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Announcing
NEW LINE
FOR
1928-1929

New Amplion Microphone
from our English Laboratory.
A sensitive, accurate single button Microphone, free from carbon noises. Takes from 6 to 35 volts with corresponding sensitivity. For broadcasting, theatre or public address use.
Equal to the finest scientific instruments costing four times the price.

Amplion Giant Dynamic Unit
Largest Ever Made
for public address or theatre use.
Built for 30 watts undistorted power.
This Giant Amplion Dynamic (weight 20 lbs.) is capable of range and volume heretofore unattainable in any unit.

Amplion Cone Unit
No. C-104
Rugged in construction yet extremely sensitive.
No. C-104—Amplion Cone Unit represents an ideal combination of improvements that are the result of years of Amplion research work.
OUTSTANDING FEATURES
1. Intense magnetic field.
2. Laminated pole pieces.
3. Light moving parts.
4. Accurately balanced restoring spring.
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Ingenious in design and precision in manufacture make Amplion Cone Unit No. C-104 the recognized standard of quality.
List $10.00

Amplion Cone Chassis No. 108
featuring Amplion Cone Unit No. C-104 and Amplion Electric Filter No. 103. 9-inch Burtex Cone. List $20.00.
BOOKLET ON REQUEST

Amplion Cone Unit in Box
C-104
A correctly designed resonating chamber, ready for immediate installation in any cabinet. For other features see Cone Unit C-104 in opposite corner.

Information on unit and 10-16 ft. exponential horns sent on request. Demonstration at our Laboratory.

New Amplion Revelaphone
Converts any phonograph, old or new, into the most modern reproducing instrument. Special folder on request. List $15.00.

AMPLION CORPORATION OF AMERICA
133 W. 21st St., New York City
Telephone Chelsea 5257
THE word "Formica" is the mark of an exceptionally good and exceptionally uniform insulating material . . . phenol fibre at its best.

It means that your shipment comes from the largest plant in its industry, with a most varied equipment of modern fabricating machinery.

That plant is near the center of industry . . . with the shortest possible average haul and the quickest possible average delivery to manufacturers everywhere.

THE FORMICA INSULATION COMPANY
4654 Spring Grove Avenue
Cincinnati, Ohio
Editorial

Our enterprising Associations have attempted to collect facts and figures on production and sales of radio sets for the year 1928. Questionnaires were transmitted to all radio manufacturers, but unfortunately they did not take advantage of them in every case.

We are informed that rough calculations indicate production in excess of 3,000,000 sets this season and a radio market capable of absorbing only slightly more than 2,000,000 sets.

If these figures are approximately correct there will be an overproduction amounting to 33Â¼ per cent of the total. The percentage is rather high for an industry still too young to counteract effectively such a condition. Nevertheless, if over-confidence is to reign in the heart of every set manufacturer it seems only reasonable to allow the light of optimism to shine more intensely on the market, which is after all in a very plastic condition. There seems to be no other course.

Slightly under 2,000,000 sets were absorbed in 1927 in the face of a decided Renaissance. The chaotic conditions brought about by a complete reversal in the design of radio receivers have subsided and the slow process of rebuilding public confidence is nearly completed.

Irrespective of what you may personally think about competitive receivers the general public has reached that heavenly stage where they firmly believe that they "can't go wrong" on any radio set. This charming and profitable public confidence was granted the automobile industry a few years ago. Observe the result.

Statistics invariably disregard psychological conditions; how well the public made jackasses out of the best prognosticating minds of Wall Street in the recent stock market furore. Surely it is true that now the public has a mind to trust the radio industry, as it has learned to trust the automobile industry and under the circumstances it is against true analysis to conclude that the market will absorb more than the estimated 2,000,000 sets. We hardly think so.

If a dealer is overstocked with a certain product he usually puts on a special sales campaign, with effective local advertising, and gets rid of his overstock. It’s done every day in the week. Wouldn’t it be a good idea for all radio manufacturers to do something of the sort, before the skies cloud, to insure equilibrium at the end of the coming season?

Why not allow constructive optimism to create a market for 3,000,000 sets?

M. L. Muhleman, Editor.

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THE sweeping success and growth of the radio has had very few counterparts in our industrial development.

But in this industry a stage has been reached where the public demands a product that will function consistently and well. Radio manufacturers have come to realize that this means quality and perfection in every part, no matter how small. No wonder they turn to Scovill for assistance in their manufacturing problems. Scovill will fill orders for large quantities of parts such as condensers, condenser parts, metal stampings, screw machine parts, switches, etc. Escutcheons and similar parts can be stamped or etched to meet your requirements. A wide variety of butts and hinges, continuous hinges and machine screws are kept on hand.

Scovill means SERVICE to all who require parts or finished products of metal. Great factories equipped with the last word in laboratories, and modern machinery manned by skilled workmen, are at your disposal. 'Phone the nearest Scovill office.

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MANUFACTURING COMPANY - - Waterbury, Connecticut

NEW YORK - CHICAGO - BOSTON - SAN FRANCISCO
DETROIT - PHILADELPHIA - LOS ANGELES - ATLANTA
PROVIDENCE - CLEVELAND - CINCINNATI
IN EUROPE - THE HAGUE, HOLLAND

Member, Copper and Brass Research Association
Will not blister, split or crack

Tube bases and adapters, with their prongs and side pins, ordinarily present manufacturing problems of no little concern. . . . But not when the material used is Durez! There is a special grade of Durez for just such parts as these—a quick-fusing, quick-hardening plastic that will not blister in the basing machine nor deteriorate in the baking process. It is so tough it scarcely ever splits or cracks when side pins are inserted. It can be drilled and tapped with utmost ease. And to its splendid working qualities is added a rare combination of strength, high dielectric properties and lustrous finish.

Durez molds so easily, eliminates so many time-consuming operations, and so markedly reduces the number of rejections, that production costs are reduced to the minimum. And for ornamental radio parts the color combinations possible with Durez make it exceptionally desirable.

Why not investigate the possibilities of Durez toward your own requirements? Our laboratory and engineering staff will gladly study and test out—in confidence and without obligation—an any application of Durez in your particular line, whether old, new or contemplated product.

General Plastics, Incorporated, 74 Walek Road, North Tonawanda, N. Y. Also New York City, Chicago, San Francisco.

Write for this free booklet, “Do it with Durez”

It tells the whole story of the mechanical and electrical properties of Durez. About manufacturing processes; about colors and artistic combination color effects. Illustrated in full colors and showing many representative parts which can be made economically with Durez.
AUTUMN CONSTRUCTION REVIEW NUMBER

The September issue of RADIO ENGINEERING will contain technical reviews and advance data on the outstanding constructional developments of the year.

Receiving units, short wave receivers and transmitters, amplifiers, power supply units—all will be described in a non-biased, semi-technical manner.

While this material is of primary interest to service men, contractor-dealers, professional builders, experimenters and students, we believe that it will also be of value to engineers, technicians and laboratory men—

We are taking this occasion to thank the manufacturers, designers and consultants who are placing advance data and releases at our disposal.
EVERY FACILITY FOR EXPERT RESEARCH

THE Research and Development Laboratory of Automatic Electric Inc., manufacturers of Strowger Automatic condensers, is one of the most completely equipped of its kind in the world. The use of its many sensitive and complex instruments enables the development engineers to know exactly rather than to guess what occurs in any electrical circuit at any time.

The design and manufacture of satisfactory condensers for radio purposes is dependent upon such exact scientific knowledge. The reliability and efficiency which have become synonymous with the name Strowger in automatic telephony, are incorporated to a like extent in the line of filter, by pass and high voltage condensers now available to the radio trade. The company's research facilities are always at the disposal of any interested parties requiring condensers of special design for special purposes.

[See that your radio set is equipped
with Strowger Automatic condensers]

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1033 WEST VAN BUREN STREET
CHICAGO, U. S. A.
REPRESENTING

STROWGER AUTOMATIC CONDENSERS
MADE BY
Automatic Electric Inc.
CHICAGO, U.S.A.
Faithfully reproducing every note in the register — from the lowest to the highest — with all the accidentals. Any instrument — any volume.

COILS for the NEW Dynamic Speakers

Again Dudlo keeps pace with Radio development in meeting the demand for special coils required by this latest trend in speakers.

All wound to give that wonderful clarity of tone characteristic of Dynamic type units.

Transformer Coils—Field Coils—Choke Coils

Superior insulation of Dudlo wire, highly skilled operators on the winding machines, trained engineers who are coil specialists, tremendous stocks and facilities—all contribute to make this the industry's headquarters for these new coils.

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NEWARK, N. J. CHICAGO, ILL. THE GENERAL CABLE CORPORATION SAN FRANCISCO, CAL.

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NEWARK, N. J. CHICAGO, ILL. ST. LOUIS, MO.
The wide acceptance and increasing use of "L.M.C." RESISTORS by the electrical and radio industry is attributable directly to the following facts—

We are not merely assemblers.
We are Metallurgists, making our own Alloys.
We are Ceramists, making our own Enamels.
We are Electrical Engineers, prepared to work out any problems pertaining to controlling devices.
We know there are other good resistors on the market, but invite manufacturers to judge the "L.M.C."

Our engineering department is at your service.
Send in your problems.
In fairness to yourself, let us quote on your requirements and send you samples.

Lautz Manufacturing Company, Inc.
Electrical Alloy Products—Controlling Devices
245 N. J. R. R. Ave., Newark, N. J.
Four Advanced Developments

1. SHIELDING. Shielding r.f. coils is accepted as improving the modern receiving set. Three additional leading manufacturers have recently tested overall “gain” in their receivers using aluminum cans on the r.f. coils. Both as a shield and in its effect on the coil characteristics, aluminum was found to be eminently satisfactory.

   Aluminum possesses advantages of lightness, workability and permanent, pleasing appearance that are offered by no substitute metal. It does not require lacquer or other treatment.

   In diameters up to 2.75 inches our extrusion process of making deep cylindrical Aluminum cans is decidedly economical. In drawn Aluminum shells intermediate annealing is eliminated.

2. CONDENSER BLADES. Aluminum condenser blade sheet is now available with tolerance of +.001 inch, and with total variation within one sheet limited to .0005 inch. This company produces finished blades of gauge tolerance and flatness hitherto unattainable.

   Aluminum possesses ation of lightness, workability and permanent, pleasing appearance that are offered by no substitute metal. It does not require lacquer or other treatment.

   In diameters up to 2.75 inches our extrusion process of making deep cylindrical Aluminum cans is decidedly economical. In drawn Aluminum shells intermediate annealing is eliminated.

3. SOLDERING TO FIXED CONDENSERS. The Research Bureau of the Aluminum Company of America has developed a satisfactory method of soldering terminals to aluminum foil fixed condensers.

4. CASINGS. Aluminum casings for audio transformers and similar apparatus possess unique electrical advantages, lightness and excellent appearance. Paint or lacquer is unnecessary.

Radio Engineers are invited to send for data on all subjects involving the use of Aluminum in radio design.

