected across the rectifier output. This method effectively reduces rectifier hum to a negligible value.

New Developments

These few remarks show the history of electrodynamic loudspeakers in so-called electrified receiver fields. A further analysis of the problem reveals that the present designs of dynamic speakers developed along with the art in general. For example, the original dry disc rectifiers brought out by Elkon, Westinghouse, etc. were of the low voltage, high current types, and this, of course, called for a step-down power supply unit. High capacity, low voltage, dry electro-chemical condensers are also of quite recent design.

The application of condensers will eliminate rectifier hum; however, it shall be found that such a method developes: (1) An increase in field coil supply voltage. (2) In certain poor designs the field coil may run excessively hot. (3) The rectifier load increases. (4) Rectifier life becomes altered. Such electrical characteristics are not desirable, and it is important that the combined field coil rectifier and shunt condenser system be designed with full appreciation of the problem. Now, let us deal with the newly developed and more modern methods of electrodynamic loudspeaker construction.



The rectifier is broken up into four main groups and connected up into a bridge circuit.

It shall be remembered that Elkon, Inc. placed on the market nearly a year ago, a new high voltage, dry disc rectifier, designed essentially for power supply systems, capable of developing B potentials up to a maximum of 250 volts. Based upon such a rectifier system it was thought logical to merely connect a properly designed unit across our standard 110-120 volt a-c. house-lighting circuit without resorting to the customary step-down transformer. This in itself would offer a large saving in manufacturing cost.

The High Voltage Rectifier

In its finally developed form it is apparent that a complete solution has been found to the direct connected house-lighting circuit type of rectifier system. The several photos reveal its general small sized construction, neatness of design, simplicity, etc. One of the illustrations (Fig. 1) shows a complete assembly of the new rectifier mounted on a dynamic speaker. It will be noted that both the step-down power transformer and condenser units have been eliminated.

Although nothing appears outwardly, the speaker shown was also equipped with a new method of hum elimination, which will be dealt with in another section. This design of loudspeaker will produce no more background rectifier hum than that of normal designs employing from 1,500 to 2,000 mf. of capacity connected across a low voltage rectifier. The illustration of Fig. 2 shows the complete rectifier system, without top cover.

These new 110 volt a-c. rectifiers follow the standard principle in general construction. It will be seen that each rectifier stack is made up of fifty cupric sulphide and magnesium couples tightly clamped together. An assembly, consisting of two units, then snaps into spring clips. Thus, element replacement is easily accomplished by the serviceman or novice.

The rectifier couples are divided electrically into four main groups and are connected up into a bridge circuit, as depicted schematically in Fig. 3. A practical circuit is seen in Fig 4. The several views illustrate how glass-type cartridge fuses protect the line supply. As a further safeguard to both rectifier and supply source, a current limiting resistor is placed on the under side of the assembly, and is shown connected up in Fig. 4.

Again glancing at the latter illustration, we gain a better picture of the performance of the new electrodynamic speaker rectifier system. Based upon a normal line voltage supply of 115 volts, the graphs of Fig. 4 show that relatively large changes in line voltage do not materially affect rectifier operation or its load circuit. Further, comparison of the a-c. load in volt-amperes vs. developed rectifier power in watts, likewise shows excellent rectifier efficiency. These graphs reveal typical performance of the new system, and it is interesting to note that for the type of rectifier load, namely a 10 henry, 250 ohm (hot) resistance field coil results in a combined line load having a 95 per cent. power factor.

From these graphs we note that the developed d-c. output voltage, say approximately 55, is greater than that ordinarily employed under low voltage rectifier systems. It is, therefore, apparent that the only necessary changes required where the new system is adopted, is to merely design the field magnet or "pot" for operation on a 55 volt potential. It is also desirable that the field possess an approximate hot resistance of 250 ohms, an arrangement which will develop a uniform and safe rectifier loading factor; under these conditions the "pot" will possess an average inductance of about 10 henrys as compared to .5 henry for a low voltage design. It is, of course, necessary to maintain the ampere turns at about 1,000 to 1,500 at the above load resistance for best operation.

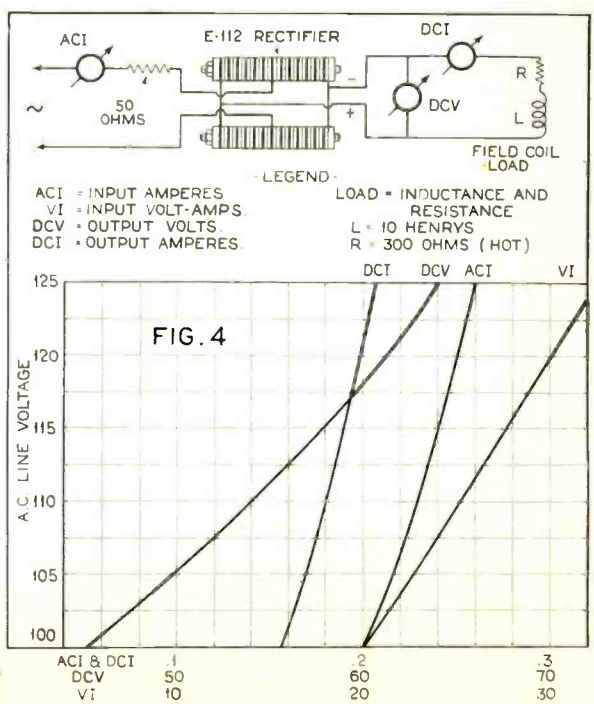
These rectifiers are designed to develop 12 watts output at a line voltage of 120; and 10 and 8 watts at 110 or 100 volts respectively; satisfactory operation being realized also at the lower line voltage, thus showing the new system to be remarkably flexible in characteristic.

Hum Elimination

Data taken from a large number of oscillograph tests, reveals that for both high and low voltage energized field coils operated without the use of shunt connected, high capacity electro-chemical condensers, that the ripple component measures about 10%.

The addition of a small amount of capacity placed across the coil terminals, has the effect of increasing rectifier output voltage up to a maximum. This increase is rapid at first and becomes very small as the capacity is increased. For example, in the case of a low voltage "pot" magnet, 500 microfarads of capacity will increase the voltage to about 95% of the maximum rating of the rectifier, but this relatively small capacity does not decrease the ripple or noise background. Ripple will show no signs of reduction until approximately 1,000 microfarads are used. The increase in rectifier voltage for this added capacity is very slight, while the ripple is reduced to about 1% where the shunt condenser is in the order of 1,500 to 2,000 microfarads.

In the case of the new high voltage rectifier, it is found that but 10 mf. will raise the rectifier voltage to about



Circuit for the high voltage rectifier, including the 50-ohm current-limiting resistor. Also performance curves taken on the rectifier in the circuit shown.

90% of maximum, but this capacity fails to show any reduction of ripple—about 10%. Under these conditions exhaustive experiment indicates that the new rectifier system requires approximately 20 mf. of capacity before any appreciable effect upon ripple is revealed, and when the capacity is raised to 40 mf. background ripple reaches a minimum value of 1%.

Another anti-hum device developed by the engineering staff of Elkon, Inc., makes use of a simple high conductivity material placed within the air gap of the "pot." Under these designs a gasket completely absorbs all a-c. flux, which of course, is the hum producing agent, and is placed somewheres within the magnetic circuit. This is accomplished without the use of so-called "bucking coils," or other systems requiring appreciable power, adjustments, or adding mass and weight to the moving coil system.

Under this development it is apparent that any slight increase in gap length must be compensated for by an increase in flux density and in turn by added ampere turns of the field. A future paper will reveal its electrical characteristics, construction details, etc.

In conclusion a few words on the merits of the two new systems of hum elimination should not prove amiss. Under proper designs of "pot" magnet, viz, (1) an ample number of ampere turns; (2) correct proportions of magnetic circuit; (3) load resistance suitable for rectifier and (4) "pot" operating potential and current to be based upon the use of a shunt condenser system or other means of hum suppressor; it will ordinarily be found that the condenser method of hum suppression possesses many ideal characteristics because it is the most effective means since the field coil then operates substantially on a direct current, which of course, is ideal for this purpose.

Finally, it can be stated that the above described apparatus for electrodynamic loudspeaker construction possess the following important characteristics:

(1) Improves reproduction qualities, since hum is reduced to a negligible value.
(2) Power transformer is eliminated while condenser capacity is reduced or may be eliminated.
(3) Ease of chassis assembly.
(4) Cuts manufacturing costs.
(5) Simplifies service and repairs.

The Problems of Radio Servicing

II. Relative to a Serviceman's Equipment, Methods of Operation and Examples of the Practical Application of Analysis

By John F. Rider, Associate Editor

THESE few pages will be devoted to the consideration of a certain phase of radio servicing which we believe to be of vital importance because it has a definite bearing upon the monetary profit accruing from the work. This phase will be known as the "process of elimination," or the "common-sense application of technical knowledge."

The application of the word "technical" should not lead the reader to believe that we mean a thorough theoretical grounding. The serviceman should be in possession of a certain amount of knowledge which must be applied in the proper manner. However, before we enter into this discussion, it is necessary to consider another significant item.

Repairs in the Home

"Where shall the serviceman do his work?" This question is undoubtedly of interest to every one in the fold. To come to a satisfactory conclusion, we must consider two sides of the problem; that of the serviceman and that of the receiver owner. All things considered, the serviceman is really the judge. He alone knows where he can operate to best advantage, but a few reasons in connection with this subject will undoubtedly throw a little light upon limitations encountered.

Let us first analyze the position of the receiver owner. It is true that he wants rapid service when he needs it. This is logical because a faulty receiver affords very little pleasure as an entertaining medium. Though the man desires rapid repair of the receiver, he does not wish to have his home littered with wrappers, frayed insulation, an assortment of tools and other paraphernalia usually carried by the serviceman. Granted that the serviceman is a neat worker, but he must operate at his convenience. The soldering iron must be connected to the power socket. A resting place for the iron support is necessary. Investigation of the chassis is possible only after it is withdrawn from the cabinet. A chassis however, cannot rest on thin air, so amidst the surroundings of a well appointed room the operations of the serviceman and his equipment cannot help but be an eyesore.

On the other hand, rapid work is of importance to the serviceman. If the repair is effected in the home of the radio receiver owner, one service call suffices. If it is necessary to make an inspection call followed by removal of the receiver chassis to the service station, an additional charge must be made. Charges of this nature are not viewed with pleasure by the receiver owner. Being unaware of the fault he may feel that the repair could have been made at his home.

Many servicemen prefer to neglect the carrying charges and the cost for receiver removal, and if this is the case and considering the effect of major service work in the home, the occasion for servicing in the man's home is not present.

The serviceman cannot conveniently work at the home of the receiver owner, and unless the work is of trivial nature, he should not do so. In view of the fact that the serviceman cannot carry all of his testing equipment, the necessary testing apparatus is not available and unless convenient operation is possible, work progresses slowly. Under the circumstances the serviceman should not attempt major repairs in the receiver owner's home. The psychological influence is not good in the first place.

In all of this discussion, we are concerned with actual receiver repair. The replacement of a tube, the soldering of a broken or loose connection does not call for the removal of a chassis to the service station. Receiver analysis, however, should be carried out in the home because upon its conclusion it is possible to advise the cost for repair. In connection with this work, it is necessary to consider the equipment required by the visiting serviceman. It is practically impossible to carry testing devices which will permit all types of analytical work, hence this equipment is limited to devices which will make possible a cursory analysis. The average a-c. and d-c. set tester, plus a continuity tester, are excellent representatives of this equipment. Tools, a soldering iron, solder, friction tape, etc. are beyond discussion. They are imperative and must be carried. In addition, every serviceman should have with him a headset, which device finds frequent application, yet is seldom a part of the average receiver installation, and last but not least, the wiring diagram of the receiver or unit to be serviced.

Methods of Operation

We queried numerous servicemen to ascertain their method of operation;

to determine just how they managed to carry out their duties without overloading themselves with superfluous equipment. Their replies were very similar. We quote one, "I usually query the person calling, assuming that the need for service is advised in person or by telephone, and ascertain the type of receiver to be serviced and make an effort to determine the possible fault from the owner's statements. In many cases, this is possible. In others, I must exercise my own discretion. If I am advised that the receiver lacks volume and the tubes are old, I make a notation about tubes for future reference. If the condition is the same, and tubes are new and the batteries old, I make a noration about batteries. If the receiver is power operated, the batteries are eliminated. These notations find use when the wiring diagram of the receiver or unit is analyzed. Upon analysis, I know the types of tubes used and if possible I carry a full set to the job. A slight inconvenience, it is true, but if the tubes are at fault as is the case in many instances, I sell a full set and obviate the necessity on the part of the receiver owner, to visit a radio store and buy the necessary tubes."

"If the receiver employs B batteries and I believe that these batteries are run down, I usually carry a single 45 volt block. The addition of this new battery is sufficient to prove that the old B batteries are at fault, assuming of course, that the B batteries are actually useless for further utility. As a matter of fact, if the source of plate potential is unsatisfactory and the replacement of a defective B unit improves reception, it is conclusive evidence in the owner's eyes that the fault is what I claim it to be."

Spare Tubes

"I find very little occasion to carry receiver parts such as transformers, resistances and condensers, fixed or variable, because I seldom attempt to make major repairs at the home. If the receiver is "dead," that is, reported dead, I do not carry any equipment particularly suited to the receiver in question unless I am advised that a tube or a number of tubes are burned out. With respect to tubes, I make it a practice to carry a single tube of each type. In other words, I carry a 201-A, a 226, a 227, a 281, a 171 and a Raytheon. These tubes consume very little space and are available when necessary to determine the efficacy of the tubes employed in the receiver. However, such tubes are not necessary if the analysis is complete and it is possible, by virtue of elimination, to isolate the trouble with accuracy."

"In connection with 'dead' receivers when I am so advised, I suggest various remedies over the telephone which are frequently very effective and go a long way to create good will. It is my opinion that the insertion of a phone cord tip or a power plug into a power socket or the proper placement of a tube into a socket, does not justify a service call. I prefer to suggest the remedy to the receiver owner. These suggestions can be made only when a wiring diagram of the receiver is at hand. The tube layout and connections to the receiver are also of importance and I make notations of various receivers when I make a call so that I have a layout for future reference. I very frequently advise receiver owners to interchange tubes and to determine if a tube filament is actually burned out because in numerous instances the tube prongs do not make proper contact and when the supposedly defective tube is placed into another socket, perfect operation is secured."

There you have the picture. The significant facts are evident. The serviceman equipped with an automobile is more fortunate than he who must use public conveyances but even the car owner will find it more convenient and profitable to repair defective receivers at the service station and to limit his testing equipment to such devices which will enable most rapid and accurate analysis.

The Process of Elimination

The isolation of a fault is the conclusion based upon analysis of performance and operating conditions. The former is a function of the latter, being good when the latter is correct and poor when the latter is incorrect. Unfortunately however, faults do not become evident immediately upon the analysis of performance because in many cases, the defect is present despite the correct operation of accessories which supply the required potential. After all, radio ailments are never mysterious, despite prevalent opinion to the contrary. Every ailment has its cause and every ailment displays some effect. In some cases, the symptoms are more readily recognized, in others, recognition is more difficult. In some cases, the effect is very evident, in others it is partially obscured.

The problems of radio servicing do not harbor as many puzzling phenomena as we are apt to believe, but without a definite method of procedure, the work will be made more difficult rather than simplified. Generally speaking, troubles do not occur in groups. Invariably they are singular unless a certain ailment, closely allied with porential in the receiver installation will so effect the system that some other portion will be damaged thus causing trouble in more than one section of the receiver. Neglecting the preceding sentence, trouble is usually limited to one part of the receiver system, unless as we have mentioned, the failure of one unit causes the failure of another. Therefore, we have two fundamental facts which are invariably substantiated in actual practice. Namely, that in practically every case, the fault is singular with respect to numbers and in one location with respect to the complete receiver. The exception proves the rule and the most prominent exception is the ruptured filter condenser which causes an overload upon the eliminator rectifying tube and damage to the tube.

Albeit the fact that several ailments will manifest the same effect and influence, variations in effect are discernible to the close observer and isolation is greatly expedited by the process of elimination; the system of operation which we recommend. This line of progress necessitates recognition of the function of each unit in the receiver and thorough comprehension of the performance of each unit and each complete system in the receiver. By units, we mean the various components such as resistances, condensers, coils, tubes, etc. By systems, we mean the radio-frequency amplifier, the detector and the audio-frequency amplifier. The systems have subclassifications such as the filament circuit, the grid circuit and the plate circuit, all of which are associated with the vacuum tube.

Recognition of Symptoms

In view of the fact that servicemen are actually operating, we must assume comprehension of the function of the various components and the function of the various systems and their sub-classifications. We hope in subsequent discussions to cover more fully these functions.

One cannot be a serviceman unless he is familiar with the work he must do and at the present moment, we take this familiarity for granted. Receiver analysis and diagnoses makes necessary recognition of symptoms which become evident in some form or other when devices perform in an incorrect manner. Recognition of these symptoms and association with certain parts of the receiver installation is half the battle and the actual basis for the process of elimination. Fortunately, the modern set analyzer greatly expedites diagnosis—but, if by applying the process of elimination, one can expedite the application of the set analyzer to a certain part of the system, time is saved and greater profit secured.

Explained in simple language, our suggested method of procedure is recognition of effects and the commonsense application of this knowledge. Specific phenomena are associated with various systems in the receiver and thoughtful discrimination between phenomena is a big stride towards the solution. It is indeed surprising to note how much is gained by a few moments of concentrated thought prior to the actual application of a set analyzer. The process of elimination does not obviate the necessity for the set analyzer. The two go hand in hand just like sales and service. The set analyzer is absolutely necessary,

but the correct application of the process of elimination makes possible more profitable utilization of the set tester.

The set tester supplements the process of elimination. This method of procedure is not a sure-fire proposition. Neither is every diagnosis made by a physician the correct diagnosis, but the failures are not numerous. The success is based upon how much the applicant knows, i.e., the amount of technical knowledge at his finger tips. The many excellent textbooks afford detailed technical information, but this data must be applied to practice; it is unsatisfactory in its theoretical form. Much of the data pertaining to receiver performance is not to be found in the average textbook because while the phenomena are the results of theory, practice and theory are divorced.

Examples of Practical Application

Let us consider a few examples of the process of elimination when diagnosing. Again we wish to stress that the applicant must have a certain amount of technical knowledge. Not necessarily thorough theoretical training necessary for design work, but practical knowledge of radio. As an illustration of the process, let us consider the Atwater-Kent receiver shown in the previous issue. (The process of elimination was briefly mentioned in the first installment of this series. This discussion is an elaboration upon this phase of servicing.) Our suggested process of operation is not limited to the receiver shown, but to all receivers regardless of type, of the number of tubes and to all amplifiers, eliminators, etc. The explanation is lengthy but the application is rapid.

The first example, involves lack of selectivity on certain stations, say 1 or 2, and also a low signal level when the receiver is tuned to these stations. Particular mention of the limited range of this condition is made because selectivity and signal level are satisfactory on the other wavelengths or stations. Selectivity as is well known, is a function of the radio-frequency amplifier, particularly the tuning circuits; also, the aerial and ground system. Since the detector input circuit is a part of the radio-frequency system, it is included under this heading. If this be true, we can immediately eliminate the entire audio-frequency amplifier, because in function it has no connection whatsoever with the radio-frequency system, other than to amplify the audio-frequency signals passed to it from the detector plate circuit. Since the receiver operates normally over a certain portion of the broadcast waveband, it is logical that the operating potentials, such as filament, grid and plate voltages are correct and since these values do not vary with wavelength, we can likewise eliminate the power supply system. Analytical interest is, therefore, focused upon one certain portion of the receiver; the aerial and ground and the radio-frequency tuning system.

In view of the fact that the tubes in the radio-frequency system perform well over a certain portion of the waveband and the design of the 226 type of tube is such that wavelengths within the normal waveband, have no effect upon its operation, we can immediately eliminate the tube as a possible source of trouble. Bearing in mind that the lack of selectivity is accompanied by low volume signifies that the trouble is not due to a poor receiving locality. Were this the case, the signal level would be low but lack of selectivity would not be a fault.

The search, therefore, narrows down to the tuning units. It is evident that the trouble, whatever it may be, is not present over the entire wavelength range. We know that a shorted turn or a number of shorted turns in an inductance, will reduce the electrical efficiency and cause broad tuning. This, however, cannot be the case since satisfactory performance is secured over a certain portion of the waveband. According to the wiring diagram, tuning is accomplished by means of a series of variable condensers, gang controlled, in shunt with a number of transformer windings. A resistance in one of these circuits would cause broad tuning but it would not be limited to one or two stations and it would not cause a decided reduction in signal intensity.

Since the coils are presumably in good condition, the only possible source of trouble is the tuning condenser system. A definite short circuit across one of the condensers would impair reception over the entire band. A short across the condenser when the plates are in a certain condition would so effect reception that the signals would cease. If the sensitivity of the receiver is so great that reception is possible with a shorted condenser, the short in one position of the condenser rotor would manifest itself by a series of clicks. Since this is not the case, the trouble is not a short circuit. The design of the tuning unit is likewise beyond discussion because of its performance over the remainder of the waveband.

Were the radio-frequency characteristic such that response on high wavelengths would be less than low wavelengths, the lack of volume would not be accompanied by lack of selectivity. Hence, the only possible cause can be incorrect resonance at a certain setting of the tuning control. This condition would create the effect we are discussing since the various circuits would not be tuned to the same frequency or wavelength for any one setting of the tuning control. A checkup of condenser capacity at various settings of the tuning dials, is therefore in order.

Tracing Distortion

As the second illustration, let us consider the subject of distortion. Receiver output volume is satisfactory, or judged to be so, but the music and speech are not clear. The causes of distortion are numerous and the points of trouble in a receiver which might cause distortion are likewise numerous but as a general rule, distortion occurs mainly in the audio-frequency system. Distortion may be present in the audio-frequency coupling units and present in the form of frequency distortion where the audio coupling unit accentuates or attenuates certain frequencies. In view of the fact that this is a design detail, it may be eliminated at the start of the analysis, since its effect is not of the type generally understood as distortion.

In view of the fact that distortion may be due to incorrect tube operation and since it is to be found most frequently in the audio-frequency amplifying system, one can for the present eliminate the radio-frequency amplifier. Since operating potentials govern the performance of the vacuum tube, the first step is to check the grid, filament and plate potentials. If these are correct, the source of potential may be eliminated as the possible source of trouble.

Now in connection with this work, if the trouble is actually in the audio-frequency amplifier, the operating potentials may not always be correct. However, if the plate current of the 171 is excessive, it is necessary to analyze the wiring of this stage. As is evident in the wiring diagram, the filament circuit of this tube is an individual circuit. The grid bias for this tube is supplied by a separate resistance, hence whatever the trouble within this tube circuit, it is safe to assume that it has no connection with any other part of the receiver and it is, therefore, unnecessary to check the other systems in the receiver until the incorrect condition in the 171 stage is rectified.

Tracing Electrical Disturbances

The third illustration is that of electrical disturbances such as crackling, sizzling and frying sounds. Sounds such as the above may be attributed to many sources, but their possible locations are fortunately less numerous. Generally speaking, four sources need be considered: 1. Outside of the receiver with entry through the aerial-ground system. 2. In the power line circuit with entry through the power devices connected to the receiver, such as A and B eliminators. 3. External of the receiver with entry, by means of induction, to the receiver or the speaker lead when a long connecting lead is employed. 4. In the receiver itself, including of course, battery supply when used in place of the eliminators.

To determine the origin we must

(*Continued on page 46*)

The Screen-Grid Vacuum Tube

A Semi-Technical Article Covering Both the Theory and the Practical Applications of the Screen-Grid Tube, Including Its Use as a Space-Charge-Grid Amplifier

*By J. E. Smith**

PART II

Characteristics of the 222-Type Screen-Grid Tube

THE arrangement of the electrode terminals of the screen-grid tube is as follows: standard UX base with two large and two small prongs. The electrode connection to each base prong may be easily ascertained by reference to Fig. 20 where, it will be noted, the arrangement is the same as for all UX tubes except that the screen-grid prong is in the position usually occupied by the prong connected to the control grid of the three-electrode tube. The control grid of the 222-type tube terminates in the metal cap on the top of the tube. Table No. 1 summarizes the battery requirements and amplification data for this tube.

Typical Radio-Frequency Circuits

The extreme sensitivity, high plate resistance and low internal capacity of the screen-grid tube requires special circuits and arrangements in order that these excellent characteristics may be utilized to the fullest extent possible. In Fig. 21 is shown a screen-grid receiver of an approved type. Two screen-grid tubes are used as radio-frequency amplifiers while the detector and audio stages are supplied with the three-electrode tubes. From a study of the Table No. 1 it will have been noted that the voltage across the screen-grid tube filaments should be 3.3 volts while the negative bias on the control grid should be 1.5 volts. Inasmuch as the voltage for the 201-A tube filaments must be not less than 5 volts for best operation it is necessary to insert a special resistor R in series with each screen-grid tube filament in order to reduce the voltage to the 3.3 volts required. The resistance of R should be 15 ohms. By using a tapped resistor, as shown, or by using two resistors, one of ten and one of five ohms, placed in series, with the larger resistor nearest to the filament, it is possible to get the correct control grid bias from the drop in voltage across R, thus avoiding the use of a "C" battery. Any one of the standard makes of broadcast radio-frequency transformers may be used for the coils L1 and L2. For L3 and L4 the primary or small coil should be removed from the transformer and the larger coil used alone. In combination with .0005 mf. variable condensers these coils will then cover the required broadcast frequency range and, at the same time have good impedance characteristics such as are required for screen-grid tube circuits.

The set builder should be careful to choose coils with a diameter of not less than 2½ inches and, if possible, to select coils wound with litz wire. Both of these suggestions, if followed,

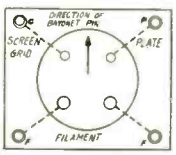


Fig. 20. Socket connections of the d-c. screen-grid tube.

will decrease the radio-frequency resistance of the coil and permit sharper tuning. Note condensers C6 and C7. These condensers should have a capacity of not less than .5 mf. They should be mounted by means of metal straps soldered or screwed to their terminals directly to the screen-grid and one filament terminal of the tube socket or else the condenser should be placed close to the socket and connected to the terminals by short wires. These condensers are used to by-pass the radio-frequency energy which may be built up by stray coupling to the screen-grid. C4 and C5 are blocking condensers so placed that they keep the plate potential of the preceding tube from being applied to the control grid of the following tube while, at the same time, providing a low resistance path for the radio-frequency currents in the circuit.

The distance from any part of coils L1, L2, L3 and L4 to the nearest point of the shielding should be not less than one and one-half inches and preferably two inches. Shielding should be complete as illustrated.

The preceding description concerned the screen-grid tubes operating as radio-frequency amplifiers in an arrangement in which three tuned circuits are utilized.

A second type of broadcast receiver employs two tuned circuits and supplies additional sensitivity and selectivity through the use of a regenerative detector as shown in Fig. 22. The same requirements as to coils and loca-

Table No. 1

Characteristics of the Screen-Grid Tube

"B" battery volts	"C" battery volts	Plate mils	Mutual conductance	Amplification factor	"A" battery volts
135	—1½	1.5	350	300	3.3

*President, National Radio Institute.

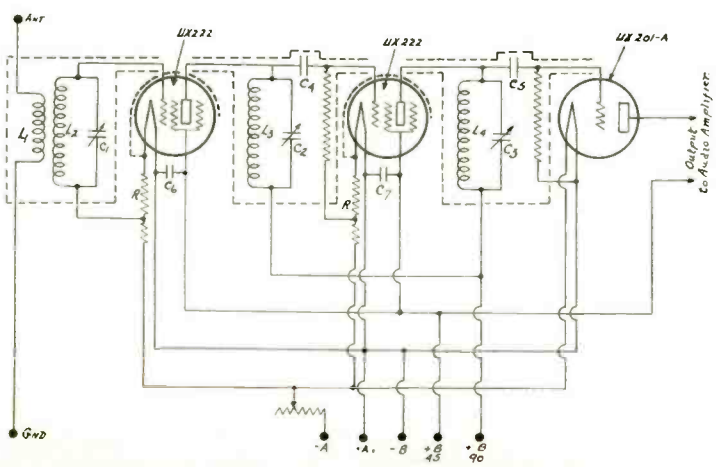


Fig. 21. Schematic diagram of a practical screen-grid, radio-frequency amplifier, employing tuned impedance coupling units.

tions apply for this type of circuit as for that shown in Fig. 21. Note also that the plate current to the screen-grid tube is supplied through a radio-frequency choke, L.

It is, of course, important in all types of receivers employing the screen-grid tube to keep all low potential wires close to the shield and separated as far as possible from the high potential wires which in turn should be as far away from the shield as possible.