ALUMINUM COMPANY OF AMERICA

ALUMINUM IN EVERY COMMERCIAL FORM
2468 Oliver Bldg. Pittsburgh, Pa.

ALUMINUM
The mark of Quality in Radio
SHAKEPROOF Locking Terminals Stay Locked!

Radio Manufacturing who use Shakeproof Locking Terminals know that their sets are going to stay “O.K.” in service, regardless of the strain and vibration in shipping or handling.

It is the exclusive multiple locking, twisted tooth construction that is responsible for this rapidly growing preference for Shakeproof—together with the fact that these locking terminals simplify assembly and make neater work.

A LOCK WASHER AND LUG TERMINAL IN ONE!
—eliminating one assembly

Test Shakeproof in your own assembly work and prove for yourself the saving possible in both time and material by using this modern locking terminal. Just mention the styles desired and your samples will reach you by return mail.

SHAKEPROOF'S “Two in One” Locking Terminals.....(Type 20)

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SHAKEPROOF LOCK WASHERS
In Sizes for Radio Work

Shakeproof Lock Washers in Types 11 and 12 are a standard assembly item with many of the leading Radio Manufacturers of the country, and provide the same multiple locking features found in the Type 20 Locking Terminals. Furnished in steel or phosphor bronze in sizes for No. 4, No. 6, No. 8 or No. 10 screws. (Also in steel in sizes up to 1¼ inches).

Be Sure to mail this Coupon
For your TEST SAMPLES

FREE SHOP TEST SAMPLES
(please specify stock numbers)

Shakeproof Lock Washer Company
2509 North Keeler Ave., Chicago, Illinois

Please send me samples of your Locking Terminals and Lock Washers as follows:

LOCKING TERMINALS

LOCK WASHERS
(sizes)

FIRM NAME

BY

CITY & STATE

TITLE

SHAKEPROOF
LOCK WASHER COMPANY
Division Illinois Tool Works
2509 North Keeler Avenue - Chicago
No Adjustments Needed on the New Air-Chrome Speaker

This year, more than ever before particular stress is being laid on the tone performance of the set. Reception from even the most perfect hook-up,—containing units of the highest possible quality,—will be far below the accepted standard unless your speaker is of the most advanced type.

Natural Reproduction on all Frequencies is Essential

Whether your set favors low, intermediate or high frequencies, the standard Air-Chrome Speaker will reproduce naturally, everything the audio amplifier gives it. It would, however, be ridiculous for us to claim that the standard Air Chrome will operate with the same efficiency on every set, but by building up the high or low frequencies, as the occasion demands, we are thus able to match the output of your set exactly.

The Custom-Built Air-Chrome

The Air-Chrome Speakers for set manufacturers are made in 3 standard sizes as shown above, 24" x 24", 18" x 23", 14" x 14". These will fit practically every cabinet.

Special sizes built if the quantities warrant.

Test the Air-Chrome in Your Own Laboratory

The only way to tell whether you want to use the Air-Chrome on your set is to try it. Try to make it chatter—demonstrate it against any speaker—if you find that some frequencies are over-emphasized, remember that we can give you exactly what you want. The tone of the Air-Chrome is unaffected by atmospheric changes. A sample speaker will be sent on memorandum to responsible set and cabinet manufacturers.

Send the coupon or write us today for complete information.

AIR-CHROME STUDIOS, INC.
162 Coit Street, Irvington, N. J.
SMOOTH Power for Dynamic Speakers from the AC Line with the ELKON DRY Rectifier

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

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

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

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

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

Radio Department
ELKON, Inc.
Division of
P. R. Mallory & Co., Inc.
PORT CHESTER, N.Y.

National Advertising Selling the DYNAMIC IDEA and ELKON RECTIFIERS

A consistent newspaper campaign has already started and will continue for 10 weeks in the following cities—New York, Chicago, Philadelphia, Boston, Pittsburgh, Detroit, Cleveland, St. Louis, Kansas City, Atlanta, Seattle, San Francisco, Los Angeles. And a special campaign in Radio, Radio News, Popular Radio and Radio Broadcast.

The copy will help sell the dynamic speaker idea and at the same time will tell the consumer to look for the Elkon name on the rectifier.

National Advertising which will help every dynamic speaker manufacturer using the Elkon Rectifier to get immediate consumer acceptance of his product.
Again Gordon triumphs with this induction electric phonograph motor

Truly a motor-marvel is this new achievement in the phonograph field.

It eliminates noise. Brushless, it is so quiet that a physician's stethoscope would be required to hear it running, once it is installed.

It obliterates interference. Of induction-type in accordance with the recommendations of the A.I.E.E., any pick up in radio or power amplifier is absolutely impossible.

Spring drive, it smoothly starts itself, attains full speed within two turns of the turntable. Then maintains that speed constantly and evenly regardless of the fluctuations in line voltage.

Designed to operate on 110 volt A.C., a transformer, supplied at slight additional cost, adapts it for 220 volt A.C.

Thus the Gordon Induction Electric Phonograph Motor solves every previous difficulty, adds many desired advantages, supplies the superb answer for the radio and phonograph needs.

It is a workmanship-like motor in every particular. The finest materials are used for every part no matter how inconsequential. Splendidly engineered.

Manufacturers are invited to write for prices on this motor of tomorrow.
Type II-I, Rectifying Unit is a full-wave rectifier, with an output of 1 to 3 amperes at 6 to 8 volts D.C. for trickle chargers and "A" power devices, etc. Made in two sizes:
B-12, List Price $4.50
B-16, List Price $5.00

Type D-24, B-L Rectifying Unit is a recent addition to the B-L line. It is a full-wave rectifier, having an output of from 1 to 2 amperes at 8 to 10 volts D.C. This unit when used with proper transformer, with or without filter, supplies direct current to excite magnetic field coils of Dynamic Speakers. List Price $6.00

Type C-110, B-L Rectifying Unit is a single-wave rectifier, used for replacing 2½ amperes, 6-volt charger bulbs. It has Edison socket screw base with a pin at the top for Fahnstock clip connector or finished with double-contact screw base.
Type C-110, List Price $4.00
Type C-210, List Price $4.00

**B-L Rectifiers**

For Dynamic Speakers and Power Devices

B-L Rectifiers for Dynamic Speakers and Power Devices are tried and proved. They are unequalled in efficiency and performance and have been adopted as standard equipment by many of the largest manufacturers. The B-L Rectifier, D-24, has met with exceptional success. If you are seeking a rectifying device to supply smooth, uniform power to Dynamic Speaker field coils, or for power devices, write us, giving specifications, and we will furnish you with sample unit, prices, etc.

B-L Rectifying Units are Bone Dry—Noiseless—Durable—Compact. An interesting booklet, explaining their characteristics and some of the many applications, is yours for the asking.

**The Benwood-Linze Co. . . St. Louis, U. S. A.**

**Bone Dry**

**Durable**

**B-L Rectifiers**

**Noiseless**

**Compact**
On Land, Sea, or in the Air
DURHAMS are Supreme! — wherever the perfect operation of radio apparatus is of paramount commercial and governmental importance — in radio transmitting or receiving apparatus — in power amplification units — in the sensitive resistance-coupled amplifiers of the photo-electric cell circuit in Television apparatus — there you will find that experienced radio engineers use and endorse DURHAM Resistors, Powerohms and Grid Suppressors! Why? Because years of experiment have proved the indisputable value of the DURHAM Metallized principle. Because these resistances are calibrated accurately according to their stated ratings. Because they are available for every practical resistance purpose from 250 ohms to 100 Megohms and in power ratings. We will be glad to send you descriptive literature explaining the entire Durham line.

DURHAM
METALLIZED
RESISTORS & POWEROHMS
Radio Engineering, August, 1928

Micarta

Radio Parts

Share in modern quality reception

The quality of the reception of modern radio receivers largely depends upon the quality of the component parts of the receiving sets. For the best reception, terminal boards for the power pack, for the power pack cable, and for the speaker, as well as the terminal strips, mounting plates, sub-panels, tube panels, and other parts must be made of a material that possesses permanent insulating qualities and life-long immunity to deterioration from heat and moisture. Micarta fulfills the requirements of an excellent radio material. It is easily punched and fabricated into any design. The punch or the saw never chip it. Because of these features and its enduring insulating qualities, Micarta always helps to produce quality reception. Micarta radio parts—in any quantity—can be obtained from—

Micarta Fabricators, Inc.
309 Canal St.
New York, N. Y.

Westinghouse Electric & Manufacturing Company
East Pittsburgh
Pennsylvania

Sells Offices in All Principal Cities of the United States and Foreign Countries
Manufacturing Procedure

History and Fundamentals of an Unusual Form of Production Structure

By Howard Rudliff

Production is a prime song. Big Business composed it shortly after the World War and distributed free copies to the Press. All the little horses picked up the ditty and spread it far and wide . . . and the public eventually danced to it. Production is a patriotic air. It saved Industry from crashing against the rocks of failure at a time when the public was practising the economical measures introduced during the war. Money was not moving.

Production is unfortunately based on a number of variables. Its structure is part factory practice, part merchandising, part advertising and part research. Eliminate but one of these major factors and the structure collapses.

Production structures differ. Since production depends a great deal on the character of the factory, the character evolving from the company executives and the nature of the product, it is obvious that an entirely different form of factory procedure will maintain, say, The National Biscuit Co. and the Remington Arms Co. If the characteristic conditions are not recognized production resolves itself into a stupendous waste.

Production Fundamentals

There are nevertheless certain fundamentals which do not alter and are practiced in all modern factories. The basic fundamental is labor-saving machinery. Simplified operation is a close relative. Simplified design of the product is also a fundamental and a decidedly important one.

Now, to the general observer in any factory it is quite possible that no great difference in procedure would be noticed. The machines are going, the employees are all carrying out specific operations. The observer cannot verify the technique because of the large number of commonplace surface operations. nor recognize the undercurrent of supervision, because of the confusion created by the myriad noises. Every worker appears to contribute only to something that is very big and broad and very obvious. Detailed and specific operations are lost sight of. Likewise, a factory executive may easily lose track of small but important details, because of the overbearing influence of the general sweep of fundamentals.

The details spring from the fundamentals and it is possible to cite many cases in the radio field where manufacturing plants found, only after a period of six or more months, that the manufacturing cost of the finished product exceeded the manufacturer's price.

Factory Procedure

Most of us associate production with a very highly standardized product with no outstanding are variable in design, such as a "B" eliminator, a tooth brush, an electric iron or an A.C. receiver. Yet large scale production exists in specific fields where general design cannot be followed. An outstanding example is the manufacture of electrical measuring or testing instruments. The demands are so wide that in the radio field alone several hundred types and ranges of meters are required for transmitting and receiving sets aside from the many special instruments needed for testing radio products during manufacture, for checking broadcast receivers and for radio laboratory and research work. At the same time every instrument must conform to definite precision requirements, which makes the matter of production on a large scale appear prohibitive.

It is just such problems as this that are apt to arise in any manufacturing field and if the problems are not solved to the satisfaction of standardized procedure quantity production is out of the question.

Surmounting Production Problems

It may prove of interest to outline the general production structure or manufacturing procedure in a large plant given over exclusively to the making of electrical measuring or testing instruments such as voltmeters, ammeters, milliammeters, microammeters, frequency meters, tachometers, etc. each model differing in many respects from the others. Likewise most of the instruments are made in many different sizes and ranges to meet the numerous industrial requirements.

This immediately lends confusion to the picture, yet manufacturing procedure and general design have been so standardized and simplified that large scale production is possible. The laurels go to the research and production engineers who developed the original structure.

Standardized Precision

Precision is the mainstay of every good testing instrument. Accuracy

Radio Engineering, August, 1928

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Views of the immense tool crib, or tool file, in the plant of a testing instrument manufacturer.

(Courtesy of Weston Electrical Instrument Corp.)
THE ESSENTIALS OF PRODUCTION

(1) WELL PLOTTED MARKET with uniformity maintained by constructive merchandising plans, well distributed sales channels and backed by advertising.

(2) RESEARCH directed towards advertising and manufacturing procedure so that each is a reflection of the other.

(3) CENTRALIZED ENGINEERING operating as a plant nucleus for the purpose of developing standardized factory procedure in accord with the characteristic nature of the engineered product.

(4) STANDARDIZATION of engineering design, plant operations, and materials.

(5) INSPECTION based on the result of research, centralized engineering and standardization as applied to the general manufacturing procedure.

A view of the General Inspection Department where parts are measured by reference to definite standards reduced to a series of "instruction cards." (Courtesy of Western Electric Instrument Corp.)

and continued dependable performance is the natural sequence of properly balanced design and precise workmanship. These qualities are essential in instruments that are expected to indicate faithfully at all times the actual conditions of the circuits under test. Quality instruments eliminate guess work and instill complete confidence in the results of test data.

Instrument parts such as pivots, pivot bases, moving elements, instrument springs, pointers and all other parts that make up a completely assembled instrument, are made with the same degree of refinement of design and precise workmanship and held to the same close tolerances whether they go into a low-priced radio meter or into the highest grade laboratory standard instrument. It is this procedure that makes it possible to manufacture such a widely divergent line of uniformly high grade meters on a quantity production basis.

The making of these small parts done by hand the cost of such standardized precision would be prohibitive and the system ridiculous. But the parts are turned out in quantity from delicate and intricate machines which take years to develop. Many of these parts are so small that they are checked for defects under a microscope.

Standardized Operations

In order to satisfy further the production structure, all operations are completely standardized. This has allowed wiring of a special radio test set. Each wire which connects one component to another is cut to the proper length and bent to the proper shape and the wiring plan is so worked out that no two connecting wires are interchangeable. The operator never varies the wiring procedure. She is provided with as many boxes as there are connections and each box contains only one shape of wire. She takes a wire out of box No. 1 and solders it in place then a wire out of box No. 2, etc., up to and including the last box when the test set is completely wired.

To assist further the maintenance of a smooth operating production structure, each department is supervised by a production engineer who checks the output of each operator, forms the schedules and cooperates with the general manufacturing department in working out production problems. Every operation is "blue printed," so to speak, and never departs from the original plan.

To insure accuracy and to reduce the time factor on each operation a great deal of thought has been given to the comfort of the operators. Fatigue has been eliminated by proper seating facilities, good light and ventilation. Since so many of the operations are delicate and the parts very small, special magnifying glasses are provided for assembly or manufacturing operations, which would cause a strain on the eyes. The girls who wind the small moving coils employ magnifying glasses as well, so that they can readily see that each turn of the wire falls in the proper place.

Standardized Inspection

In a factory where every operative has been appointed an inspector of the results of his individual skill and where many hundreds are cooperative-ly engaged in raising the general standard to the highest plane of perfection, it is readily seen that the General Inspection Department would be vested with unusual functions.

There is a vast difference in results between that kind of inspection, which makes much of стандартизацион craftsmen, and a system of espionage designed to uncover defects resulting from faulty production methods and indifferent or inexperienced workmen.

The Inspection Department has been molded into a highly organized Clearing House through which materials, finished parts and craftsmanship are measured by reference to definite and precise standards before they are adjudged satisfactory.

These standards are reduced to "inspection cards"—one for every part drawing material specification or operation.

Ninety per cent of all inspection work is conducted in the Clearing House under conditions where fine gauges, microscopical examinations and properly constructed laboratory equipment give the best inspection results. The remaining inspection work, usually of delicate character on parts which should not be needlessly handled, is accomplished in the departments where the parts are made. As an example of the number of inspections performed,
a single instrument, a well known model of wattmeter, receives approximately 240 individual parts and assembly inspections.

The magnitude of the inspection work and its delicacy can be gained from an example of the extreme accuracy required in making the small pivot base: First, it is cut from stock, formed to rough diameter and then turned down to true diameter and centered. Next, the hole is made, with a .0153 in. drill, the flats milled and the pivot base threaded .0030 in. diam., 200 threads to the inch. The pointers for the measuring instruments are threaded at the ends to take the small balance nuts. There are 500 threads to the inch on the pointers and the holes in the balance nuts are .0155 in. diameter. Some of the instrument springs are only 1/2 of a thousandth of an inch in thickness and in inspection are held to a tolerance of 1/100,000 of an inch.

**Standardized Reconditioning**

A permanent technical record is kept of instruments leaving the factory. By reference to this record file an instrument can be readily duplicated. Also, when required, additional accessories such as shunts, resistors, multipliers, etc., usually can be provided without the necessity of returning the instrument. For example, a record includes the exact value of the shunt resistance in a specific instrument, i.e., that value of resistance determined by test to provide the proper meter reading; therefore should the resistance be damaged a new one of the same value can be supplied.

The reconditioning of instruments is handled by an exclusive repair department self-functioning, a factory within a factory. This individual department is also highly standardized in inspection procedure and reassembly work. This department draws on the stock of standard parts maintained by the factory and if the instrument to be reconditioned is one of a very old model the department draws on the immense tool crib for the tool to make the particular part. The tool crib is a huge file of every tool made for turning out instrument parts. It is, therefore, possible to make, on order, out-of-date models to meet specific requirements, without disrupting production. The tool crib is, obviously, one of the greatest assets of the company.

**Conclusion**

We believe that the outstanding note in the production structure outlined is the engineering facilities. Research has done more to develop production than any other one item. With a corps headed by a chief engineer and including research engineers, department engineers, production engineers and supervisors each step of the way has been virtually "blue printed." Concentrated intelligence directing every move of the operatives appears to be the most logical course. To this end the development of labor saving machinery, which after all is the backbone of a production structure, should rest partially, if not wholly, in the hands of the engineers, who best understand the problems of electrical and mechanical design and the intimate problems of the factory.
Research Methods

The Importance of Research in Relation to Large Scale Production and Commercial Applications

By Frank B. Jewett

Imagine that a large part of the population who give any thought to it think of research in the physical sciences as something new among man's activities. As a matter of fact, it is not at all a new thing. Research work in its broadest sense has been going on for centuries. Every engineering problem that was ever undertaken, which required the planning of some new thing, involved some form of research work. There has come about within the last two hundred years a realization that to get authentic and lasting results one has to perform experiments based on a well-considered plan, worked out from the experience of the past, and so controlled that data can be capable of definite interpretation. One of the hardest things we research people and engineers have to contend with is the temptation to draw conclusions from complex experiments or experience in terms of only a part of the factors of the problem. Even in our modern institutions and industrial research laboratories, equipped with the best means and men available, we find this tendency continually cropping up. Results are stated with a complete knowledge of only part of the factors, and sooner or later we realize that our conclusions were unjustified because of neglected factors which have played an appreciable part in the results.

Variables

Engineers and scientific people alike do this sort of thing, not consciously but unconsciously. To get a result that means anything, in most cases one must so control his investigation that but one factor is variable at a time. If you have two, it is very difficult to interpret your result as between the two factors. If you have three or more, it is practically impossible. Yet this is attempted every day, usually with the result that progress, when it comes at all, comes from doing a thing over and over again, until by statistical methods we arrive at some sort of an approximation to the truth.

There is another thing which we are very prone to do and that is to try out initial experiments on too large a scale. Suppose you have an idea and perform an experiment on a large scale and the result does not come out as you thought it was going to; you do not know why it didn't, you do not know whether your assumption was wrong or whether failure was due to unrecognized and uncontrolled factors. Having decided what one wants to do and having made an assumption as to the correct method of doing it, he must try it out on what is essentially a laboratory scale. It has to be tried out under conditions that, so far as is humanly possible, are precisely controlled to provide only a single variable factor in a given experiment. If at the conclusion of that experiment we obtain results which are in line with our expectations, we may fairly assume that the thing we started to do can be done, at least experimentally. We may want to repeat the experiment once or twice under other conditions to make sure of our conclusions. We are then ready to start the next part of the experiment, namely to see if we can transfer this laboratory process into a large scale operation.

Production Scale

I have seen experiments started on the assumption—and I am afraid I have been guilty myself at times—that certain operations can be launched at once on essentially a commercial or large scale engineering basis because they have worked on a small scale. If you can do a thing in a test tube in a laboratory under controlled conditions, you may be able to do it on a large scale, but not necessarily. In order to bridge the gap between small scale and large scale experiments, our method in the telephone industry has for years followed these lines. Let us assume that the problem in hand has for its end the design of a complicated piece of apparatus. The first experiments are primarily to check up the necessary fundamental physical or chemical characteristics or reactions. We have succeeded, let us assume, in checking our fundamentals. The next step in the process is to make a piece of apparatus which as nearly as possible conforms to the ideal requirements. It is the best we can do regardless of cost. We use the best machinery and the best men and the best materials we can to make this thing an ideal piece of apparatus. Any results we obtain with it are a test, not of the fundamental principles since these have already been checked, but are a test of our ability, with the tools at present at our disposal, to make a physical thing giving certain desired results. When this carefully made sample is tested under actual operating conditions, it is a test to one chance that certain difficulties appear which our earlier and more fundamental tests did not disclose. It means that we must make modifications if we are going to use our fundamental principles commercially.

Commercial Adaptability

Finally, let us suppose we have an operating piece of apparatus made under this ideal condition but which is not at all commercial. For example, this particular piece of apparatus may have cost a thousand times what we
know we can afford to pay for a large number of these pieces of apparatus used commercially. We have shown, however, that the thing can be done.

The next step in the process is to build what we call tool-made models. These models conform as nearly as possible to the ideal thing but are made under commercial processes applicable to large scale production and with ultimate cost considered. Tests on tool-made models are not tests of the fundamental thing nor of our ability to make one thing to conform to the ideal, but are tests of our ability to make in a physical, economical fashion a large number of things capable of producing a desired result.

It is only after we have gone through all three of these steps and have tried the tool-made models under service conditions and found them satisfactory that we feel safe in going into production on a large scale and using the apparatus as a part of our standard equipment.

This general process must be gone through with in one way or another in practically every line of industry where science is applied for practical purposes.