High-Frequency Receivers

The two foregoing diagrams have applied to receivers to be used in the broadcast frequencies. Standard parts and known circuits which need but slight modification to be applicable to the screen-grid tube make the task of changing over existing sets or building a new receiver with screen-grid tubes a comparatively easy one for the broadcast set-builder. In the amplification of frequencies higher than 3000 kilocycles, however, the situation is not and has not been so easy. It

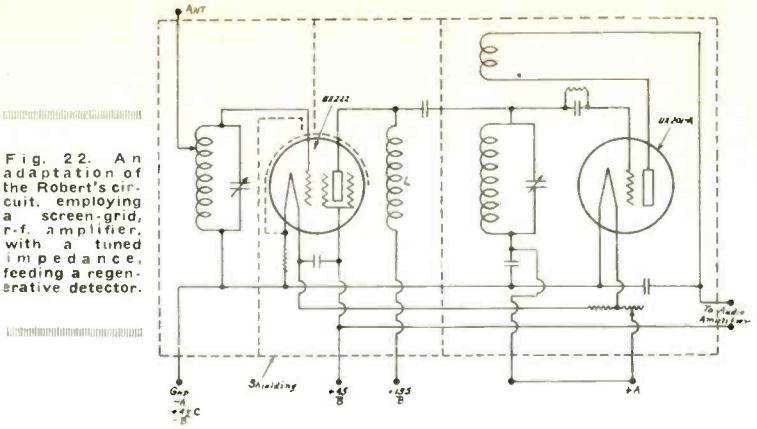


Fig. 22. An adaptation of the Robert's circuit, employing a screen-grid, r-f. amplifier, with a tuned impedance, feeding a regenerative detector.

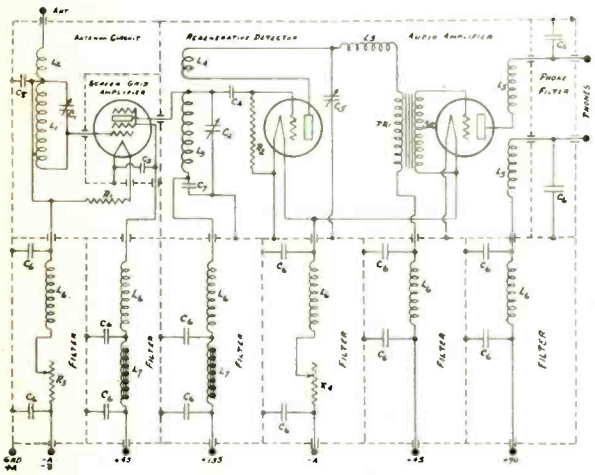


Fig. 23. Schematic diagram of a good short-wave, screen-grid receiver. All circuits are isolated by the use of r-f. and a-f. chokes.

is only with the use of screen-grid tubes that amplification has been obtained at all at the very high frequencies. Even with the screen-grid tube it is necessary to take careful steps in the wiring and assembly and to provide filters in the battery and phone leads.

The receiver illustrated in Fig. 23 is sufficiently sensitive for any purpose on short wavelengths. The construction details will be considered at some length because of the excellent results which may be achieved on the higher frequencies from a well made short-wave receiver of this type.

The first question to be considered is the shielding. This must be absolutely complete except where wires enter the various compartments. A metal box should be secured and the compartment joints should be soldered or tightly screwed to angle pieces. Wire holes should not be larger than necessary to clear the insulation. The cover should fit tightly over the box and have angle pieces screwed or riveted on so that slots are formed into which the shielding walls can fit and make a good shield joint between compartments. The amplifier tube should be located in a separate small compartment, as shown, in order that the several circuits may not be coupled together through their wires which connect to the screen-grid amplifier tube. A series of small compartments should be built under the receiver proper—these sections to take the different battery wires and introduce a filter between the battery and the receiver. Only a small coil and "postage stamp" condenser are in each of these filter sections so that these compartments need only have limited space.

All wires from the filter compartments to the points where they are connected to the tubes, coils or condensers inside the receiver compartment should be covered with a copper braid for shielding purposes as a further precaution against stray couplings.

Taking the circuits in order: Condensers C1 and C2 are of the variable type and should have a capacity of about 150 micromicrofarads. A good vernier dial should be provided to secure easy tuning. Over the wavelength band of from 30 to 50 meters the coil L1 should be made up of 12 turns of number 12 cotton covered wire wound to make a two and one-half inch diameter coil of the self supporting type. Turns should be spaced the width of the wire by means of string. The whole assembly should be boiled in paraffin after completion. L2 is the antenna coupling coil and should be made of two turns of ordinary annunciator wire 2½ inches in diameter and placed so that the coupling to L1 is quite close. C8 is an insulating capacity intended to separate the negative filament from the grounded shield while permitting an easy path to ground for the radio-frequency currents in L1 and L2. The capacity of C8 should be about .001 microfarad and the condenser should be of the postage stamp mica variety.

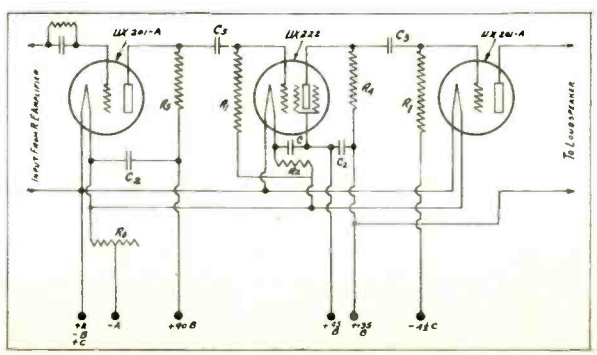


Fig. 24. A screen-grid tube used in the normal manner in a resistance-coupled, a-f. amplifier. The tube provides a high voltage gain.

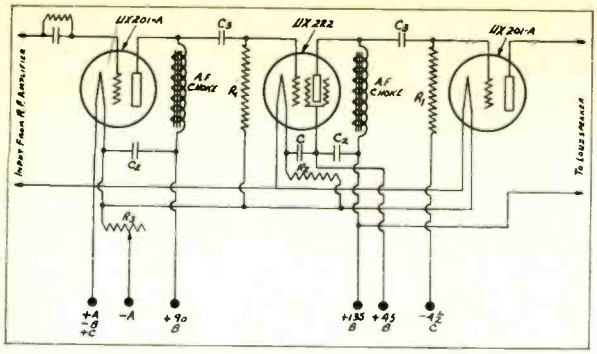


Fig. 25. The screen-grid tube used in an impedance-resistance coupled audio-frequency amplifier. The gain is high.

The high potential wire from the tuning circuit L1-C1 passes through the upper part of the shield and goes directly to the control grid cap on the screen-grid tube. R1 is a small fixed resistor in series with the negative filament of the screen-grid tube. The resistance of R1 is ten ohms and it supplies the necessary voltage drop for proper filament voltage and grid bias for the tube. C3 is the screen-grid to filament by-pass condenser, an item all too frequently left out in these circuits, yet a most important part if the best operation is desired. As noted before. C3 has a capacity of .5 microfarad and may be a paper condenser.

The plate of the radio-frequency amplifying (screen-grid) tube connects through to the coil L3 and condenser L2 which make up the tuned plate circuit of the amplifier tube. For the 30 to 50 meter band L3 may be a 2½ inch diameter coil similar in construction to L1 but having eight turns only. L3 is at high d-c. potenrial because it is part of the plate battery circuits, hence an insulating mica condenser of .001 microfarad capacity is connnected between the low potential end of L3 and the low potential end of condenser C2. The low potential end of C2 is also grounded to the shielding.

C4 is a mica condenser having a capacity of .00025 microfarad and is the capacity which couples the circuit L3-C2 to the grid of the detector tube. The three-megohm resistor R2 acts as the leak for the grid of the detector tube and also, by reason of its being connected to the positive filament, provides the positive bias, necessary for rectification, to the detector grid. L4 acts as the tickler and is an inch in diameter with eight closely wound turns of number twenty-six cotton covered paraffined wire. The condenser C5 is a small variable type and controls regeneration.

Inductances L5 are radio-frequency chokes which prevent high-frequency currents from circulating in the audio-frequency circuits. These chokes may be made from 200 turns of No. 30 wire either in a universal winding or in a home-made thin coil shaped like a disc. Condensers C6 are paper dielectric 0.1 microfarad capacities which act as by-passes in the various filter circuits. Inductances L6 are the radio-frequency chokes contained in the filter circuits and should be formed of a single layer winding of number forty enameled wire two inches long on a half inch thick paraffined dowel stick. R3 and R4 are variable resistors used to control the filament current in the vacuum tubes. R3 should have a resistance of twenty ohms and R4 a resistance of 6 ohms.

The arrangement of the circuits should be similar to that shown in the diagram. In particular, the filter circuits should have their apertures through which the receiver wires pass as close to the connecting element as possible.

L7 is an iron-cored audio-frequency choke of good commercial design. The two chokes L7 prevent modulation and microphonic noises by "ironing out" the plate current.

The importance of suitable filter circuits on high-frequency receivers can hardly be overemphasized. Especially should a sensitive receiver of the type described have all the battery and phone leads pass through filters. By the use of filters the major part of the interfering noises found in a high-frequency receiver are eliminated.

It is possible, however, under favorable conditions to secure good results with the receiver described even without the filter circuits. If, for reasons of economy or simplicity the filters are not desired, the receiver may be built without them. In such a case the wiring diagram will be identical with that shown in Fig. 23 except that all lower compartments with their associated circuits are left out and the wires from the receiver are brought directly out to the batteries.

The Screen-Grid Tube as an Audio Amplifier

So far the practical application of this tube has had to do with radio-frequency circuits only. The tube has excellent characteristics as an audio amplifier also. Where a high amplification is desired an arrangement like that shown in Fig. 24 may be employed. It is advisable to use only one stage of screen-grid audio amplification and to place that stage immediately after the detector tube in order that the power output of the tube may not be exceeded. In Fig. 24 only the circuit from the detector tube through the audio stages is shown—the radio-frequency amplifier may be of any conventional type or may include a screen-grid stage. As in the radio-frequency case a screen-grid tube used as an audio-frequency amplifier must be carefully shielded and special pains must be taken to keep the control grid and the plate leads well separated and individually shielded. It is also desirable to have a large capacity by-pass condenser between screen-grid and filament. Referring again to the diagram of Fig. 24, the plate of the detector tube works into a resistive load and is supplied with plate current through resistor R5 which has a value of from 25,000 to 100,000 ohms. C2 is

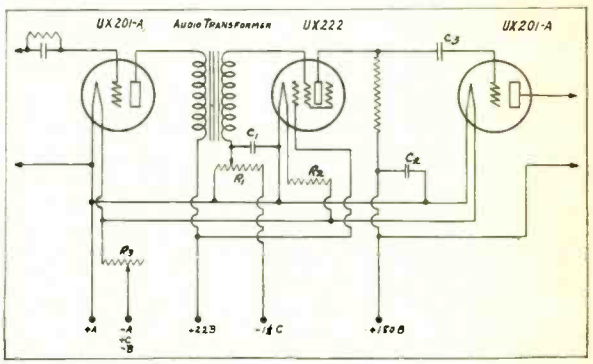


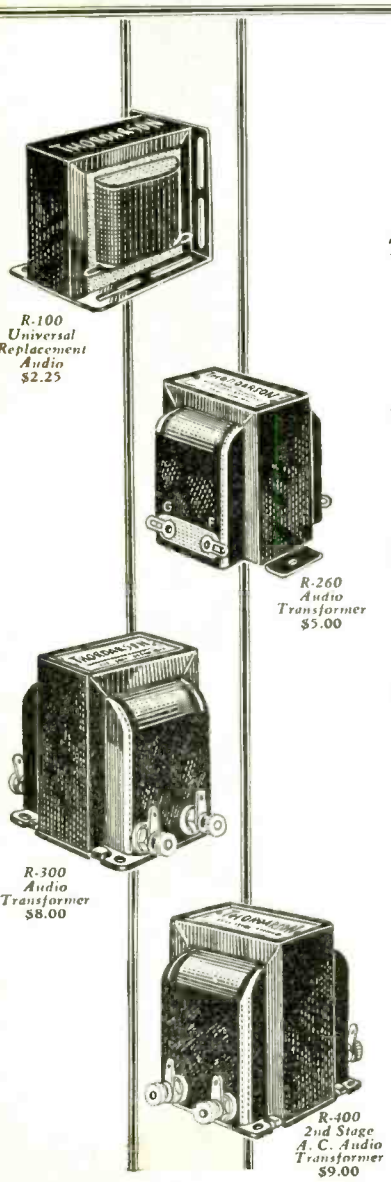
Fig. 26. The screen-grid tube employed as a space-charge-grid amplifier, in an a-f. circuit. The voltage gain is very high in this case.

Table No. 2

Characteristics of the Space-Charge-Grid Tube

"B" battery volts	"C" battery volts	Plate mils	Mutual conductance	Amplification factor	"A" battery volts
180	—1½	0.3	400	60	3.3

New THORDARSON AUDIO TRANSFORMERS



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R-260 Audio Transformer $5.00

R-300 Audio Transformer $8.00

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ONCE again Thordarson steps into the foreground, this time with three new audio transformers of unrivaled performance—fitting companions for the Famous R-300.

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The R-260 introduces a new standard of performance for small audio transformers. Wound on a core of Thordarson "DX-Metal" this audio unit is capable of reproducing plenty of "lows." It is entirely devoid of resonant peaks and performs with unusual brilliance over the entire audible band. List price $5.00.

The R-300 needs no introduction to the discriminating set builder. It is commonly recognized by set manufacturers and individuals alike as the peer of audio coupling transformers, regardless of price. The high frequency cut-off at 8,000 cycles confines the amplification to useful frequencies only. List price $8.00.

The R-400 is the first and only audio transformer built expressly for use with A. C. tubes. It is similar to the R-300 type in appearance and performance but possesses a better inductance characteristic when working under high primary current conditions such as are encountered in coupling the first and second stages of audio amplifiers using 226 or 227 type tubes in the first stage. List price $9.00.

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a by-pass condenser from the low potential end of the resistor R5 to ground and the value of the capacity is about .02 microfarad. The filament resistance combination R2, R3, is similar to that which has been described before and serves to reduce the voltage across the tubes to the proper amount as well as to furnish the correct grid biasing potential. In this case R2 has ten ohms resistance, and R3 has six ohms resistance. R3 is, of course, variable as shown. C3-C3 are coupling condensers between tubes and should have a capacity of .01 microfarad. R1-R1 are grid leaks and should have a resistance of approximately three megohms. R4 should be a resistor of about 250,000 ohms (¼ megohm).

A modification of the above circuit and one which works very satisfactorily is shown in Fig. 25. In this audio amplifier the detector and screen-grid tube high resistance loads are composed of iron-cored chokes. These chokes should have an inductance of twenty or thirty henrys for best operation. By placing large condensers across these audio chokes it is possible to tune at specific audio frequencies, a feature that is sometimes very desirable for code reception.

The Space-Charge-Grid Audio Amplifier

A third method audio amplification which is simpler in its application makes use of the tube as a space-charge-grid tube. It will be remembered that the space-charge-grid method does not prevent feed-back and, hence, is of no value in radio-frequency circuits. It is, however, applicable to audio-frequency use and is, possibly, somewhat easier to handle than an audio-frequency screen-grid amplifier. The constants of the tube as a space charge amplifier are somewhat different from those of the tube as a screen-grid amplifier. Table No. 2 summarizes in tabular form the characteristics of the tube for the space-charge-grid arrangement. In this hookup it is also important to remember that the grid connected from the socket base becomes once more the control grid and the metal cap from the top of the tube is the space-charge-grid.