Constituents

Now another thing. We have learned, particularly in the past thirty or forty years, that it is not always safe to neglect very small admixtures of foreign substances. This is particularly true with regard to things chemical. There was a time not so long ago when a thousandth of a gram or a hundredth of a gram of a foreign body in a chemical mixture was looked upon merely as an incidental inclusion which could have no appreciable effect on the characteristics of the substance. We have learned in recent years that this is an absolutely erroneous idea.

I might cite a situation which developed in an undertaking of the Engineering Division of the National Research Council some years ago. In connection with the problem of marine borers, teredos and the like, a study was made of substitutes for wooden structures, particularly concrete. In the course of the work, industry all over the United States and Canada and abroad became involved, and it developed from the extensive data gathered that concrete, good concrete or what people thought was good concrete, when immersed in sea water was a very variable thing. The records show that some concrete structures have stood up for an almost indefinite time, with very little deterioration. Yet right alongside of them other concrete structures, presumably made in exactly the same way, had gone to pieces in a very short time.

Investigation pointed to the conclusion that this variation was not so much due to variations in the mechanical processes of mixing the concrete as it was due to chance variation of composition in the cement, sand and stone employed. Although different concretes might be nearly alike chemically, they probably reacted slightly differently when submerged in sea water, and similarly with the other ingredients. The trouble, where trouble occurred, really went back to the raw materials used in making the concrete and their chemical composition. It seemed clear that no satisfactory answer to the problem of concrete structures in sea water could be hoped for until light was thrown on the constituents of the materials.

I am citing these instances to emphasize that experience teaches us to use extreme caution. Good engineering practice must be based on conclusions drawn from controlled experiments where one variable at a time is involved, and frequently the variables are incredible present only in greatly attenuated amount.

Picture Scanning With Natural Light

**Development of Bell Telephone Laboratories Brings Television Into The Open, Through Use of Telescope Lens**

ENGINEERS of the Bell Telephone Laboratories who over a year ago gave the first demonstration of television disclosed some of the further progress which they have made during their continued researches by demonstrating a new transmitting device which is capable of putting upon the television circuit outdoor scenes. On the roof of the Laboratories actors boxed and danced, swinging baseball bats and tennis rackets to appear in brightly illuminated pictures in one of the Laboratories on the eighth floor. The present apparatus differs radically from that of the first demonstration when the scene to be transmitted was illuminated by a powerful artificial light and only the actor’s head and shoulders appeared in transmission. With the improved apparatus the scene was illuminated by ordinary sunlight and covered the area occupied by two men engaged in a friendly boxing match.

In the first form of apparatus demonstrated in April of last year, the scene was illuminated by a rapidly oscillating beam from a powerful arc light and that limited the scene to be transmitted to a very small area. The new development frees television from one of its most serious limitations.

**Large Lens Employed**

The scene or event to be transmitted is reduced to the form of an image by a large lens, this image being scanned by a rapidly rotating disc similar to that previously employed but much larger. The lens serves somewhat the same purpose in the television apparatus as the large lens of an astronomical telescope, and, like the latter, it should be large to gather as much light as possible.

The experiments show that moving persons and objects can be successfully scanned although at a considerable distance from the lens and therefore in such a position that the focus of the lens does not require changing from moment to moment. Light passing through the lens and scanning disc is caused to actuate a light responsive device of extreme sensitiveness and generate an electric current which, after amplification may be transmitted either by wire or radio.

The developments in television which were demonstrated were perfected by Dr. Frank Gray of the Laboratories working in collaboration with Dr. Herbert E. Ives.
The Design of the Tuned Double-Impedance Amplifier

Covering the Technical Elements of the System and the Outstanding Advantages

By Edward E. Hiler*

The function of the tuned double-impedance type audio-amplifying system is described in its application. The title of "tuned" double-impedance designates three things: first, that impedances are utilized in the coupling unit; second, that two such impedances are employed and third, that the system can be tuned or made resonant to a predetermined frequency. The basis for the tuning is founded upon the demand for a presonance amplification and fidelity of reproduction, which makes necessary the presence of all audio frequencies transmitted during speech and musical renditions, has been the public demand ever since the inception of commercial radio broadcasting.

With the development of efficient loud speakers and amplifying tubes possessing fair values of output impedance, the lack of low frequency response in the audio amplifier has developed into a widely discussed subject. General improvements upon units designed for radio receiver installations have extended the operating audio bands, but the reproduction of frequencies between 30 and 80 cycles is still shrouded with difficulty. Experiments have shown that speakers will respond to the low frequencies providing sufficient energy is fed into the speaker driving mechanism. Poor audio amplification, that is, poor low frequency response, fails to provide required power. That power requirements of loud speakers are not uniform over the band of audio frequencies is beyond the subject at this time, since experiments have conclusively demonstrated that audio amplifiers of proper design can compensate for the loud speaker deficiency on the low frequencies. The attainment of the above is the function of the tuned double-impedance amplifier. However, it is not its only salient feature.

Magnetic Isolation and Series Resonance

In direct contrast to conventional audio-amplifying systems, the tuned double-impedance arrangement utilizes two phenomena foreign to other systems, namely magnetic isolation, which is equivalent to minimum leakage reactance, and series resonance. These terms applied to electrical practice are not new, but when applied to radio receiver audio amplifiers introduce a new era, because of the operating characteristics they make available. "Magnetic isolation" is applied to the electrical design of the unit, consisting as it does of two windings mounted upon the outer leg of a figure-8 laminated core, one winding on each leg as shown in Fig. 1. P and B are the two terminals for the plate winding and G and F are the two terminals for the grid winding. The effect of this mechanical arrangement practically isolates, magnetically, the two windings. A fixed capacity which serves a double purpose is included in the same case.

Magnetic isolation of the plate and grid windings by means of the figure 8 core, is one of the most important factors in the design of the tuned double-impedance unit. In contradistinction with other forms of audio-frequency coupling, such as the conventional audio-frequency transformer, the leakage reactance between the plate and grid windings in the tuned double-impedance unit is tremendously great, being millions of ohms, but its action is completely nullified by the coupling capacity. The action of this capacity, whose reactance with the leakage reactance is very small, is practically to short-circuit the leakage reactance and to nullify its action as a coupling medium. As a result, the only coupling between the plate and grid windings is through the coupling capacity. Empirical determinations of the resonance peak in the tuned double-impedance unit has shown the plate winding as negligible; that is, the coupling between the plate and grid winding through the core is so little that the plate coil has no effect upon the frequency setting at resonance. In fact, the magnetic isolation in the tuned double-impedance coupler, is equivalent to the use of two individual coils housed in individual containers placed at right angles to each other for zero coupling. The elimination of the effect of leakage reactance provides beneficial operating characteristics unavailable with systems or coupling units possessed of leakage reactance.

Elimination of Leakage Reactance

The presence of leakage reactance in an audio coupling unit is detrimental
for several reasons. In the first place, it causes a change in the operating characteristic of the coupling unit, such as a conventional transformer, when the transformer is under load. A thorough analysis of the action of leakage reactance and its effects upon audio-frequency transformers was made by Diamond & Webb, September, 1927. Proceedings of the Institute of Radio Engineers. They show how the resonance peak on the upper audio register shifts from 8000 to 4000 cycles, with load, occasioned by the action of the leakage reactance variation. By virtue of the leakage reactance present and the reflection from the secondary to the primary, full low-frequency amplification is not obtained because of the momentary reduction of the plate load inductance. The presence of leakage reactance makes imperative the total elimination of grid current, since current flow through the secondary winding causes an increase in leakage reactance with highly detrimental results.

Elimination of leakage reactance in the tuned double-impedance coupler by the arrangement mentioned eliminates all of the above faults. The frequency characteristic curve of the unit remains constant under load and elimination of grid current in the grid coil is unnecessary as far as its effect upon the coupling unit is concerned. Experiments have shown satisfactory operation of the tuned double-impedance unit with 100 microamperes of grid current. This figure is not quoted as a recommended value, but simply as an example of the effect of magnetic isolation of the two windings upon the frequency characteristic of the unit. The frequency setting of the peak in the lower audio register band remains constant under load. Its actual setting and amplitude are within the control of the operator and the system is possessed of utmost versatility. By selecting the proper electrical constants, this low-frequency peak can be set at any value within the audio band or at a value below the normal audio band, say 15 cycles, in which case the frequency characteristic curve of the unit will be absolutely flat between 30 and 8000 cycles and practically flat to a value considerably above the upper audio limit. A schematic layout of a single stage is shown in Fig. 2.

The voltage drop across the inductance is equal to \( 2 \pi FLI \), since the ratio between the reactance resistance of \( L \) is very high. Substituting our values we have

\[
0.28 \times 40 \times 290 \times 0.01 = 502.4 \text{ volts.}
\]

It is evident in this illustration of series resonance that the drop across the inductance is equal to approximately 50 times the applied voltage. Here we have used a ratio of 50 to 1 between reactance and resistance. With a lower value of resistance, the voltage drop would be greater, consequently the resonant peak would be steeper. The voltage step-up in the tuned double-impedance system is identical to the series resonance illustration. Regeneration in the conventional audio amplifier circuit tends to increase the phase angle of the coupling unit circuit. With zero resistance, the voltage step-up in the series resonant circuit would be infinite. This state, however, is never obtained because resistance is always present in the system. Previous articles mention the use of a variable grid resistance in the "C" minus load of the grid choke for the purpose of controlling the height of the resonant peak in circuits where regeneration is very pronounced. The effect of this resistance can be gleamed by a study of the above formulas.

The above illustration of a series resonant circuit should explain the presence of the peak present in the tuned double-impedance system, since the arrangements in Figs. 3 and 4 are practically identical. We have assumed an ideal state for purpose of illustration. The peak in the system is not limited to 50 cycles as shown in Fig. 6 but can be by proper selection of the coupling capacity, assuming a definite value of grid inductance be located within or below the normal audio-frequency band.