In Fig. 26 is a diagram of a detector and two-stage audio amplifier in which the first audio stage is of the space-charge-grid type. Referring to Fig. 26, the output from the detector is fed into an audio-frequency transformer in the usual manner. Any good audio transformer may be used in this place. The secondary of the transformer connects, on one side, to the control grid (a socket terminal) while the other or low potential end of the secondary connects to a potentiometer R1 placed across a single dry cell. It is advisable to by-pass the potentiometer-battery with a condenser C1 having a capacity of one microfarad. The space-charge-grid (top of tube) is brought directly out to a battery supply of plus 22 volts. Across the plate circuit of the tube is placed a resistive load of from .1 to .3 megohm and the resistor is by-passed to ground at its lower end through a 1.0 microfarad condenser C2. The coupling from the space-charge-tube to the following tube is taken care of by C3 which is a good quality mica condenser with a capacity of about .01 microfarad. Note that the plate voltage for the space-charge-tube is 180 volts. In other respects the amplifier resembles those that have been described before.

(The end)

LIGHT-SENSITIVE CELLS

(Continued from page 32)

tances, daylight, sunlight or the incandescent filament lamp may be used. It is also possible to use color filters for certain work where it is desirable to reduce the discrepancy between the effect of light on the cell and on the human eye, but such compensation is of rather limited application: for there is little similarity between the sensitivity curve for the eye and, for instance, a potassium hydride photoelectric cell. The latter has, as has been previously noted, a maximum sensitivity in the blue-violet of the spectrum, while the average eye is more sensitive to the yellow-green. This is, of course, only a special instance; in most applications the choice of an illuminant presents no serious difficulties.

(To be continued)

THE ENGINEERING RISE IN RADIO

(Continued from page 36)

ing the tone in the receiver—the spark frequency not being noticeable in the telephones. It was called a "Hyrone" system of transmission.

In the realm of sustained waves it was found that by using a coupling of about sixty-five per cent. and a well cooled rotary gap, single impulses could be produced in the gap circuit which would transmit their energy to the oscillating circuit with good efficiency. These impacts occurred so rapidly that the antenna received new energy before its energy absorption had damped out its oscillations, yielding sustained waves.

The advent of the oscillating audion, as described in Chapter 10, so far as radio telephony is concerned, brought in a new era of transmitter development. The audion may be employed to generate radio-frequency alternating currents of any desired frequency. Experience with the tube in the improved receivers wherein the grid potential-plate current characteristic indicated that a slight change in the grid potential causes a relatively large variation of the plate circuit current, was the clue to the discovery of its oscillating properties. Soon it became plain that if a three-electrode tube were connected so as to produce continuous oscillations and a microphone transmitter and battery were connected inductively, or conductively, to the grid circuit, the grid potential would rise and fall in accordance with the modulations of the human voice, and the amplitude of the radio-frequency carrier wave would be modulated at vocal frequencies.

(To be continued)

RADIO SERVICING

(Continued from page 41)

proceed step by step and eliminate each channel after test. The aerial and ground system is, of course, the simplest and should be tackled first. With the receiver adjusted to maximum sensitivity so that the disturbance is loudest, disconnect the aerial. If the disturbance ceases, its source is external of the receiver and the associated power equipment. By this simple process, we preclude the necessity of testing the remaining equipment. Since we know the means of entry, the aerial, we must attempt to locate the origin. Unfortunately, this test is very limited but the results are conclusive nevertheless.

An examination of the aerial is the next step, because a swaying aerial which strikes or makes intermittent contact with grounded objects, such as pipes, stacks, metal poles, metal skylights or other aerials, will cause a click each time contact is made and broken. If the trouble originates at this source, remedy is simple, but if the aerial is perfect, the disturbance originates at some nearby source and is radiated, just as the radio signal to be picked up by the aerial and passed into the radio receiver as if it were a desired signal. Remedy at the receiving end is impossible—the disturbance must be suppressed at its source. Any device connected into the aerial system in order to attenuate or eliminate the disturbance, will also eliminate the desired signal. Complaint that such disturbance is more pronounced at the lower end of the tuning dial or on the low wavelengths, is due to greater receiver sensitivity on the low wavelengths.

Assuming that the disturbance is present when the aerial is disconnected, we can take for granted that it is not picked up by the aerial. Hence, one channel is eliminated. The next step is to determine the possibility of induction, as mentioned. A few minutes expended to alter the position of the receiver and the speaker will show if this form of entry is existing. If the changes in position do not help, we have eliminated another channel.

Operation along this basis has been found extremely satisfactory. It is impossible to give additional illustrations of the process of elimination although they are very numerous and it is hoped that what has been said is sufficient to illustrate the idea. It is true that it is more applicable to certain types of analysis than to others but whenever applied, it is conducive to more rapid progress.

The next discussion will dwell upon the possible faults in radio-frequency amplifying systems.

(To be continued)

Peter L. Jensen, President and in charge of Research and Development, Jensen Radio Manufacturing Co.

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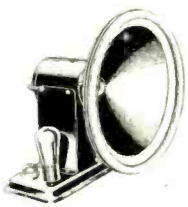

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A 245 Push-Pull Radio and Phonograph Amplifier

An A-C. Operated Power Amplifier and Power Unit, Containing a Number of New Features

By Joseph Riley

THE designing of an all-purpose power amplifier and power supply unit is not an easy task, when it is taken into consideration that in order to obtain satisfactory results under all conditions, proper impedance relations must be maintained. Take, as an example, the input circuit. The primary impedance of the usual input audio transformer is not suited for use in direct connection with a phonograph pick-up. If impedance relations are to be maintained, it is necessary to use a separate transformer in conjunction with the pick-up, or design the standard input audio transformer to accommodate both the impedance requirements of a pick-up and the plate impedance of the detector tube in the receiver.

Special Features

In the power amplifier to be described, a specially designed input transformer is employed. The primary of this transformer is tapped at a point that provides the proper impedance for the pick-up connection. This is transformer T, in the schematic diagram of Fig. 2. The double pole, double throw switch, SW, provides a means for changing the input connections from the pick-up to the detector tube; the only necessary operation to change from radio to phonograph.

It will be noticed that when the switch SW is in "P" position, both the plate of the detector tube and the B supply lead are disconnected from the primary of the transformer T. When the switch is in the "R" position, the pick-up is in an open circuit.

Another interesting feature of this power amplifier is the output push-pull transformer, T2. It will be noticed that there are two secondary windings. The winding M is of high impedance and matches the impedance of the average electromagnetic speaker. The winding D is of low impedance and is for use in connection with electrodynamic speakers. This winding eliminates the necessity of employing a separate impedance-matching transformer in the moving coil circuit, or input circuit, of the dynamic speaker.

Obviously, if the dynamic speaker has its own impedance-matching transformer, it should be connected to the high impedance winding M of the transformer T2.

The input push-pull transformer T1, is also of special design and has a primary impedance and frequency characteristic, most desirable when a 227-type tube is employed in the first audio stage. This is an important matter, as the characteristics of the 227-type tube are not the same as such tubes as the 201-A, the 226 or the 112 tube.

While on the subject of the first-stage tube, note that the grid bias is obtained through the drop in voltage across the 2,000 ohm resistor, R. Also note that the secondary of the first-stage transformer, T, and the primary of the input push-pull transformer, T1, are by-passed to the cathode of the 227 tube by the 1 mf. condensers, C7 and C8 respectively.

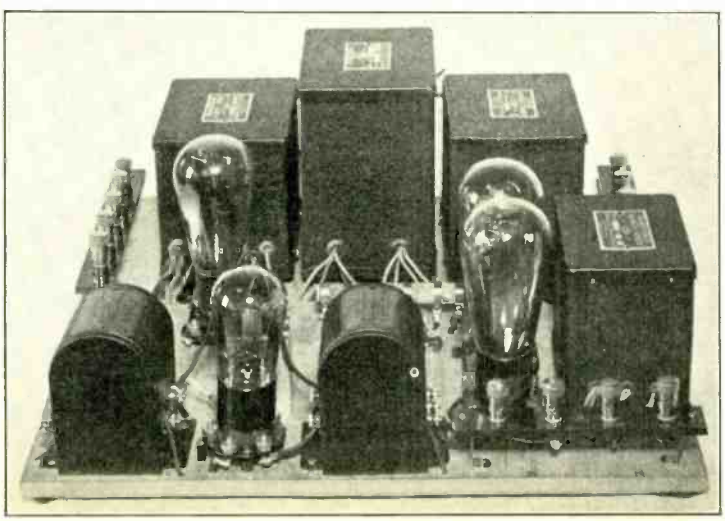

Fig. 1. View of the completed push-pull radio and phonograph amplifier. The use of the 245 power tubes provides a substantial energy output which is particularly desirable when a dynamic speaker is used. This unit is entirely a-c. operated and will supply operating power for a receiver as well. The first stage transformer in this amplifier has a special tap for an electric phonograph pick-up.

Advantages of the 245 Tubes

Some people may question the advisability of the use of two 245 tubes in push-pull in the event that the amplifier is to be used in the home, or in a small hall. Ignoring the desires of the volume hound, how much energy output is required in the average home, or in a small hall, to obtain the best quality?

Most engineers agree that the output of a single 171 is sufficient for such purposes, and they are correct, in so far as set conditions go. This is on the assumption that a magnetic speaker is employed and that the average listener is not particularly squeamish about low registers. However, the single 171 tube has not sufficient output to operate effectively a dynamic speaker, and even two 171 tubes in push-pull are not capable of operating a good dynamic speaker to best advantage. It must be remembered that a dynamic speaker is capable of reproducing low frequencies that the average magnetic speaker cannot reach—and in view of this it is evident that a greater output is required to obtain any appreciable movement of the moving coil at bass notes.

Surely, it is not necessary to cover the advantages of push-pull amplification; everyone is well acquainted with them by this time. The main advantage, of course, is the elimination of harmonic distortion and this alone is sufficient to recommend the use of a push-pull amplifier.

Now, regarding the energy output: a single 245 tube develops an undistorted energy output of 750 milliwatts at a plate voltage of 180, and 1600 milliwatts at a plate voltage of 250. With the present power amplifier one is assured of plenty of energy for driving the speaker, even though the maximum plate voltage will be lower than the full 250 volts. A study of the voltage characteristics of the 280 full-wave rectifier will indicate that with the high current drain of the 245 tubes, it is not possible to maintain the maximum voltage. However, the voltage drop is not so great as to detract appreciably from the operation of the amplifier; the energy output is sufficient for all the purposes the unit would ordinarily be put to.

The Power Supply Unit

Now let us take a look at the power supply unit. The power transformer, T3 has five windings; the primary winding, connecting to the 110-volt, a-c. light socket; a 2.5-volt filament winding to supply filament voltage to the receiver, if desired; another 2.5-volt winding to supply the filaments of the two 245 tubes and the 227 tube; a 5-volt winding supplying the filament of the 280 full-wave rectifier, and a high-voltage winding, providing a maximum of 250 volts at the output, under normal loads.

It will be noticed that all of the filament heater windings have center taps and, therefore, it is not necessary to employ center-tapped resistors to balance out hum.

The filter system of the power unit is made up of two filter chokes, Ch., Ch, and the high-voltage filter condensers, C, C1 and C2, with the capacities indicated. These three condensers, as well as the condensers C3, C4, C5 and C6 are all contained in a single condenser block. The two filter chokes Ch., Ch. are in a separate case.

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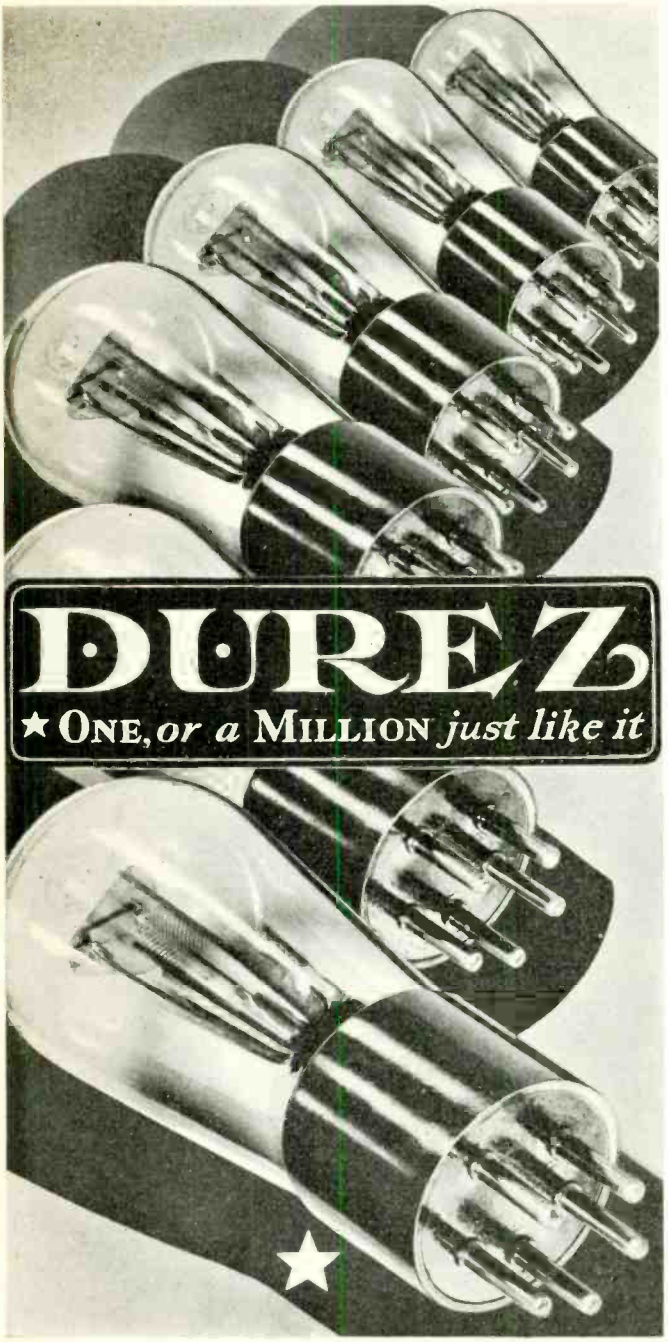

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The condensers, C3, C4 and C5 by-pass the taps on the voltage divider resistance, R2, which supplies B voltage for the amplifier tubes as well as the tubes in the receiver. Condenser C6 by-passes the 800-ohm resistor R1, which provides the proper C bias for the grids of the 245 tubes. This resistor, as well as all of the condensers, terminate at point CT, which is the common terminal, or B minus. The condensers are actually connected together inside the condenser block and there is but one common terminal connection from this unit. The two exceptions are the low voltage condensers C7 and C8 which can be seen mounted together on the baseboard in the illustration of Fig. 3.