**Series Resonance Phenomenon**

The peak on the lower audio frequency is the result of the series resonance phenomenon. The electrical circuit for purpose of analysis, is shown in Fig. 4. As is evident, condenser \( C \) and inductance \( Lg \) with respect to the voltage source \( E \) constitutes a series circuit. For purpose of explanation, we can consider a simple series circuit—shown in Fig. 3—as being equivalent with respect to the applied voltage, to the circuit shown in Fig. 4. Since the effect of \( Lp \) or the plate choke is negligible, it is a well known fact that the voltage drop across the inductance of a series circuit consisting of a capacity and an inductance, when resonant to an applied frequency, may be 100 times as great as the applied voltage. Since the \( A \) voltage drop across the grid choke in the tuned double-impedance unit is utilized as the signal voltage for the succeeding tube grid, we can readily understand the voltage step-up effect at the resonant frequency and the peak in the amplification curve. A sample curve of a single stage unit is shown in Fig. 7. Here we show the frequency characteristic of a single unit resonated at 50 cycles. Note the peak due to the voltage step-up at 50 cycles and the flat response on the higher frequencies. An example of the voltage step-up in a series circuit to illustrate the action of series resonance in the tuned double-impedance system is as follows:

Suppose we take a simple series circuit such as that shown in Fig. 3. \( f \) is 40 cycles. \( E \) is 50 volts. \( L \) is 200 henrys and \( C \) is a capacity whose reactance is equal to that of the inductance \( L \) at 40 cycles. The effective resistance \( R \) of the coil is 1,900 ohms. The current \( I \) in the circuit is equal to

\[
I = \frac{E}{\sqrt{R^2 + \left(\frac{6.28 \times F \times L}{6.28 \times F \times C}\right)^2}}
\]

\[
I = \frac{1}{\sqrt{(1,000)^2 + (50.240 - 50.240)^2}}
\]

\[
I = .01 \text{ of an ampere}
\]
5. Here, too, we are realizing an ideal state, without resistance. E is the input voltage available from the tube and applied across the circuit. Rp is the tube output resistance. The choke adjacent to Ze is the plate choke and the choke adjacent to Gz is the grid choke. The condenser shown is the coupling capacity. Eg is the voltage available across the grid choke for application to the succeeding tube grid. The available grid voltage Eg is governed by the impedance relation of the various circuits, or

\[ Eg = \frac{Ze \times Zg}{Zt} \]

Zg is the impedance of the grid choke, Zr is the impedance of the circuit consisting of the grid choke and the coupling condenser, Ze is the impedance of the circuit consisting of the grid choke and coupling capacity and the plate choke. Zt is the total impedance including rp. At any value approximating resonance, Zg can be classified as being equal to "e", a very small quantity approaching 0 as a limit at resonance. Ze is equal to 2 π fl. At a frequency approximating resonance, Ze is equal to "e", since the circuit consisting of Zr is a practical short across the plate choke. Zt being equal to Ze + Rp it is therefore equal plus rp. Substituting in the formula for Eg we obtain

\[ Eg = \frac{e}{e + \frac{2 \pi fl}{rp}} \]

where l is the inductance of the grid choke.

Cancelling the small quantity e in the numerator and the denominator, we find that

\[ Eg = \frac{2 \pi fl}{e + \frac{2 \pi fl}{rp}} \]

therefore \[ Eg = \frac{2 \pi fl \times rp}{e + \frac{2 \pi fl}{rp}} \] since e approaches 0 at resonance.

Suppose we substitute in the above formula the approximate values used in the average tuned double-impedance stage of amplification. Let us assume that we are using a tuned double-impedance unit resonant to 50 cycles in conjunction with a 227 A.C. tube. The grid impedance is rated at 200 henrys and the coupling capacity is of .051 mfd. (approximate). Consider the input voltage e as 1 volt. Substituting our values we obtain.

\[ Eg = \frac{314 \times 200}{8000} = 7.85 \]

Hence we see that the amplification at resonance or the voltage step-up at resonance within the tuned double-impedance unit is equal to 7.85 for the conditions cited. Due to the characteristic of the resonance curve, a voltage step-up is obtained for a certain band of frequencies each side of the resonant frequency. Beyond a certain band above the resonant frequency the curve flattens out and is constant at a step-up ratio equal to unity.

**INTRODUCING THE NEW RADIO KITS**

The new Radio Kits for the 1928-29 radio season will be introduced for the first time at the Fifth Annual Radio World’s Fair, in New York City, opening September 17th.

**Radio Engineering** has arranged to publish in the September issue concise reviews of the outstanding circuits. These reviews will cover the latest developments in custom-built receivers, high gain audio amplifiers, power amplifiers, band selector circuits and screen-grid radio and audio frequency amplifiers.

Each circuit review will include a complete list of parts and the names of the manufacturers for your benefit.

There are some decidedly interesting developments to be released and we are sure that you will find the coming issue of **Radio Engineering** particularly valuable.

— Editor.

**Fig. 7**

Indicating the effect of the coupling capacity on the resonant frequency of a single stage tuned double impedance amplifier.

The development of the "R" battery eliminator and the A.C. tube have been great factors in increasing the popularity of this system, that is, insofar as the economical factor was concerned. The realization that the peak on the low frequency can be arranged to compensate for loud speaker deficiency on the low audio register was the mainstay of the system, but many refrained from installing the system because three stages are necessary for the average amplifier. Now that the price of tubes has been greatly reduced, the economical problem is solved.

**Loud Speaker Characteristics**

Because of the close association between this type of audio amplifier and the average loud speaker, a few words pertaining thereto will doubtless be of interest. Many are awaiting the development of a perfect loud speaker, of a speaker which would have a flat characteristic over the entire audio band. Such a speaker would upset conventional radio design since it would necessitate the re-designing of all R.F., detector and A.F. systems. Is it not much easier to adjust the audio amplifier to suit the requirements of the present day speaker and to compensate for the operating characteristics of the remainder of the receiver? By adjusting the amplifier, to have a peak, high or low so as to compensate for the speaker deficiency or adjusting the amplifier for a flat characteristic, only one circuit is undergoing a change and the present speaker investment is saved. With R.F. and loud speaker characteristics known, the adjustment of the amplifier operating characteristic to give best results is a simple task—the selection of the proper coupling capacities.
Application of the Four-Electrode Receiving Tube

A Discussion of the Uses of the UX-222 as a Screen-Grid and Space-Charge-Grid Tube

By Alan C. Rockwood and B. J. Thompson

PART II

It will be of interest to consider the actual performance of the UX-222 and to compare this with the UX-201-A. At broadcast frequencies in carefully designed amplifiers using the UX-222 amplifications of 40 to 50 per stage have been obtained with complete stability. With the UX-201-A in neutralized circuits and with the best transformers, an amplification of about 10 per stage is the practical limit. At a frequency of 20,000 kilocycles (15 meters) amplification of 10 to 15 per stage is obtained from the UX-222. It is practically impossible to operate the UX-201-A as a radio-frequency amplifier in the short-wave bands, because of oscillation even with careful neutralization. In the intermediate frequencies, 40 to 100 K.C. amplification from 100 to 150 per stage may be obtained from the UX-222 while 20 to 40 is the best that may be done with the UX-201-A.

While 45 volts is the recommended voltage for the screen-grid tube for all such uses as those just described, increasing it to 67.5 volts will usually result in a slight increase in amplification, although this is not advised in most cases as it results in increased plate current. While 90 volts will usually be a satisfactory plate voltage, the use of 115 volts results in increased amplification and better performance; this voltage should not be exceeded. In nearly all cases a negative control grid bias of about 15 volts should be used.

Where resonant impedances are used in the load circuit the plate resistance of the tube operating into the load acts as a shunt across this load, and hence affects the sharpness of the tuning, or the selectivity. The UX-222, with a plate resistance of 850,000 ohms, acts as a very high resistance shunt, and consequently gives greater selectivity than a tube having lower plate resistance.

Another important use of the UX-222 as a screen-grid tube is in resistance-coupled amplifiers. Here again it is possible to realize considerable amplification by the use of high impedance loads, while the low feed-back capacity makes possible amplification at higher frequencies than with three-electrode tubes.

It must not be supposed, as might at first seem the case, that by using an 800,000-ohm resistance in the load circuit, an amplification of 150 per stage will be obtained. To do this would require over 1,300 volts B supply due to the high D.C. voltage drop in the load resistance. By examining Fig. 15, the effect of this will be seen. This diagram presents a family of plate characteristics of the UX-222 taken at 45 volts on the screen. If it be assumed that the B supply voltage is 180 volts and that the load resistance is to be 250,000 ohms, the line A-B represents the voltage-current curve for the load, passing through zero current at 180 volts. The intersection of this load resistance line with the plate characteristic of the tube indicates the operating voltage and current of the tube for the grid bias corresponding to the curve used. It will be seen that, with all biases of less than 4.5 volts negative, the tube operates at such a low plate voltage that the amplification factor is negligible. With negative 6 volts bias on the control grid the mutual conductance of the tubes has dropped off so much that the amplification is only about 40 per stage.

Fig. 15 shows a similar family of curves taken with 22.5 volts on the screen. It will be noticed here that the tube operates satisfactorily with only 1.5 negative volts grid bias. Under these conditions, the amplification is again about 40 per stage.

Fig. 16 shows an equivalent circuit for a resistance-coupled amplifier. Here: 

\[ C_p = C_{PG} + C_{t} + C_{g} \]

when \( C_{PG} \) is the plate-grid capacity of
the tube, $C_p$, the plate-screen capacity, and $C_r$ the plate-flament capacity, all including wiring capacities. Also:

$$C_{e} = C_{ax} + C_{et} + C_{ap}, (A_{e} + 1)$$

where $C_{ax}$ is the capacity between grid and screen of the next tube in the amplifier, $C_{et}$ the grid-flament capacity, $C_{ap}$ the grid-plate capacity, and $A_{e}$, the voltage amplification, all of the next tube. $C$ is the blocking condenser, while $R_{p}$ and $R_{s}$ are the plate and grid coupling resistors. The value $C_{e}$ is the effective grid capacity shunted across the load resistance of the preceding stage and serves to reduce the amplification of the high frequencies, due to its by-passing effect. The gain in fidelity due to the reduction of the effective grid-plate capacity of the amplifier tubes will be appreciable. The UX-222, for example ($C_{p} = 0.025$ mfd., max.) will have a value for $C_{e}$ of 9 mfd. as compared with that of 200 mfd. for the UX-240 ($C_{p} = 9$ mfd.).

It must be understood that these capacity values neglect the external portion of $C_{ap}$ due to capacity coupling between the plate and grid circuit wiring. It is easy, unless care is taken in laying out the parts, to set up an audio-frequency amplifier that will have an input capacity of 50 to 100 mfd. as a result of a $C_{ap}$ of approximately 1 mfd. in the circuit external to the tubes. In Fig. 18 is shown a comparison of two such amplifier circuits using the same open layout in each case with reasonable precautions to avoid coupling between tubes. The improvement in fidelity resulting from the characteristics of the UX-222 is evident, as well as is the increased voltage amplification. If greater fidelity is desired the use of shielded amplifier stages is desirable.

Fig. 19 is a circuit diagram for a two-stage amplifier using UX-222's with a UX-171 output tube. The voltages and constants given in Table No. 2, given above, are recommended for ordinary audio amplifiers. Increased amplification may be obtained by using a higher B-supply voltage and making the proper adjustment of the screen voltage.

Resistance-coupled amplifiers for special purposes have been built using...
the UX-222, and then give satisfactory amplification at more than 50,000 cycles.

As a Space-Charge-Grid Tube

Space-charge-grid tubes are the result of the work of Langmuir in this country and by Schootky and Barkhausen abroad. While, as before mentioned, the UX-222 was not designed primarily for this purpose, it may be operated as a space-charge tube with satisfactory results.