The switch A, is in one of the primary leads of the power transformer, T3 and can be any form of 110-volt snap switch. This switch, of course, turns on and off both the amplifier and the receiver, providing the receiver obtains its power from this unit. In the event that there is an appreciable amount of line voltage variation where the amplifier is to be employed, it is suggested that some form of line voltage regulator be used. As a matter of fact, it is a very good idea to use one anyway. It can be connected in the same lead carrying the switch A.

Construction

There is very little to say regarding the construction of this power amplifier. Most of the details can be gathered from the accompanying illustrations. The major portion of the wiring is done underneath the baseboard, the latter being raised by four rubber feet.

Follow the usual set of suggestions in regards to wiring and the placement of parts. Keep all the twisted filament leads well away from, or at right angles to grid and plate leads. Likewise, keep all grid and plate leads well separated. The parts should be so mounted that all leads can be as short as possible and in this case, give most consideration to the grid leads. It is well to follow the general layout indicated in the illustration, but there is nothing against altering the position of some of the parts to suit individual requirements, providing such changes will not alter the wiring scheme to any great extent.

The illustration of Fig. 1 shows the general position of most of the parts. At the back of the baseboard are mounted, from left to right, the power transformer, T3, the condenser block, containing the high voltage condensers, C, C1, C2, C3, C4, C5 and C6, and the filter choke unit, containing the chokes Ch., Ch.

The UX-280, full-wave rectifier tube is mounted directly in front of the power transformer case. The 245 power tubes are mounted together directly to the left of the push-pull output transformer, T2, which is at the extreme right, and to the front, of the baseboard.

The 227 tube is mounted between two of the transformers; the transformer to the left of the tube is the input audio unit, T, and the one to the right of the tube is the input push-pull transformer, T1.

The binding post strip to the right and front of the baseboard carries the output terminals. From left to right: the first two posts are the terminal connections for a dynamic speaker and the next two posts are the terminals for a magnetic speaker.

Referring to the illustration of Fig. 3, the two by-pass condensers, C7 and C8 are mounted directly at the back of the 227 tube socket. The 2,000-ohm grid bias resistor, R, is in the form of a strip, and does not show up clearly in the illustration, but is connected from the cathode post on the 227 tube socket to a terminal on the first stage audio transformer.

The voltage divider resistor, R2, can be seen directly in front of the condenser block—and in front of this resistor unit is the 800-ohm C bias resistor, R1, which provides the proper bias for the two 245 tubes.

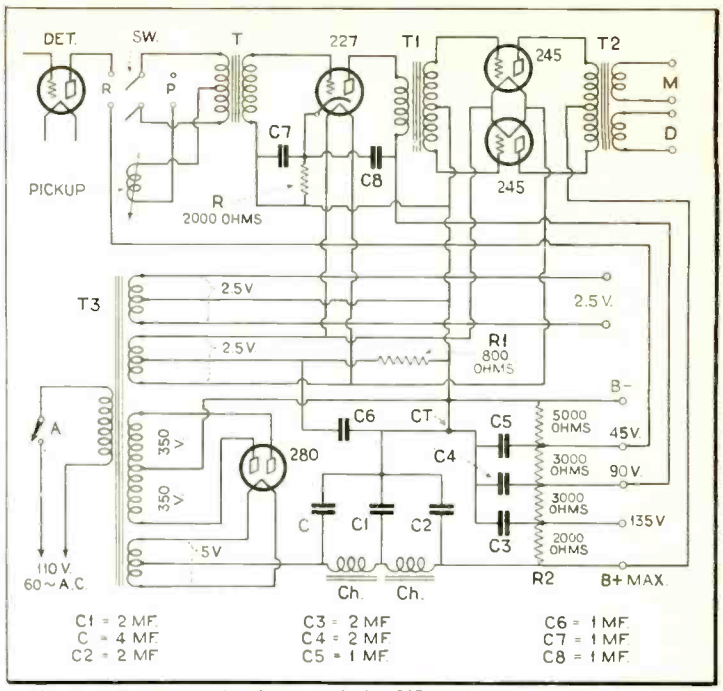

Fig. 2. The schematic diagram of the 245 push-pull amplifier described in this article. Note that the pick-up is thrown in to the primary circuit of the first stage transformer, rather than in the grid circuit of the detector tube. This is made possible by the use of a tapped primary winding. Also note that the output push-pull transformer has both a high and a low impedance winding, for magnetic and dynamic speakers.

The binding post strip at the left of the baseboard (Fig. 3) carries a portion of the external connection terminals. They are, from top to bottom: the two 2.5-volt filament terminals, detector plate connection, and the two terminal connections for the phonograph pick-up.

The binding post strip mounted on the right hand side of the baseboard carries the B voltage terminals. The top post is B plus 135, then B plus 90, B plus 45 and the last post, B minus.

The double pole, double throw, phonograph-radio switch, SW, is seen mounted a bit to the left of the 280 tube socket. In the event that the power amplifier is to be placed inside of a cabinet, the five leads connecting to this switch may be brought out to the panel of the radio receiver or any other desirable position and the switch mounted within easy reach. The same holds true of the switch A.

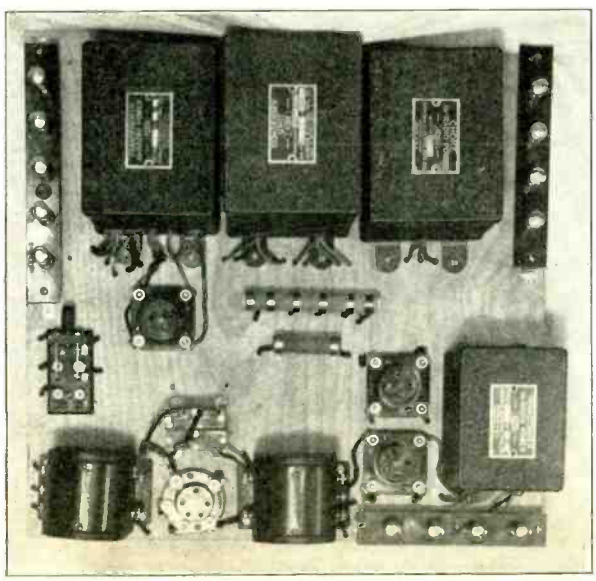

Fig. 3. A top view of the completed push-pull amplifier. All of the power supply units are mounted at the rear of the baseboard and the amplifier units at the front. The detector plate lead and the phonograph pick-up connect to posts on the terminal strip mounted on the left side of the baseboard. The B voltage terminals are grouped on the strip to the right.

LIST OF PARTS REQUIRED

1—Dongan 1st stage audio transformer, Type H-2124 (T).
1—Dongan input push-pull transformer, Type H-2142 (T_1).
1—Dongan output push-pull transformer, No. 2189 (T_2).
1—Dongan power transformer, No. 994 (T_3).
1—Dongan filter choke unit, No. 5554 (Ch., Ch.).
1—Dongan condenser unit, No. D-946 (C, C_1, C_2, C_3, C_4, C_5, C_6).
2—Tobe 1.0 mf. fixed condensers (C_7, C_8).
1—Electrad 2,000-ohm grid bias resistor (R).
1—Electrad B-S resistor (R_1).
1—Electrad C-130-S resistor (R_2).
1—Muter D. P. D. T. switch (SW).
3—Benjamin, No. 9040, four-prong tube sockets.
1—Benjamin, No. 9036, five-prong tube socket.
1—UY-227 tube.
2—UX-245 power tubes.
1—UX-280 full-wave rectifier tube.
1—Binding post strip 8" x 1" x $\frac{3}{16}$".
2—Binding post strips 7" x 1" x $\frac{3}{16}$".
13—X-L binding posts.
1—Roll Corwico "Braidite" twisted wire.
1—Roll Corwico "Braidite" hookup wire.
1—Veneer baseboard 15" x 15½" x ½".
4—Rubber feet, for baseboard.

Accessories

1—Electric phonograph pick-up.
1—Line voltage regulator.
1—110-volt line switch.

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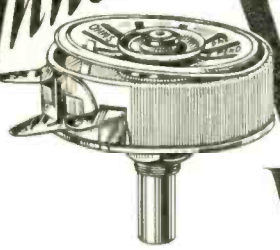

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And these engineering efforts are now presented in the new CLAROSTAT WIRE-WOUND VOLUME CONTROL. This device is an entirely new conception. It is available in the highest resistance values required. It is a *genuine* wire-wound job—not to be confused with carbonized paper devices hitherto necessary for high resistance ranges. Nor is it to be confused with fine wire windings and sliding contacts, which wear out in short order. This Clarostat offering is unique, revolutionary, better, indispensable

High Resistance With Wire

Wire-wound variable resistors have heretofore been limited to a maximum resistance of 5000 ohms, which is inadequate for volume control in most circuits. The CLAROSTAT WIRE-WOUND VOLUME CONTROL is available in resistance values up to 25,000 ohms. An unique threaded support holds the turns in their proper places, accurately and permanently. They cannot shift or short-circuit.

A New Form of Contact

When using the fine wire necessary to obtain the high resistance values, it is impractical to employ a sliding contact. In the first place, with sufficient pressure to establish a clean contact, there is serious wear and tear on the fine wire, resulting in early breakdown of the device. If insufficient pressure is applied, the slight oxide formed on the wire prevents clean contact, and such a device is apt to be as noisy as the carbonized paper type.

In seeking the ideal compromise, the Clarostat Engineering Staff has developed an unique form of contact. It is a pressure contact, established at any point on the winding, without scraping or wear. The fine wire is never disturbed. It cannot wear out. Yet a positive, noiseless, velvety adjustment is readily made.

A Simple and Ingenious Mechanism

The accompanying illustration of the CLAROSTAT WIRE-WOUND VOLUME CONTROL tells the story. Around the metal casing, 1½ inches in diameter, a bakelite strip, pre-threaded, is wound with fine wire. The shaft passes through a long bearing and carries two washers so punched as to produce an inclined surface between themselves. Between the washers or cams is a phosphor-bronze disk radially slotted for greatest resiliency, and so located as to rock or gyrate as the shaft revolves, yet this disk, chromium plated, cannot turn with the shaft since it is held in permanent position by a projection of the middle contact on the casing. This simple mechanism causes the contact disk to establish contact at any point around the circle.

Available in Any Type for Any Application

The CLAROSTAT WIRE-WOUND VOLUME CONTROL is manufactured in a type with three terminals, or potentiometer style; in a type with two terminals, or rheostat style; and also in a tandem or duo-volume control style for regulating two circuits with one knob.

But this is not the whole story. A sample will tell more than ten thousand words of description, so——

Designers and Manufacturers of A-C Sets

WRITE for a sample of the CLAROSTAT WIRE-WOUND VOLUME CONTROL, on your business stationery, and one will be sent for your examination and test. Also, don't forget that the CLAROSTAT line includes resistors for every radio need—fixed, variable and automatic. Tell us about your resistance problems and we shall tell you how to solve them.

CLAROSTAT MANUFACTURING COMPANY, Inc.
Specialists in Radio Aids
282 North Sixth Street : : Brooklyn, N. Y.

CLAROSTAT

NEWS OF THE INDUSTRY

SERVICE MAN'S MANUAL READY SOON

Two books written by John F. Rider for the radio serviceman will be ready soon, is the announcement received from the Radio Treatise Co., 1440 Broadway, New York City.

These two treatises constitute a two-volume series, entitled "The Service Man's Manual." The first volume, entitled "The Mathematics of Radio," explains radio phenomena in a practical manner, with examples of all calculation, so that the serviceman may be in a position to solve all technical problems. This book leads up to the second volume. An idea of the contents of Volume 1 is "Ohm's Law, Resistances, D-C. Filament Circuits, A-C. Filament Circuits, Capacity, Voltage Divider Systems for B Eliminators, Induction, Reactance and Impedance, Resonant Circuits, Iron Core Chokes and Transformers, Vacuum Tubes, Three-Element Tubes, Power Amplification, Graphs and Response Curves, Multiple-Stage Amplifiers, Alternating-Current Tubes, Screen-Grid Tubes, A and B Eliminators".

The second volume, entitled "The Trouble Shooting Manual," is written to fill a long felt want. It contains the diagnosis of receiver systems, R-F. Amplifiers, A-F. Amplifiers, Eliminators, etc. Trouble shooting in these systems with commercial set testers and analysis of symptoms. Wiring dingram of Weston and Jewell set testers, application of these testers and about 150 wiring diagrams of old and modern commercial receivers. A few of the receiver manufacturers represented in this volume are Radio Corporation of America, Fada, Freed-Eismann, Kolster, Federal, Zenith, Crosley, Stromberg-Carlson and others. The books are 8½ x 11" and the price is $5.00 for the two volumes: $2.00 for Volume 1 and $3.00 for Volume 2.

ARCTURUS FACTORIES WILL RUN ALL SUMMER

Stockholders of Arcturus Radio Tube Company, at their annual meeting, were informed by President Chester H. Braselton that satisfactory progress is being made in the company's recently announced expansion program. The company's plants will run at capacity through the summer months, according to present outlook, he said, and the newly purchased factory in Newark, containing 111,000 square feet of floor space, is expected to begin operations not later than June. Directors were re-elected.

TEMPLE SPEAKER PLANT NOW SEPARATE UNIT

Due to the demand for Temple dynamic units, which are equipped with the improved Temple hum eliminator, plant No. 2, 1925 South Western Avenue, is now being used for the manufacture of speakers only and is in charge of Captain F. W. Piper, former Western sales manager of the United Reproducers Corporation.

Plant No. 1, which is situated at 5253 West 65th Street is being devoted to the manufacture of the Templetone Radio Set exclusively.

BILL ALLEY TO DIRECT RMA MERCHANDISING SERVICE

President H. H. Frost of the Radio Manufacturers Association has announced the appointment of Mr. William Alley, former managing editor of *Radio Retailing*, as merchandising manager for the new established Merchandising Bureau of the RMA at its New York headquarters.

The new RMA Merchandising Bureau is another new service for the members, and also for radio jobbers and dealers. Comprehensive merchandising service, industry surveys and special service for members will be developed by Mr. Alley who for years has been an outstanding authority on radio merchandising. The new Merchandising Bureau will operate under the immediate guidance of the RMA Merchandising Committee, headed by Mr. L. E. Noble, of Buffalo, Chairman, following the policies outlined by the RMA Board of Directors.

"Bill" Alley, as he is widely known throughout the radio industry, becomes the RMA merchandising manager with a wealth of experience and industry connections. He has been connected with *Radio Retailing* since its inception in 1924, and lately as managing editor. Mr. Alley took over the editorial management of the trade magazine upon the appointment of its editor, Mr. O. H. Caldwell, to the Radio Commission in March, 1927. From 1924 to 1927 Mr. Alley was associate editor and for the past two years has been managing editor and has written extensively on mer-

WILLIAM ALLEY
Merchandising Manager, R.M.A.

chandising subjects. He has been in close contact with the development of the radio trade and industry, its problems passing over his desk daily during the past five years.

Prior to his publishing experience, Mr. Alley had practical experience in radio merchandising through the operation of a small chain of retail radio stores in New York and Connecticut. This experience ranged from wrapping bundles behind the counter to vice-president and advertising manager of the retail chain.

Mr. Alley's aim is to afford comprehensive merchandising service and a source for authentic industry information for RMA members and also jobbers and dealers of radio.

CUNNINGHAM BOOKLET RECEIVES TRADE APPROVAL

One of the best dealer helps of the year is found in the Cunningham Socket Booklet distributed by E. T. Cunningham, Inc.

This booklet is a loose leaf affair with an attractive and serviceable binder that affords a handy and permanent reference to the data sheets.

Each page gives the manufacturer of the receiver, the model name or number, a diagram of the socket position, a socket number and the circuit position of each socket. Below is a table listing the proper type Cunningham radio tube to insert in each socket for correct operation and maximum reception.

At present the booklet contains 237 models—past and present of 36 different set manufacturers. It is the intention of the Cunningham Company to issue additional pages as new models appear.

The popularity and need for this booklet is attested by the fact that three printings have been necessary to take care of the trade demand.

This booklet is available for radio dealers and their servicemen, free of charge, if they will address their requests to the Sales Promotional Department of E. T. Cunningham, Inc., 370 Seventh Avenue, New York, N. Y.

CODY AND FISKE JOIN GOLD SEAL

J. K. I. Cody has been appointed general sales manager of the Gold Seal Electrical Company, Inc., of New York.

Mr. Cody, although new in tube activities is well known as a successful executive as general manager of the National Cash Register business in Japan, where his efforts were largely responsible for the commanding position N.C.R. occupied in the Japanese Empire.

Edward R. Fiske (formerly assistant general sales manager of the Ceco Mfg. Co.), has been placed at the head of the field force, as general field supervisor.

Mr. Fiske has a host of friends in the trade, and has achieved considerable distinction for the fine showing he made in the Ceco operation during 1926, 1927 and 1928.

SONATRON OPENS CHICAGO PLANT

The Sonatron Tube Company have taken over a five-story and basement brick building at Fillmore and Central Park Avenues, in Chicago. The building, which was acquired a few weeks ago, is the most recent addition to the Sonatron Tube Company's production facilities. Its acquisition was necessitated by the increasing demand for Sonatron products in the west, according to Harry Chirelstein, president of the company. The main factories are located at Newark, New Jersey.

The Chicago plant is a model factory structure. It has a total of 75,000 square feet of floor space, and is located on a switch track.

According to Mr. Chirelstein, production in the new plant will be stepped up to 40,000 tubes a day. This, together with a similar number to be produced when the new addition to the Newark factory is in operation, will make the contemplated output for all factories 80,000 tubes a day within a short time.

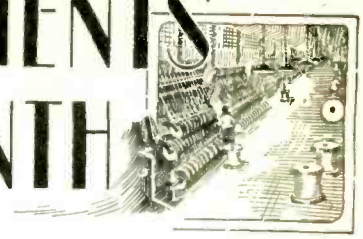
O'NEIL JOINS A. H. LYNCH, INC.

Announcement is made by Arthur H. Lynch, Inc., 1775 Broadway—General Motors Building—New York City, that Mr. J. F. O'Neil, the Pennsylvania representative for the CeCo Manufacturing Company, has severed his connection with that organization as of April 15th to take on the general managership of the Lynch corporation.

Mr. O'Neil was for eight years Superintendent of Agencies for the Curtis Publishing Company before going with the CeCo company. In his new connection with Arthur H. Lynch, Inc., he will have charge of a group of sales experts in all parts of the country. Negotiations are under way with several tube manufacturers and it is expected that the Lynch organization will represent one of them very shortly.

Mr. O'Neil is well known among New York, New Jersey and Pennsylvania jobbers and under his direction it is expected that the sales representation section of the Lynch corporation will show material progress during the coming season.

NEW DEVELOPMENTS OF THE MONTH



RADIOTRON UY-224

A new four-electrode, screen-grid amplifier tube, Radiotron UY-224, embodying a 2.5 volt heater element which permits operation from alternating current has been placed on the market by the Radio Corporation of America.

This new Radiotron is recommended for use primarily as a radio-frequency amplifier in circuits especially designed for it but it may also be used in special circuits as a detector or as an audio-frequency amplifier.

Radiotron UY-224, a-c. screen-grid tube.

Characteristics of the UY-224 follows:

Plate voltage, maximum and recommended, 180 volts
Negative grid voltage.....1.5 volts
Screen voltage, maximum.....75 volts
Plate current .....4 milliamperes
Screen current, not over ⅓ of plate current
Plate resistance.....400,000 ohms.
Amplification factor.....420
Mutual Conductance.....1050 micromhos
Heater .....Volts 2.5.....Amperes 1.75
Maxi. overall, Length 5¼", Diam. 1 13/16"
Base.....Standard UY (5 Prong)

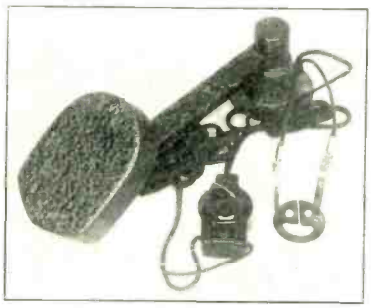
GERD STANDPEAK CONDENSERS

The Gerd Electric Co., a newly formed organization, located in the Kendall Square Building, Cambridge, Mass., have gone into production on a very fine grade of low and high voltage, filter and by-pass condensers and power blocks, to meet all special and general requirements.

The 200 d-c. working voltage, by-pass condensers are made in capacities ranging from 0.1 mf. to 2.0 mf. The filter condensers, with a working voltage of 400 d-c., are made in capacities from 1.0 to 4.0 mf. The power condensers are made in the same capacities but have a working voltage of 600 to 1,000 d-c.

The Gerd power blocks are made up for 171, 210 and 250 power packs.

One of the main features of the Gerd condensers lies in the method of manufacture. Each condenser is impregnated twice, through a special process. The materials and the complete condensers are given a total of eight tests. Ten processes are involved in their manufacture.



The new Best theatre pick-up.

NEW BEST THEATRE PICK-UP

A new phonograph pick-up has been announced by the Best Manufacturing Company of Irvington, N. J., manufacturers of the famous BBL Motor.

One of the serious objections to pick-ups has been the damage they do to the records. When one first looks at the Best Theatre Pick-up one would think its large size and tremendous weight would wear out the records even quicker than the other pick-ups.

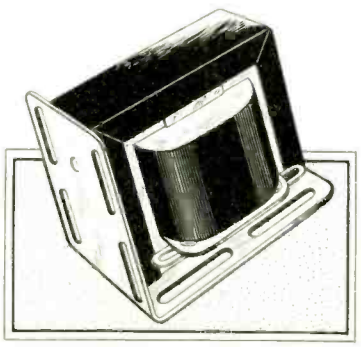
The Theatre Pick-up, however, is so finely counterbalanced that just enough weight bears on the record for the needle to track perfectly. That is true of high and low frequencies.

The idea of the Best engineers was to design a pick-up which would give the general public the benefit of a pick-up which would be in every way comparable with those now used in the theatres and which cost well over $200. The Best Theatre Pick-up has a response curve which is remarkably close to the high priced, oil-floated types it is claimed.

Needle scratch is appreciably less and record life is thereby greatly increased.

THORDARSON REPLACEMENT TRANSFORMER

The Thordarson Electric Co., of Chicago, have introduced a new audio-frequency transformer, known as R-100, so designed that it may be easily and conveniently installed in any make of receiver, or individual amplifier unit, to replace a damaged transformer.



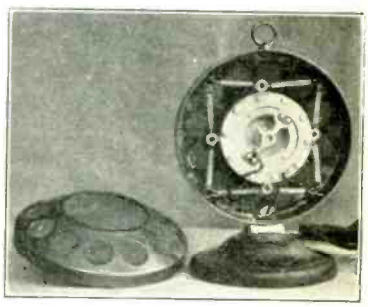
Thordarson R-100 Replacement Transformer.

The accompanying illustration indicates the special features of the R-100 unit. The brackets are so arranged that the transformer can be screwed or bolted in place and in most any position desired. Convenient soldering tabs are at each of the four transformer terminals.

The R-100 Replacement Transformer measures only 2⅝" x 2" x 1¾", yet it is a quality unit. The list price is $2.25.

UNIVERSAL "KK" MICROPHONE

The new model Universal Broadcast Station Microphone is now available through the New York and Chicago offices of the Gotham Engineering and Sales Co., or from the Universal Microphone Co., Inglewood, Calif. This is a superior two-button unit with solid back, stretched duralumin diaphragm, and gold contact surfaces. The curve of response is unusually flat from 30 to 10,000 cycles, and the absence of bothersome "hiss" is notable. It can be supplied complete as shown in the photograph, equipped with ring desk mount, covers, and cord, or the microphones alone can be procured.



Universal "KK" two-button microphone.

This microphone is ideal for use in broadcast studios, public address work, announcements in connection with talking movie installations, or wherever the most perfect pick-up of the carbon granule type is required. The unit alone lists at $75.00, or complete with ring desk mount, covers, and cord, as shown, at $98.50.

NEW UNITED CO. ELECTRIC MOTOR

The United Air Cleaner Co., Chicago, is introducing to the trade a new electric motor known as No. 1, which is furnished complete with turntable, speed regulator, switch and all accessories, ready to install. The new motor, which is popularly priced, was designed and developed with particular attention to efficient operation in radio-phonograph combination instruments. The motor is a complete unit and is started by the throwing of a small switch and it may be regulated to any desired speed.

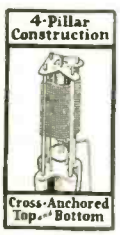
United electric motor No. 1 is an induction, squirrel cage type a-c. motor. A driving-worm is pressed to the end of the motor shaft and engages with a vulcanized fibre gear on the turntable shaft. One end of the governor shaft is coupled to the motor shaft with a jaw-clutch construction and is, therefore, a positive drive. The other end of the governor shaft runs in a bronze bearing having a reservoir on the outer end which is filled with oil-soaked felt. The entire motor may be lubricated by removing the turntable.

Two NEW "Health Tubes"

These two new A. C. tubes meet the demand for types required in many newly-designed radio sets now in production.

And they allow that many more set owners to have completely Raytheon-equipped apparatus.

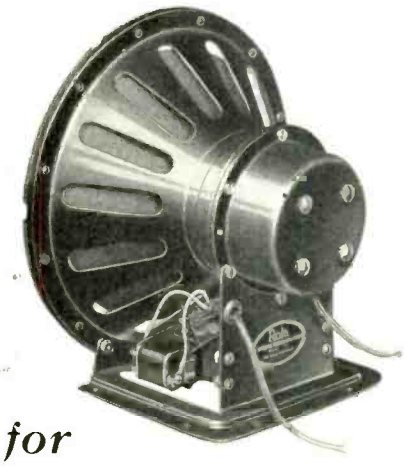
Like all other Raytheon A. C. tubes, these new types have the exclusive Raytheon construction that eliminates microphonic noises and insures long tube-life by permanently preserving the correct interspacing of the elements.



Raytheon Mfg. Company
Cambridge, Mass.

Raytheon
LONG LIFE RADIO TUBES

ROLA



for

Receiving Sets *and* Phonographs

ROLA Electro-dynamic reproducers possess mechanical and performance characteristics especially desirable for "high-quality" service.

The response range is substantially uniform over the best amplifier range. Sensitivity is high, due to use of high flux-densities which Rola's short air-gap makes possible without excessive exciting power.

Large amplitude of vibration is permitted by an exceptionally free floating spider and leather support, insuring ample volume capacity for all purposes.

Large mechanical safety-factors eliminate break-downs frequently encountered in ordinary dynamic construction. Rola's exclusive welded housing-to-shell construction prevents dis-aligning of moving coil, even under extreme conditions of cabinet or baffle warping.

Supplied in any quantity, with or without field windings. Write for prices and specifications.

Inquiries for details, blueprints and prices from responsible manufacturers are solicited.

The ROLA COMPANY

CLEVELAND, Ohio
2570 E. Superior Ave.

OAKLAND, California
Forty-fifth and Hollis Sts.

Super-TONATROL

NEW! DIFFERENT! BETTER!

U. S. Pats. No. 1034102 —1034104 and Pats. Pending.

The resistance element is graphite paint, fused to an enameled metal base at high temperature. Pure silver floating contact. Metal cover for rapid heat dissipation.

AN exceptional volume control for use where heavy currents are to be handled and exceptionally long life is desired. Easily dissipates 5-watts without breaking down or varying in resistance. The action is amazingly smooth and actually improves with use. Built for endurance beyond all expectations. Variable or tapered curve. Manufacturers, ask for test sample and tell us your requirements.

Patents Pending

A New Standard in Covered Resistances

Heavier-than-usual Nichrome resistance wire on a high-grade refractory tube. Monel-metal contacts and slotted soldering lugs. Entire unit protected by insulating enamel baked on at low temperature that can do no damage to wire or contacts. Can be made in practically any resistance value and wattage rating desired.

ELECTRAD INC.

ELECTRAD, INC., Dept. R E 5, 175 Varick St., New York
Send us complete data and test samples of:
—5-watt Super-TONATROL —COVERED RESISTANCE.

Manufacturer .....
Address .....
City .....
State .....

Sense the unintentional

compliment, when the dealer says,

"JUST AS GOOD"

and *still* insist on Cardwells

"THE STANDARD OF COMPARISON"
Since the days of receiving crystals and phones

Transmitting for powers to 50 kw.
Receiving in all standard capacities.

CARDWELL CONDENSERS

Have You Our Literature?

The Allen D. Cardwell Mfg. Corp.
81 Prospect Street Brooklyn, New York

[*IF YOUR DEALER DOES NOT STOCK, ORDER DIRECT*]

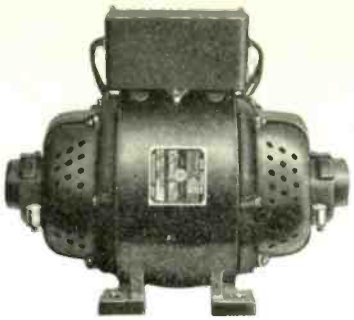
FOIL

OF ALL KINDS

Aluminum
Composition
Lead
Tin
Zinc

REYNOLDS METALS CO., INC.

LOUISVILLE, KENTUCKY



Dynamotor with Filter for Radio Receivers

MACHINES for OPERATING 60-CYCLE A. C. RADIO RECEIVERS, LOUD SPEAKERS and PHONOGRAPHS from DIRECT CURRENT LIGHTING SOCKETS WITHOUT OBJECTIONABLE NOISES OF ANY KIND

The dynamotors and motor generators are suitable for radio receivers and for combination instruments containing phonographs and receivers. Filters are usually required. The dynamotors and motor generators with filters give as good or better results than are obtained from ordinary 60-cycle lighting sockets. They are furnished completely assembled and connected and are very easily installed.