If a two-grid tube is connected, as shown in Fig. 20, with the inner grid at a positive voltage and the outer grid at a negative bias, electrons are drawn away from the filament by the inner grid and thrown into the space between the two grids. Most of these electrons come to a stop very close to the outer grid, and then fall back to the inner grid. The ones which fall back are replaced by others, so that there is a continuous cylinder of electrons very close to the outer grid. This has the effect of a cathode placed very close to the outer grid, giving low plate resistance. The amplification factor between the outer grid and the plate is only slightly affected by this, so that the result is high mutual conductance.

Space-charge tubes have been popular in Europe where low operating voltages and a small number of tubes were desired. In America, where there is no government tax on sets based on the number of tubes, and where power tube operation of loud speakers has necessitated high plate voltage, there has been little demand for such a tube.

The UX-222 operated as a space-charge tube is somewhat different from many of the European tubes. It is a high-amplification factor tube requiring moderately high voltages to operate. Its advantage is higher gain per stage than is practicable with three-electrode tubes, due to higher mutual conductance.

Figs. 21 and 22 give the static characteristics of the UX-222 space-charge tube. They differ little from those of three-electrode tubes, with the exception of the added inner grid current, and the high mutual conductance for a tube of such a high amplification factor.

The UX-222 space-charge tube may be operated the same as any three-electrode tube having high amplification factor. The most important use for such tubes is in resistance- or impedance-coupled audio amplifiers. Such an amplifier is shown in Fig. 23. A B-supply voltage of 135 to 180 volts with a coupling resistance of 0.1 to 0.3 megohm is recommended. Suggested operating conditions and the resulting tube constants are given in Table No. 3 (page 20).

High Frequencies Attenuated

Due to the high capacity between outer, or control, grid and plate, the amplification of such an amplifier falls off at high frequencies. This is shown in Fig. 24, which is a curve of amplification against frequency for the amplifier of Fig. 23 and Table No. 3. The gain in amplification over the UX-240 is also shown.

Over one hundred circuits are known to have been developed using the space-charge tube in various combinations of reflex, double regenerative, and similar circuits. Among these are included a large number making use of the negative change of the space-charge grid current with the plate current upon variation of control grid bias. It is doubtful, however, if the greater part of these circuits produce the results as effectively or economically as less involved circuits using a greater number of lower priced tubes.

[THE END]
“A” Filters Using Dry Type High-Capacity Condensers

Embodying the Results of Tests on “A” Units Employing Dry Rectifiers and Dry Condensers

By P. E. Edelman, E.E.*

A power supply suitable for operating filaments in standard parallel connection must be substantially free from residual ripple. Apparatus of this kind has been successfully used for operation of sets originally built for use of D.C. type tubes, without requiring any changes in regular wiring. The screen-grid type of tubes are also satisfactorily operated thereby. A new proven use is found in the operation of the field magnet of dynamic type speakers.

An exemplification is shown in Fig. 1 where it will be noticed that the alternating current socket outlet is employed to energize a small transformer, whose secondary output will approximate 10 volts. Equally satisfactory operation is had on 25, 50 or 60 cycle source, according to the design of this transformer.

The transformer feeds a rectifier of the Pavlovsky type (U. S. Patent No. 8309124). This is a dry disc contact assembly of prepared oriented current-conducting couples, as for instance, prepared magnesium discs pressed against crystalline pellets of copper sulphide. The rectifier sections are connected in Wheatstone bridge mesh and afford a pulsating unidirectional current output. High capacity dry type electrochemical condensers (Edelman U. S. Patent No. 1058974) are shunt connected in combination with series inductances, as shown by Fig. 1. The condensers have effective capacity of the order of 1,500 mfd., and the chokes need not be larger than 2 henry each. Outputs may be had at 6 volts up to 3½ amperes or 4 volts, 1 ampere.

*Patentee, 7258 Yates Ave., Chicago, III.

Comparative costs with other methods of filament excitation show decided economy of this method. The dry contact rectifier, as well as the dry electrochemical condenser, have proven commercial durability and efficiency.

The condenser elements accomplish part of the filtering action by their properties other than as true condensers. The chemical composition is selected to withstand operating service and temperatures without detriment and should not be confused with certain imitations which rapidly deteriorate and corrode in service.

Outstanding Advantages

The outstanding advantages of this type of filter are: absence of hum troubles, instantaneous starting action, suitability to standard type tubes and sets, absence of radio-frequency modulation effects, freedom from water ing service, and long maintained constant output.

The condenser elements used are each approximately 6 inches high by 2½ inches elliptical oval shape. They are made by winding sheet aluminum electrodes sandwiched between absorbent fibrous sheets impregnated with a conducting chemical mixture, which is solidified and held suspended therein. An interlocked mass of crystals with smooth surfaces pressing against the electrodes is thus obtained and serves as a filter element by its functions, including capacity. The condenser elements are prepared with one electrode polarized with respect to the other. The ionic mass of the electrodes is designed to maintain the operating temperature below the critical temperature of the crystallized chemical mass. Such condensers differ from wet electrolytic or paste or jelly types as well as from paraffin or wax paper types. They are sealed from the atmosphere and have a very long operating life. Similar condensers have been built for other purposes and higher operating voltages, such as required for plate or “B” supply units.

The capacity of such condensers is equivalent to very high values per employed area and the leakage current is very small, usually less than three milliamperes. They are tested by the customary bridge method with both direct- and alternating-current components supplied to the condenser terminals. No watering or charge forming is required for use.

In the accompanying oscillograph
records the current and voltage relations are shown, according to the following table.

Fig. 2. Rectified current; output current and output voltage of unit connected to non-inductive load; line voltage; rectifier voltage; and input voltage to rectifier. D.C. unit output measured 6 volts, 1.15 amperes for this test.

Fig. 3. Rectified current; current flowing through condensers No. 1 and No. 2; output current: rectifier voltage and rectifier input current; load on unit being 6 volts and 1.15 amperes for this test.

Fig. 4. Output voltage maintained at 6 volts. Rectifier current; current through condenser No. 2; current flowing between first choke coil and second condenser; current through first condenser, rectifier voltage; input current; operating conditions.

Fig. 5. Transient conditions immediately upon energizing unit with output adjusted to 6 volts. Rectifier current; current through condenser No. 2; Im current between first choke coil and second condenser; current through condenser No. 1; rectified voltage; and input current.

Calibrations of curves traced are indicated.

Referring to Fig. 2 it will be noticed that the rectified current remains at zero value during a considerable fraction of the cycle. The output voltage and current are substantially free from ripples. The unit introduces no hum in the output of the connected radio set by either amplification or modulation.

In Fig. 3 also, the input current and rectified current have a considerable period of each cycle at zero value. The current in condenser No. 2 is small and but a fraction of the current in the first condenser. The output current is substantially free from residual ripple.

In Fig. 4, the input current and the rectified current both have a considerable zero value component in each cycle, characteristic of this type of rectifier circuit. Condenser No. 2 current is but a small fraction of the current in the first condenser. One will notice the similarity of the curves for Im current flowing between the first choke coil and the second condenser and the current through the second condenser, showing that effective filtering action is obtained by use of this second condenser.

Fig. 5 shows interesting surge current in the second condenser and corresponding current Im flowing between first choke coil and second condenser. The rectified voltage increases promptly to a steady value, as does also the output current. The current in No. 1 condenser reaches a steady value promptly. The peculiar cut-off effect shown in the oscillograph curves is characteristic of the dry-disc rectifier, because an established minimum current and voltage must be reached to permit permeation through it.
The Engineering Rise in Radio

By Donald McNicol

Fellow A.I.E.E., Fellow I.R.E.

Past-President, Institute of Radio Engineers

PART III

Source of Marconi's Knowledge

It is stated in the foregoing that one of the books read by Marconi in 1894 or 1895, when he was twenty years of age and while he was seeking information about high-frequency electric phenomena, was a book by Martin dealing with Tesla's researches in America. A search through this publication in an effort to locate matter which might have been of value, or suggestive to Marconi does not uncover anything which could have been particularly helpful to the young Italian. The book was published in New York in 1894. The section of the work which approaches the subject of Hertzian waves is Chapter 26, containing a lecture on the subject: "Experiments With Alternate Currents of Very High Frequency ..." delivered in New York on May 20, 1891.1

Judging the matter appearing on page 174 of Mr. Martin's book, it is apparent that Tesla had the notion that the bulk of the energy produced by the condenser discharge (clamped from a high-tension induction coil) was taken up and converted into heat in the discharge area, and in the conducting and insulating materials of the condenser. There is no thought of detached waves being propagated into space.

In view of the idea expressed in Kerr's book, seven years later, that possibly Marconi was employing a form of radiation differing from Hertzian waves, it is not surprising that in America in 1890 the truth had not been fully recognized. Hertz's announcements in 1888, and Dr. Lodge's investigations conducted at about the same time did not immediately receive wide circulation in published form. And, even in quarters where the information was early received, there was a natural disposition to gain knowledge of the subject through duplication of the original experiments. This was time-consuming and accounts for some of the delay which occurred in arriving at a correct understanding.

Analyzing the state of the art at that time in the only way now possible—

1 The lecture was printed in full in the Electrical World, New York, June 11, 1891.
tion with highly exhausted vacuum tubes of special design. The wavelength of X-rays is very small compared with that of Hertzian waves.

This reference is introduced at this point to enable the reader that in Germany the physicists were losing little time in contributing materially to advances in knowledge made possible by Maxwell and Hertz.

Before wireless telegraphy, however, the Germans appear to have been a little slow in getting started. One of the earliest of the German scientists who made up the work was a scientific genius in the field of engineering, Dr. Slaby was aware of what Marconi had been doing in the way of improving devices and circuits, for, in Kerr's book of 1898 (previously referred to herein) Professor Sylvanus Thompson is quoted as saying (page 82): "Dr. Slaby abandoned every one of the 열ities introduced by Marconi and fell back upon knowledge previously known."

It is reported that Dr. Slaby was present on May 13, 1907, at tests carried on in the British Channel by Mr. Marconi and upon his return to Germany made a series of extensive investigations. The results of these investigations are highly interesting in the field of telegraphy and the transmission of wireless signals. The investigations were made in the field of wireless telegraphy and are of great importance in the field of telegraphy and the transmission of wireless signals.

In France II. Poisson, A. Turpin, A. E. Blondel and Commandant Tissot were early workers in the field. The results of their investigations are of great importance in the field of telegraphy and the transmission of wireless signals.

The Beginning in America

Following Joseph Henry's announce-

The final experiment by Mr. Edison recorded in this series (December 20, 1878) shows that the observed effect was noted at a distance of eight feet, four inches. It is interesting to speculate on what the outcome might have been had the inquiry been directed toward experiments in reflection, refraction and penetration.

One of Mr. Edison's biographers advances the explanation: "When we think of the discoveries of the four inches, it is interesting to speculate on what the outcome might have been had the inquiry been directed toward experiments in reflection, refraction and penetration."

Thomas A. Edison's Experiment

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Thomas A. Edison's Experiment

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been laid aside as one of the matters to be, perhaps, taken up some other time when there were more hours to a day."