These machines are furnished with wool-packed bearings which require very little attention, and are very quiet running.

ELECTRIC SPECIALTY COMPANY
TRADE **"ESCO"** MARK
411 South Street **Stamford, Conn.**

AEROVOX
BUILT BETTER
CONDENSERS AND RESISTORS

Moulded Mica Condensers Standard for R. F. Circuits

THE fact that moulded mica condensers, as a class, will give best results in radio frequency circuits is universally accepted as standard practice in engineering circles.

But to get best results—accuracy, minimum dielectric losses and freedom from change under the influence of varying temperature, weather and chemical action—the capacity unit must be carefully constructed, accurately measured and securely sealed in its bakelite housing.

In Aerovox Moulded Mica Condensers—made in a variety of shapes and sizes to suit the requirements of receiver manufacturers and experimenters—only the best grade of India Ruby Mica, pure tinfoil plates and high quality bakelite are employed. The capacity of the elements is pre-determined and accurately adjusted to the desired value, the units are thoroughly impregnated and moulded in bakelite—safe against the action of time and weather.

Send for Complete Catalog

Complete specifications of all Aerovox units, including filter, bypass and mica condensers, Pyrohm, wire-wound and Lavite resistors will be sent free of charge on request.

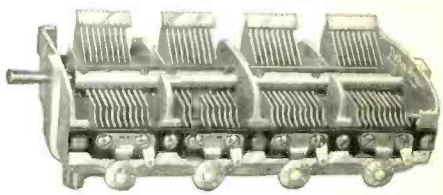
AEROVOX WIRELESS CORP.
76 Washington Street, Brooklyn, N. Y.
PRODUCTS THAT ENDURE

PRE-CISION
DeJur-Amsco

Precision in manufacturers' condensers is assured by DeJur-Amsco. These famous "Bath-Tub" Condensers are available in single, double, triple and quadruple types in all capacities.

Send us your specifications and let us quote on your requirements.

DeJur-Amsco Corporation
Broome and Lafayette Sts., New York City



Protected by Patents, Patents Pending and Patents Applied For

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PHOTOELECTRIC CELLS
Television—Talking Pictures—Research

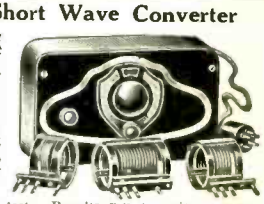
G-M VISITRON cells of the alkali metal hydride type are of highest sensitivity, low dark current, long life, and respond to the smallest changes of light intensity and color. Their high quality and uniform sensitivity make them the choice of leading engineers. Get technical Bulletin P-14 Free.

G-M LABORATORIES INC
1802 Grace St., Chicago, Ill.

MOLYBDENUM WIRE
FOR RADIO AND LAMPS
NEON, HELIUM AND ARGON GAS
Highly purified
FLASHLIGHT BULBS
Furnished by
PALATINE INDUSTRIAL CO., Inc., 111-5th Ave., New York

Hear the Aero-Call Short Wave Converter

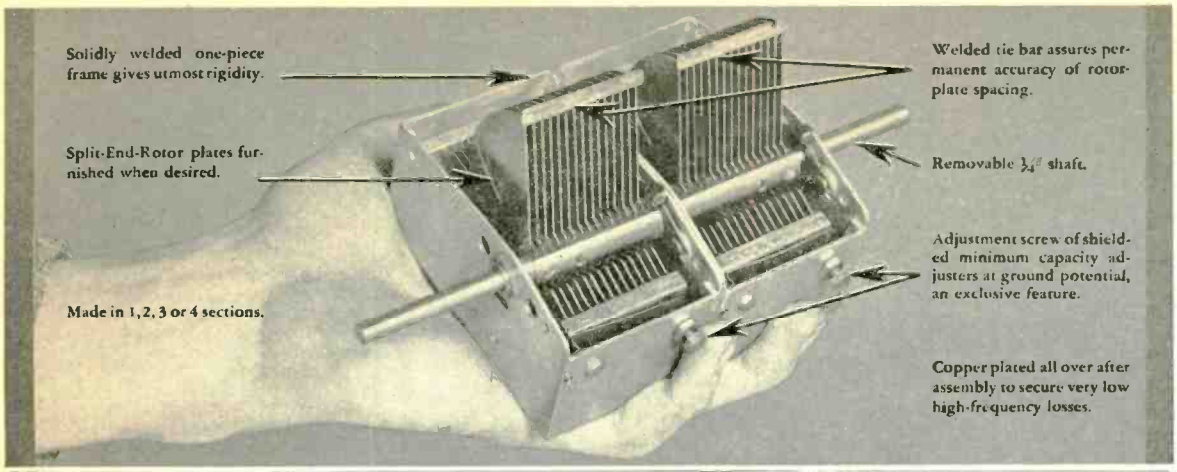
Factory-Built, Ready to Plug Into Your Present Radio Set



The Aero 1929 Converter is a compact factory-built short-wave adapter equipped with special short-wave coils. It is designed for both A.C. and D.C. sets. Operates without motor-boating, by an auxiliary filter system control, an exclusive feature (patent applied for). It can be plugged into any regular radio set. This amazing radio instrument now makes it possible for you to reach 'round the world. G3o. Morcroft of Pa. tuned in England, Holland and Australia on his initial test. Permits you to enjoy programs from coast-to-coast that your regular receiver cannot get. What a thrill it is to plug this into a tube socket on your regular set and instantly be in another world! No change or wiring required. All complete, ready to operate, tubes and coils hidden, no apparatus in sight, except the neat, golden-brown, compact metal cabinet in crackle finish. Size, 9 x 5½ x 2½ in.

The only converter we know of that really works on all sets. Two models—A.C. and D.C. Write for Catalog and literature, or send $25.00 and name of your dealer. Model A, without tube, for A.C. sets $25.00. Model D, without tube, for D.C. sets $25.00. *At leading dealers and jobbers.*

AERO PRODUCTS INCORPORATED
4611 E. Ravenswood Ave., Dept. 759
CHICAGO, ILL.



QUALITY . . . But at a lower price . . .

NATIONAL CO. INC. offers a new type of variable condenser for manufacturers, the utmost in engineering design, quality and durability. Units are matched to an accuracy of one-quarter of one percent.

Manufacturers, write or wire for prices
NATIONAL CO. INC., MALDEN, MASS.
Est. 1914

WELD-BUILT
NATIONAL
Type M

Meet that Production Schedule!

EVER since the beginning of radio, ***Fast*** has specialized in one thing only—Condensers. In the development of an organization to meet the rapidly expanding requirements of radio set manufacturers, special machinery had to be designed, production methods standardized and labor and time-saving equipment utilized to the utmost.

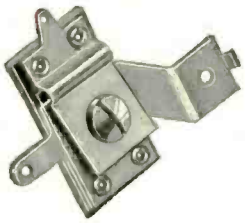
How well we have been able to meet these conditions, is attested by the fact that millions of condensers are produced here annually for the country's leading set manufacturers.

An example of ***Fast*** production methods is shown in the illustration of our winding room in which scores of dual machines perform intricate operations rapidly and dependably on a tremendous production schedule. Don't take chances of having broken delivery promises ruin your production schedule. Establish a reliable, if need be, auxiliary source of supply to meet every contingency.

Send us your specifications and let us show you how your condenser worries can be overcome.

JOHN E. FAST & CO.
RMA
3982 Barry Avenue **Chicago, Illinois**

Special Equalizing and Neutralizing CONDENSERS



Made to Your Specifications

WHEN the standard Hammarlund Equalizing and Neutralizing Condensers do not quite fit into your receiver design, we are prepared to make special models, either single or in gang, according to your specifications. The Hammarlund Equalizing and Neutralizing Condenser is superbly made — compact, accurate, efficient. Bakelite base; brass stator plate; mica dielectric; phosphor bronze spring plate; convenient adjusting screw and connecting lugs.

Write Dept. RE5 about your needs

HAMMARLUND MFG. CO.
424–438 W. 33rd St. New York, N. Y.

For Better Radio
Hammarlund
PRECISION
PRODUCTS

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, OF RADIO ENGINEERING.

Published monthly at Albany, N. Y., for April 1, 1929.

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

Before me, a Notary Public in and for the State and county aforesaid, personally appeared B. S. Davis, who, having been duly sworn according to law, deposes and says that he is the Business Manager of RADIO ENGINEERING, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24th, 1912, embodied in section 411, Postal Laws and Regulations, to wit: 1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Bryan Davis Publishing Co., Inc., 52 Vanderbilt Avenue, New York; Editor, M. L. Muhleman, Mount Vernon, N. Y.; managing editor, G. C. B. Rowe, Mount Vernon, N. Y.; Business Manager, B. S. Davis, Scarsdale, N. Y. 2. That the owners are: B. S. Davis, Scarsdale, N. Y.; Roy T. Atwood, Albany, N. Y. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1% or more of the total amount of bonds, mortgages, or other securities are: None. 4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where a stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustees is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) B. S. DAVIS, Business Manager.

Sworn to and subscribed before me this 1st day of April, 1929.
(Seal) J. A. WALKER, Notary Public.

Kings County.
Kings Co., Clerk's No. 363.
Kings Co., Registers No. 1062.
New York Co., Clerk's No. 167.
New York Co., Registers No. 1W177.
Commission expires March 30, 1931.

Buyers Directory of Materials 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 70.

ADAPTERS:
Insuline Corp. of Amer.
Lynch, Arthur H., Inc.

ALUMINUM:
Aluminum Co. of America

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

AMMETERS:
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

AMPLIFIERS, POWER:
General Amplifier Co.
General Radio Co.
National Co., Inc.

ANTENNAE, LAMP SOCKET:
Dubilier Condenser Mfg. Co.
Electrad, Inc.

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

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

BAFFLES:
Wright-DeCoster, Inc.

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

BRACKETS, ANGLE:
Electrad, Inc.
Insuline Corp. of Amer.
Scovill Mfg. Co.

BRASS:
Scovill Mfg. Co.

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

BULBS, PANEL:
Palatine Industrial Co., Inc.

BUTTS:
Scovill Mfg. Co.

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

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

CHARGERS:
Benwood-Linze Co.
Elkon Co.

CHASSES
Aluminum Co. of America.
United Scientific Laboratories, Inc.

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

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.
Jefferson Electric Co.
Silver-Marshall, Inc.
Transformer Co. of Amer.
Valley Appliances, Inc.

CLAMPS, GROUND:
Insuline Corp. of Amer.
Scovill Mfg. Co.

CLIPS, SPRING:
Electrad, Inc.
Scovill Mfg. Co.

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

COIL WINDING:
Acme Wire Co.
Dudlo Mfg. Co.
Herald Electric Co.
Rome Wire Co.

COILS, CHOKE:
Acme Wire Co.
Dudlo Mfg. Co.
Herald Electric Co.
Jefferson Electric Co.
Rome Wire Co.

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

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

COILS, MAGNET:
Acme Wire Co.
Dudlo Mfg. Co.
Herald Electric Co.
Rome Wire Co.

COILS, RETARD:
Hammarlund Mfg. Co.

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

COILS, TRANSFORMER:
Acme Wire Co.
Dudlo Mfg. Co.
Rome Wire Co.
Valley Appliances, Inc.

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

CONDENSERS, BY-PASS:
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Electrad, Inc.
Fast, John E. & Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

CONDENSERS, FILTER:
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E. & Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

CONDENSERS, FIXED:
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Electrad, Inc.
Electro-Motive Eng. Co.
Fast, John E., & Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

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

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

CONDENSERS TRANSMITTING:
Dubilier Condenser Mfg. Co.

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

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

CONNECTORS:
Cornish Wire Co.
Scovill Mfg. Co.

CONTROLS, CURRENT:
Central Radio Laboratories
DeJur-Amsco Corp.
Insuline Corp. of Amer.

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

CONTROLS, VOLUME:
Central Radio Laboratories
Clarostat Co.
Electrad, Inc.

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

CONVERTERS, ROTARY:
Electric Specialty Co.

COPPER:
Scovill Mfg. Co.

CORDS, EXTENSION:
Acme Wire Co.
Cornish Wire Co.

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

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

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Hammarlund Mfg. Co.
National Co., Inc.
Silver-Marshall, Inc.
United Scientific Laboratories

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Willor Mfg. Corp.

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Electric Specialty Co.

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Allied Engineering Institute

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Crowe Nameplate & Mfg. Co.
Scovill Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FILAMENTS:
Gilby Wire Co
Vacuum Tube Products Co.

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

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

GALVANOMETERS:
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.

GASES, RARE:
Palatine Industrial Co., Inc.

GEARS:
Chicago Stock Gear Wks.

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Electric Specialty Co.

GETTER MATERIAL:
Cohn, Sigmund.
Gilby Wire Co.

GRID LEAKS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
DeJur-Amsco Co.
Electrad, Inc.
Electro Motive Eng. Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lautz Mfg. Co.
Lynch, Arthur H., Inc.

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Cornish Wire Co.
Eby, H. H. Co.

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Scovill Mfg. Co.

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Amplion Co. of Amer.
Best Mfg. Co.
Temple, Inc.
Wright-DeCoster, Inc.

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Aero Products, Inc.
General Radio Co.
Silver-Marshall, Inc.

INSTRUMENTS, ELECTRICAL:
General Electric Co.
Jewell Elec. Inst. Co.

INSULATION LAMINATED
Formica Insulation Co.
General Electric Co.
National Vulcanized Fibre Co.
Synthane Corp.

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

INSULATION, VARNISHED:
Acme Wire Co.

IRON, MAGNETIC:
Reid, David, Jr.

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

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

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

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

KITS, TESTING:
General Radio Co.
Jewell Elec. Inst. Co

KITS, TRANSMITTING:
Aero Products, Inc.

LACQUERS:
Zapon Co., The

LABORATORIES, TESTING:
Electrical Testing Labs.

LABORATORIES, ENGINEERINGS
Allied Engineering Institute

LAMINATIONS:
Lamination Stamping Co.
Valley Appliances, Inc.
Willor Mfg. Co.

LEAD-INS:
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Insuline Corp. of Amer.

LOCK WASHERS:
Shakeproof Lock Washer Co

LUGS:
Scovill Mfg. Co.
Shakeproof Lock Washer Co.

MACHINES, SPECIAL
Willor Mfg. Corp.

MAGNESIUM:
Aluminum Co. of America.

MAGNETS:
Reid, David, Jr.
Valley Appliances, Inc.

METERS:
General Electric Co.
Jewell Elec. Inst. Co.
Weston Elec. Instr. Co.

MICROPHONES:
Amplion Co. of America
Universal Microphone Co.

MOLDING MATERIALS
Bakelite Corp.
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Synthane Corp.