The situation reminds us of Dr. Lodge’s account, twenty years later, of how a twenty-one-year old Italian youth, Marconi, ‘reaped the harvest bowed and sown by others. He wrote: ‘... so far as the present author was concerned he did not hail that there would be a particular practical advantage in thus with difficulty telegraphing across space instead of with ease by the highly developed and standardized graphic and telephonic methods rendered possible by the use of connecting wires.’

Elilhu Thomson, M. I. Pupin, A. E. Dolbear and Other American Investigators

In the year 1880, Elilhu Thomson, then president of the American Institute of Electrical Engineers, read an important paper on the subject “Alternating Currents and Electric Waves,” which was one of the earliest papers on the subject of the relation between Maxwell’s deductions and alternating currents.

It is noteworthy, also, that in 1889 Columbia University, New York, inaugurated a regular course in electrical engineering organized by F. B. Crocker and M. I. Pupin. Dr. Pupin was at that time thirty-one years of age. He had been graduated from Columbia University in 1883, but had later taken graduate work at Cambridge, England, and at Berlin. In 1892, at Columbia, he took up the study of electrical resonance and developed the theory of tuned electrical circuits.

In tracing American thought in the period following, now is the time to consider the American technical literature of the time which was to play an important role in the development of the telegraphy, the telegraph, the wire telephone, the dynamo and motor, and the telephone. The American Institute of Electrical Engineers, founded in 1884, devoted itself to the promotion of technical progress and the encouragement of electrical research.

In addition to Professor Trowbridge, others who were in positions to maintain places on the fringe of scientific advance were Elilhu Thomson, Nikola Tesla, Thomas A. Edison, A. E. Dolbear, A. G. Bell, Elisha Gray, M. I. Pupin, F. B. Crocker, and Professor Hutchins, of Bowdoin. And, it is no reflection on the scientific achievements of any of these savants that Heaviside, Lodge, Popoff and Marconi, in Europe, were in the van in investigations which revolutionized electric communication.

American technical literature of the period 1888-1896 discloses that scientific papers published in Europe were being gleaned in order that there should be no lag in the information available to American workers.

Dr. Pupin, as previously noted, in 1892, developed tuned, selective circuit theory, which later was of importance in the design of practical radio signaling systems. In 1894 he applied to telephone wires on wires his mathematical solution of the purely dynamical problem of a stretched string carrying weights at equal intervals, very greatly improving the efficiency of transmission of telephonic currents over long lines. The solution was to place cleverly selected inductance coils at intervals in the long lines.

Writings of A. E. Dolbear and Prof. Trowbridge,8 which appeared at about the date of Marconi’s initial demonstrations, show that Maxwell’s and Hertz’s announcements were fairly well understood by these men.

Professor Trowbridge was one of the earliest, if not the first, to employ a machine generator in the production of electric waves for experimental investigation. The machine used 120 volts, at 15 to 25 amperes, which, connected to a suitable transformer, enabled him to develop potentials high enough to produce sparks of adequate length between oscillating spheres, or points. With this arrangement he duplicated experiments previously performed by means of induction coils and Leyden jar condensers. All of the ground covered by Lodge and Hertz was gone over, including the measurement of electric waves along wires, and detecting electric waves transmitted by an oscillator in another room. The detecting system consisting of a large loop of wire, condenser and small spark gap, similar to that of the radio system.

Professor Trowbridge, it would seem, did not envisage the prospect suggested by Maxwell and presented by Lodge. Possibility of transmitting or receiving, he was bound too closely to the observed range of magnetic induction, as were others of his time. It was difficult to conceive of electric waves traveling away from their source through space, to great distances; for, in 1891 he stated: “It is hardly probable that any electrical method could be devised in which the air, or the ether of space, could advantageously replace a metallic conductor on land for signaling over considerable distances.” This was practically the same thought entertained by Dr. Lodge four years later.

That these inquiries were going on in America at the same time identical investigations were under way in Europe reflects the state of the art here at the time of Marconi’s visit to England, in 1896.

Nikola Tesla

While considering what was to be the fore in America just prior to and

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immediately following Marconi's invention of wireless telegraphy by means of electric waves, it is important to attempt to discover what Mr. Tesla's experiments led him to think about Maxwell's and Hertz's work.

As previously stated, Marconi, in 1895, had read parts of T. C. Marcl's book dealing with Tesla's experiments in high-frequency phenomena, published in 1894. This book contained reproductions of three lectures delivered by Mr. Tesla; one in New York in 1891, one in London in 1892, and one in Philadelphia in 1893. From the matter appearing in the 1891 lecture it is clear that Mr. Tesla was to some extent familiar with the work of Hertz and Lodge. But this was four or five years before Marconi's convincing demonstrations, and Mr. Tesla was of the opinion that the bulk of the energy of an oscillating system was consumed in impact and collisional losses—heat vibrations on the surface and in the immediate vicinity—and was not radiated into space to any considerable distance.

There is no escaping the thought that Mr. Tesla had not fully interpreted the main point of Maxwell's message. Possibly, also, he had not had opportunity to analyze Hertz's results of 1888. In his 1893 lecture in Philadelphia he said: "Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far, but I do firmly believe it is practicable to disturb by means of powerful machines the electrostatic conditions of the earth and thus transmit intelligible signals and perhaps power."

It might be supposed that the prior experiments of Morse, Lindsay, Prece, and Trowbridge in telegraphing, and by Bell and others in telephoning, comparatively short distances by means of induction and by earth conduction, had exhausted all immediate possibilities in these directions. In 1897, a little over a year after Marconi's first demonstrations in England, Mr. Tesla announced that he had completed a system to such an extent as to permit of telegraphy through the earth for a distance of twenty miles or more, and that his experiments satisfied him of the feasibility of reaching greater distances.

Mr. Tesla, in 1886 and 1897 took out nine important American patents covering systems for the production of high-frequency oscillations, employing iron-core transformers for stepping up primary alternating current, thereby obtaining high potentials for charging circuits which included condensers and inductance units, similar to the prior induction coil practice. In 1897, several additional patents were taken out covering variations of connections and values.

As stated in the chapter on Transformers, the transformer method of producing high-frequency currents for electric wave telegraphy, in time replaced many of the induction coil installations, where sources of primary alternating current were available.

CHAPTER 3

Syntony, Tuning, Selectivity

These terms are practically synonymous, and are given here in the historical order in which they have been used from Marconi's and Lodge's early experiments to the present time.

In the utilization of electromagnetic waves for transmitting signals across space it was clear in the beginning that a commercial future for the invention would depend upon the development of means whereby more than two stations might satisfactorily carry on communication simultaneously in the same territory.

In the older, wire systems of telegraphy and telephony continuous wire conductors are connected between the individual stations, so that as many separate communications may be carried on simultaneously as there are individual wires (this aside from the modern additions of multiplex, phantom and carrier-current channels on trunk lines).

In the case of "wireless" transmission, employing electromagnetic waves, the medium through which the signals pass between all stations is the same: as if in wire telegraphy and telephony all systems and stations had but one common conductor through which to operate. Obviously, in the latter situation the result would be an unintelligible jumble of sounds, unless there is devised a system of separation (tuning) which would permit all of the various signaling currents to function properly between the respective stations or instruments without interference.

The early oscillators of Hertz and Righi, and the original space telegraph system invented by Marconi were quite deficient in this respect, wireless signaling for practical purposes could not advance far beyond the spectacular top stage until something was done to provide some degree of syntony, of tuning, of selectivity.

It was early realized that the secret of selective signaling was a matter of wave length. Any two stations desiring to communicate would of necessity have to employ electromagnetic waves differing in length from those of other stations if interference was to be avoided.

Maxwell's mathematical deductions included the phenomenon of wave length, and in his writings he suggested what the factors of wave length measurement would be to find. Hertz, in 1888, assuredly laid the foundation for further intelligent inquiry into the subject, and Lodge's investigations of the same period relating to wave propagation over conductors clearly dealt with the same problem in another form.

Lodge, in 1888,1 had conducted experiments in the production and detection of electric waves on a system of parallel wires suspended on insulators around a large room, excited by discharges from condensers. He secured experimental evidence of the existence of nodes and loops on such wires, and also worked out a method of measuring the approximate wave length.

In 1890, Lodge, in the presence of Lord Kelvin, performed an experiment illustrating wave phenomena along wires in which the conductors explored were connected to the outside and inside, respectively, of a Leyden jar condenser; this latter not connected with, and situated at some distance away from an oscillating system consisting of discharger, condenser and spark gap. These examinations will be recognized as fundamental, even if elaborations of the discoveries of Hertz.

Oliver Heaviside recognized that the propagation of electric waves along wires was in all essentials identical (in respect to the laws governing the motion) with the propagation of electric

waves through space. Heaviside used the terms inductance, capacitance, reactance, permeance and permittance, all of which fell in time to become house-
hold words in the terminology em-
ployed by engineers engaged in solving problems closely associated with the advancement of radio signaling.

It would have been unusual had the
lessons of Maxwell and Hertz on this
point gone unheeded. The prior hints
of Faraday and Henry, and the work of
William Thomson on the early sub-
marine cables led some of the scientists which in time were bound to reach fruition. Out of Hertz’s and Lodge’s discoveries came the dictum that when two oscillatory circuits have the same time period they are recognized as being
syntonic, and are said to be in
resonance with each other; an oscillatory circuit being one in which some
form of inductance, and some form
capacity are associated, the re-
sistance of the circuit being small in
comparison with the inductance—
clearly pointed out by Thomson.

Mr. Marconi studied the
reports of Hertz’s experiments, per-
formed seven years previously, and he
has stated that he realized if Hertz’s
oscillator was to actuate efficiently a
receiving system flat these would have to be tuned together—the send-
ing and receiving circuit systems
should be of the same oscillation
period. When straight wires or plates
were employed at each end, or when
loops or rings of wire were employed these should be of the same physical
dimensions.

It was not until 1898, however, that
Marconi used inductance coils in
antenna circuits. In his earliest sys-
tem parasitic reflectors of the Hertz type
and radiation were not used, the radiation being
referred to as a ray from a mirror.

Early Ideas of Tuning

In Lodge’s lecture of 1894 on the
subject of Hertz’s work he pointed out the necessity for a persistent train
of waves if selectivity was to be ob-
tained between oscillator and receiver,
and stated that conspicuous energy of
radiation and persistent oscillation
were incompatible—referring to a
single circuit.

In 1897, Lodge had opportunity to
study the results of the early Marconi trials, with respect to the fourth year in increasing the
distance of operation. These observations supplemen-
ting his own laboratory work
led to the invention2 of a radiator sys-
tem consisting of an inductance, a
large capacity antenna in order to
prolong the train of waves sent out
and so improve selectivity.

The first patent issued covering a
system for ether wave telegraphy was
Marconi’s grant No. 12,089, of 1896.
the important claim of which was for
the use of an elevated antenna con-
derator. The method covered was ele-
mentary and suffered from the limita-
tion pointed out by Lodge as stated
above.