MOTORS:
Electric Specialty Co.

MOTOR-GENERATORS:
Electric Specialty Co.

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

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

NICKEL:
Cohn, Sigmund

NUTS:
Shakeproof Lock Washer Co.

OHMMETERS:
General Radio Co.
Western Elec. Instru. Co.

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

OSCILLOSCOPE:
Burt, Dr. Rob't C.

PANELS, COMPOSITION:
Formica Insulation Co.
Insuline Corp. of Amer.
Synthane Corp.

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

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Dexter, C. H. & Sons, Inc.

PAPER, CONE SPEAKER:
Seymour Co.

PHONOGRAPH MOTORS:
(See Motors)

PHOTOELECTRIC CELLS:
(See Cells)

PICK-UPS, PHONOGRAPH:
Amplion Co. of Amer.
Jensen Co.
Wright DeCoster

PLATES, OUTLET:
Carter Radio Co.

PLATING:
Valley Appliances, Inc.

PLUGS:
Carter Radio Co.
General Radio Co.

POTENTIOMETERS:
Allen-Bradley Co.
Central Radio Laboratories
DeJur-Amsco Co.
Electrad, Inc.
General Radio Co.
United Scientific Laboratories

POWER UNITS, A-:
Elkon, Inc.
Jefferson Electric Co.
Kodel Radio Corp.

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

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

POWER UNITS, PARTS FOR:
Acme Wire Co.
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Jefferson Electric Co.
Kodel Radio Corp.
Lynch, Arthur H., Inc.
National Co., Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of Amer.

PRESSINGS:
Scovill Mfg. Co.
Valley Appliances, Inc.

PUNCHINGS:
Aluminum Co. of America
Scovill Mfg. Co.
Valley Appliances, Inc.

RECEIVERS, ELECTRIC:
United Scientific Laboratories.

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

REGULATORS, VOLTAGE:
Central Radio Laboratories
DeJur-Amsco Co.
Insuline Corp. of Amer.
Radiall Co.

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

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Allen-Bradley Co.
Central Radio Laboratories.
DeJur-Amsco Co.
Electrad, Inc.
Electro-Motive Co
Hardwick, Hindle Inc.
International Resistance Co.
Lautz Mfg. Co.
Lynch, Arthur H., Inc.

RESISTANCES, VARIABLE:
Allen-Bradley Co.
American Mechanical Labs.
Central Radio Laboratories.
Electrad, Inc.
Electro-Motive Co.
Hardwick, Hindle Inc.
International Resistance Co.
Lynch, Arthur H., Inc.

RHEOSTATS:
Allen-Bradley Co.
Central Radio Laboratories.
DeJur-Amsco Co.
Electrad, Inc.
Electro-Motive Co.
General Radio Co.
United Scientific Laboratories.

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

SEALING COMPOUNDS:
Candy & Co.

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

SHIELDS, TUBE:
Carter Radio Co

SHORT WAVE APPARATUS:
Cardwell, Allen D., Co.
General Radio Co.
Insuline Corp. of Amer.
Lynch, Arthur H., Inc.
Silver-Marshall, Inc.

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

SOLDER:
Chicago Solder Co.

SOUND CHAMBERS:
Amplion Corp. of Amer.
Jensen Radio Mfg. Co.
Rola Co., The
Wright-DeCoster, Inc.

SPAGHETTI:
(See Wire, Spaghetti).

SPEAKERS:
Amplion Corp. of Amer.
Best Mfg. Co.
Jensen Radio Mfg. Co.
Rola Co., The
Silver-Marshall, Inc.
Temple, Inc.
Transformer Co. of Amer.
Wright-DeCoster, Inc.

STAMPINGS, METAL:
Aluminum Co. of America
Scovill Mfg. Co.
Valley Appliances, Inc.

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

SPRAYING:
Valley Appliances, inc.

SUBPANELS:
Formica Ins. Co.
Insuline Corp. of Amer.
General Radio Co.
National Vulcanized Fibre Co.
Westinghouse Elec. & Mfg. Co.

SWITCHES:
Electrad, Inc.
Insuline Corp. of Amer.

TAPPERS
Eastern Tube and Tool Co.

TELEVISION PARTS:
Allen-Bradley Co.
Clarostat Co., Inc.
Insuline Corp. of Amer.
Lynch, Arthur H., Inc.

TESTERS, B-ELIMINATOR:
General Radio Co.
Jewell Electrical Inst. Co.

TESTERS, TUBE:
General Radio Co.
Jewell Elec. Inst. Co.

TESTING INSTRUMENTS:
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

TESTING KITS:
Jewell Elec. Inst. Co.

TESTING LABORATORIES:
Electrical Testing Labs.

TINFOIL:
Reynolds Metals Co., Inc.

TOOLS:
Eastern Tube and Tool Co.
Willor Mfg. Corp.

TRANSFORMERS, AUDIO:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Sangamo Elec. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.

TRANSFORMERS, B-POWER UNIT:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Sangamo Elec. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.

TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
Jefferson Electric Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.

TRANSFORMERS, OUTPUT:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
Sangamo Elec. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.

TRANSFORMERS, POWER:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.
Silver-Marshall, Inc.

TRANSFORMERS, STEP-DOWN:
Amplion Corp. of Amer.

TUBES, A.C.:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Supply Co.
Ceco Mfg. Co.
De Forest Radio Co.
Gold Seal Elec. Co., Inc.
Perryman Electric Co.

TUBES, RECTIFIER:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Supply Co.
Ceco Mfg. Co.
Gold Seal Elec. Co., Inc.
Perryman Electric Co.
Raytheon Mfg. Co.

TUBES, TELEVISION
See (*Cells, Photoelectric.*)

TUBES, VACUUM:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Supply Co.
Ceco Mfg. Co.
Gold Seal Elec. Co., Inc.
De Forest Radio Co.
Perryman Electric Co.
Raytheon Mfg. Co.

UNITS, SPEAKER:
Amplion Corp.
Best Mfg. Co.
Jensen Radio Mfg. Co.
Rola Co.
Silver-Marshall, Inc.
Temple, Inc.
Transformer Co. of Amer.
Wright DeCoster, Inc.

VOLTMETERS, A. C.:
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

VOLTMETERS, D. C.:
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

WASHERS:
Aluminum Co. of America
Scovill Mfg. Co.
Shakeproof Lock Washer Co.
Synthane Corp.

WAXES, IMPREGNATING:
Candy and Co.

WAXES, INSULATING:
Candy and Co.

WAXES, SEALING:
Candy and Co.

WIRE, ANTENNA:
Acme Wire Co.
Cornish Wire Co.
Dudlo Mfg. Corp.
National Vulcanized Fibre Co.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, BARE COPPER:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, COTTON COVERED:
Acme Wire Co.
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, ENAMELED COPPER:
Acme Wire Co.
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, FILAMENT:
Gilby Wire Co.
Vacuum Tube Products Co.

WIRE, HOOK-UP:
Acme Wire Co.
Cornish Wire Co.
Dudlo Mfg. Co.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, LITZENDRAHT:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, MOLYBDENUM:
Palatine Industrial Co., Inc.

WIRE, PIGTAIL:
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, RESISTANCE
Gilby Wire Co.

WIRE, SILK COVERED:
Acme Wire Co.
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

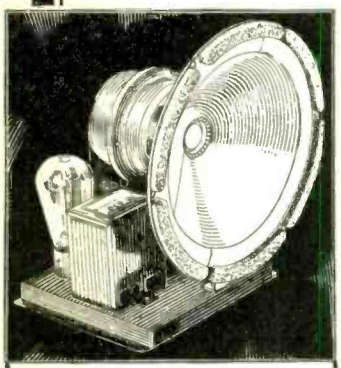
WIRE, SPAGHETTI:
Acme Wire Co.
Cornish Wire Co.
Rome Wire Co.

WIRE, TINNED COPPER:
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.
Rome Wire Co.

ZINC FOIL:
Reynolds Metals Co., Inc.

INDEX OF ADVERTISERS

S-M Reduced Prices Mark a New Era Of Confidence



YES—
Something Happened in Speakers When the S-M Appeared

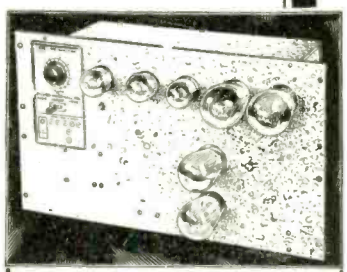
The new S-M speaker is fast becoming as famous an audio product as Silver-Marshall's immensely popular Clough-system audio transformers. So accurately designed is this new speaker unit that it eliminates all objectionable hum as well as "drummy" tones, and brings out both low and high pitches with a fidelity hitherto unobtainable. Two types: 851 for 110-volt d.c., $29.10 *net*. 850, for 50-60 cycle 105-120 volt a.c. (using 1—'80 tube), $35.10 *net*.

FOR a long time Silver-Marshall has felt that the "list price" method of pricing prevalent in the radio parts business was not conducive to public confidence, and that it should be discarded in favor of an honest and straightforward policy. The situation today is that fully 95% of all radio parts sold go to professional setbuilders, service men or experimenters with commercial connections, who buy at a fictitious "list" price less a discount, usually about 40%. As this discount is available thru, actually, millions of mail order and jobber catalogues, to any and every buyer, the list price is indeed fictitious, and serves no purpose except to destroy confidence.

For this reason Silver-Marshall, as America's largest parts manufacturer, believes that the time has come to "clean house" in the industry—alone if necessary. Therefore, effective April 15th, all S-M list prices were reduced 40%, so that the new *list* prices are now about the *net* prices available to all. No "dollars and cents" change is made—an outworn fiction only is discarded. Henceforth, the professional setbuilder and service man will never be embarrassed when, after selling a set, he is confronted by his customer with a net price catalog. There will be only one selling price on S-M apparatus—the new "net-list," at which consumers, setbuilders, and professional setbuilders can all buy.

This change is intended to, and will, protect service stations and professionals, who, buying parts at the same prices their customers obtain, have their profits insured by a fair and generous differential (to cover their labor) between the cost of parts to their customers and the cost of *factory wired* sets.

S-M believes that this frank and open policy will insure confidence among those it is designed to protect and help—the consumer, the setbuilder, the service station and jobbers, for it protects the professional from cut-price competition, consequently makes selling easier, and inspires confidence, not mistrust, in his customer.



S-M Power Amplifiers With Clough-System Tone

Operating entirely from the a.c. light socket, and using the famous S-M Clough-system audio transformers, these amplifiers give the very finest reproduction at auditorium-volume obtainable on the market today.

S-M 690, to reach 2000 or more people, has three stages (last two push-pull); supplies 6 to 12 or more dynamic speakers. Fading control on panel, and three-point switch for record—microphone—radio input selection. Uses 1—'27, 2—'26, 2—'50, and 2—'81 tubes. Price, less tubes, $147, net.

S-M 679, to reach 1000 or more people, has two stages; supplies 2 to 4 or more dynamic speakers. Binding posts for microphone—radio—record pickup input. Uses 1—'26, 1—'50, 2—'81 tubes. Price less tubes, $81, *net*.

S-M "PA" type amplifiers are available for all larger experimental installations at surprisingly reduced prices, as shown in our new April 15th catalog.

S-M's monthly publication, The RADIOBUILDER, is mighty interesting reading these days. Issue No. 12 (April, 1929) contained a forecast of band selector tuning as it will characterize 1930 receivers; also a timely discussion of the "one-stage" audio trend. If you are not getting the RADIOBUILDER, be sure to send the coupon—and send it anyway for the new S-M April catalog, containing new low S-M list prices, which are net.

Authorized S-M Service Stations have made money this season, and still bigger opportunities are opening up for them. Ask us about the Service Station appointment.

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....No 5. 720 Screen Grid Six Receiver
....No. 6. 740 "Coast-to-Coast" Screen Grid Four
....No. 7. 675ABC High-Voltage Power Supply and 676 Dynamic Speaker Amplifier
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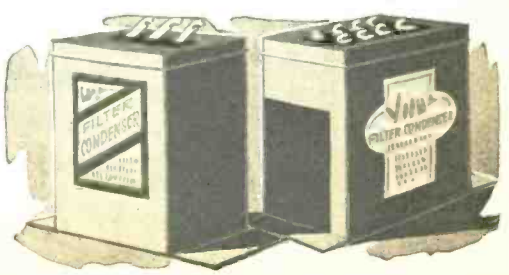

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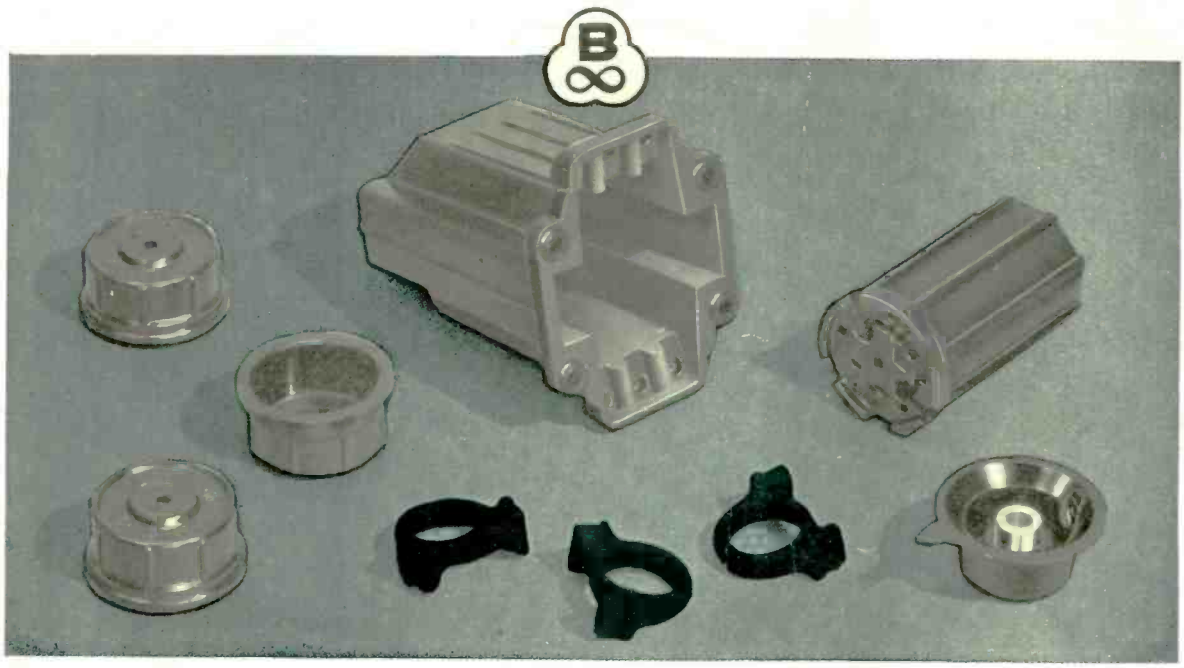

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