In Germany, in 1895, Oberbeck,3 and
V. Björnlin,4 had sensed that the
problem of the utility of electric waves
was bound up with the necessity for
syntonic balancing of associated cir-
cuits, the principles of which were ex-
plained in their technical papers. In
Germany, also, Ferdinand Braun5 pro-
posed a transmitting system to be de-
signed for the purpose of producing
electric waves of greater length than
those radiated by the simple Richi
oscillator at first employed by Mar-
coni. Braun suggested for a trans-
imitting system a closed oscillatory
system, containing condensers and in-
duction coils, coupled inductively to the
antenna.

The Braun disclosures were more of
a prophetic nature than of claims to
invention. The employment of coupled
circuits in a transmitting system
would have been novel in 1898, had
they been availed of.

The technique of tuning in electric
wave telegraphy may seem to have
been slow in developing, but the fact
was there was much to learn. In some
instances useful theories were worked
out on paper, but got no further than
that. In some cases physicists who
were driving into theoretical consider-
ations had not at hand the experimental
means with which to check theory.

Also, it is well known that there have
been, and are today, physicists gifted
with ability to prosecute pure research
who are but little inclined toward ex-
perimental demonstration.

In later times (1910, forward) this
situation has been considerably
remedied by bringing together in single
organizations often under one roof, the
mathematicians, the physicists, the ex-
perimental workers, and the engineers,
who accounts for the more consistent
and rapid progress made in recent
years, especially in the United States.

Prior to the advent of the science
laboratories of the large corporations, the occasional forward steps noted
were made by investigators, remotely
separated, laboring independently in small laboratories or in the colleges.
And, although this condition is not
likely ever to be completely changed,
for obvious reasons, it results in much
duplication of effort, if in independent,
simultaneous discoveries of impor-
tance, around which there shall always
be no end of disagreement and dis-
pute as to priority.

Practical Considerations

At this point we are engaged in
tracing the growth of ideas bearing
on the problems involved in attempt-
ing to operate a multiplicity of space
telegraph stations simultaneously in a
common territory, and in improving
methods of transmission to the end
that greater distances might be worked
over, as these problems confronted
Marconi and others in the four or five
years following the first trials in
England in 1896.

Looking back at the situation as it
existed at that time we may recognize
that the next step, that taken by
Marconi, in 1900, constituted a distinct
advantage along the line which held a
promise of improvement.

For the purpose of increasing the
efficiency of transmission and of secu-
ring selectivity, Marconi, in 1900, em-
ployed a closed oscillating circuit
coupled to an open radiating circuit,
adjusting the circuits to have the
same time period. At the receiving end he utilized separate absorbing and
oscillating circuits, coupled together,
permitting tuning to a given fre-
quency and its harmonics. An exam-
nation of the wiring arrangements
covered in this development shows
that no advantage was taken of the
improvements of Lodge, and also of those suggested by Braun, previously
referred to. Marconi, however, had
advanced his ideas of practical tuning,
and these he applied in a very credit-
able manner.

In the year 1900 the need for a
workable system of tuning was a sub-
ject of the utmost importance. Con-
siderable headway had been made in
extending the distance over which
communication could be carried on.
Some of the distance gains recorded
were: March 1897, eight miles; Novem-
ber, 1897, eighteen miles; July, 1898,
twenty-five miles, and 1899, one hun-
dred and fifty miles.

So long as but one operating com-
pany or organization maintained serv-
ice in a given area the difficulties of
interference were under that degree of
control which suppresses competitive
transmissions. But this handling of
service and the mother of invention
who applied the road.

In October, 1899, Mr. Marconi had
been engaged by the New York Herald
to bring over an equipment which
could be used to report the progress of
the boats sailing in the International
Yacht Races of the Nyasvi sinking
Hillands, near New York. In 1901, when
the Shamrock was pitted against the
Columbia, the same service was under-
taken by the Marconi company, but in
the meantime in the United States the
American DeForest Wireless Tele-
graph Company had made some
progress in the development of a
workable system, as also had the Ameri-
Can Wireless Telephone and Telegraph
Company, so it followed that in report-
ing the yacht races three rival wireless
system were attempting to operate
simultaneously in a common territory.

The result was what might have been
expected. Immediately it was appar-
tent that whatever had been

(Continued on page 37)
The Mathematics of Radio

Definition of Reactance and Impedance and How to Calculate Reactance and Impedance Values

By John F. Rider, Associate Editor

PART IX

BEFORE entering into the discussion of vacuum tubes, radio-frequency transformers and other radio units thus far omitted, we must consider some terms often used, seldom described and of importance for future discussion, namely, "reactance" and "impedance." These two factors are found to be of extreme importance when considering vacuum tubes, audio-frequency coupling units and their association and effect upon general receiver performance. As a matter of fact, many radio units in daily operation could be greatly improved if the significance of reactance and impedance were realized and applied to the units in the receiver. That is to say, if the units chosen were based upon a knowledge of their reactance and impedance.

These two considerations are of extreme importance in the design of radio and audio-frequency amplifiers and are essential to the correct selection of the various units. The calculation of alternating voltage and current in radio circuits has a direct bearing upon design, since only then can one know, if a certain item, unit or design is performing as well as expected. Empirical determinations are not always possible, in fact, are not always economical. Many factors of design and performance in radio receivers can be ascertained without any experimental work. The actual experiment or the determination with the actual apparatus, will perhaps differ from calculations, but if the calculations are correct, the difference will not be appreciable.

We do not mean to enter into a deep discussion of alternating-current calculations. We hope to cover some of the important details of interest to the individual who has occasion to select and purchase radio parts, and who has occasion to utilize design details in everyday radio practice.

Our material thus far pertained to the formula utilized to calculate electrical constants, such as capacity, inductance, number of turns, etc. Now we will consider the calculation of current and voltage in A.C. circuits. These values can be determined only after a knowledge of the significance of reactance and impedance. Interpreting these terms into electrical values, will afford an idea of the performance of various units in different parts of a receiver, and give one an idea of the constants necessary to achieve a certain end.

Definition of Reactance and Impedance

Resistance in any circuit is the opposition of that circuit to a force applied to the circuit and a steady current in a circuit meets but one opposition, the resistance of the circuit. In A.C. circuits, however, where the direction of current flow changes periodically, according to the frequency of the current, the above does not hold true. If a condenser is present in the circuit, it manifests a controlling influence upon the current in the circuit, by virtue of the constant charging and discharging of the condenser. This controlling influence is really opposition to the current and the extent of opposition is designated as a value of "reactance" and is expressed in ohms. The reactance of a condenser is designated by the letters Xc and since it is expressed in ohms, is illustrated as a reactance; Figs. 48 and 48A. To calculate the current in a radio circuit such as that of Fig. 48 where we have a voltage E and a condenser C, it is necessary to know both the resistance and the reactance. In general, all radio circuits possess a certain amount of resistance which must be taken into consideration when calculating the current. Since both the resistance and the reactance constitute a force which opposes the current flow, the total hindrance or opposition in the circuit is that of the resistance and reactance and is expressed as the "impedance," usually designated by the symbol Z.

The reactance of a condenser in an electrical circuit (A) is expressed in ohms and carries the symbol of resistance (B) if expressed as XC, inferring capacity reactance.

\[
X_c = \frac{1,000,000}{0.283 \times P \times C}
\]

The numerator, 1,000,000 and the portion of the denominator, 0.283, which in reality is 2π, are constants. P and C are variables depending upon the frequency and the capacity. As is evident from the formula, the higher the value of P or frequency, the lower the value of reactance with a constant capacity. With a constant frequency, the larger the value of C, the lower the reactance. Generally speaking, condenser reactance varies inversely with the frequency and with the capacity. That is to say, if at a certain capacity the frequency is doubled, reactance will be halved. If at a certain frequency the capacity is doubled,
reactance will be halved. If at a certain frequency the capacity is doubled the reactance will again be halved.

<table>
<thead>
<tr>
<th>Capacity (μF)</th>
<th>Reactance in ohms at various frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
</tr>
<tr>
<td>0.001</td>
<td>2,000,000</td>
</tr>
<tr>
<td>0.01</td>
<td>20,600</td>
</tr>
<tr>
<td>0.1</td>
<td>206,000</td>
</tr>
<tr>
<td>1</td>
<td>2,060,000</td>
</tr>
<tr>
<td>10</td>
<td>20,600</td>
</tr>
<tr>
<td>100</td>
<td>2,060,000</td>
</tr>
<tr>
<td>1000</td>
<td>20,600</td>
</tr>
</tbody>
</table>

(These figures are slide rule calculations and only approximate.)

An idea of this variation is found in the accompanying table. The effective current in the circuit is then equal to

\[ I = \frac{E}{X_c} \]

**Capacitive Reactance**

As an illustration of the reactance of a condenser and its action in a radio circuit, let us consider a 2 Mfd. condenser at 60 cycles. According to the above formula for \( X_c \), the value in ohms is 1256. In other words a 2 Mfd. condenser across a 60-cycle line will offer opposition or will have a reactance equal to 1256 ohms. Now let us suppose, as in Fig. 51, that this condenser \( C_2 \) is connected across a resistance \( R_2 \) which is a section of the voltage distributing system in a half-wave "B" eliminator. The function of this condenser is to bypass the 60-cycle ripple remaining in the system. The other functions of this condenser at this time are inapplicable. If the value of \( R_2 \) in ohms is less than that of the reactance of the condenser, it is evident that it will offer an easier path, with the result that the A.C. ripple will flow through the resistance rather than through the condenser. Hence, it is important when selecting by-pass condensers for the various sections of "B" power unit voltage distributing systems, and "C" bias resistances, to select capacities whose reactance values will be less than the ohmic value of the resistance being bypassed. This is particularly true when by-passing "C" bias resistances, since the ohmic value of these resistances is usually very low. The effect upon regeneration in a receiver installation utilizing "B" eliminators is increased if the condenser reactance by-passing any of the voltage distribution system sections is greater than the ohmic value of the section being by-passed. This, of course, is just one illustration of the need to know how to calculate condenser reactance and its application in radio receiver installations. More will follow later.

**Inductive Reactance**

In direct contrast to an A.C. circuit containing a capacity, the reactance of an A.C. circuit containing an inductance only increases with frequency and with the value of inductance. If we assume for the present an A.C. circuit such as shown in Fig. 49 containing an inductance with negligible D.C. resistance, the reactance of that inductance is equal to

\[ X_L = 6.283 \times F \times L \]

As in the case of the condenser, the reactance of an inductance is also designated by the symbol \( X \) and is illustrated by means of a resistance, since inductive reactance as well as capacitive reactance is expressed in ohms. An examination of the above formula, will show that an increase in frequency for a constant value of inductance will increase the value of reactance and an increase in inductance for a constant frequency will do likewise. The value 6.283 is again a constant. The effective current in an A.C. circuit containing inductance with negligible resistance is equal to

\[ I = \frac{E}{X_L} \]

We made mention in a previous paragraph that the total hindrance in a circuit is that of the reactance and the resistance, the combination of both being known as the impedance. In direct contrast to an A.C. circuit containing a capacity with negligible resistance, A.C. circuits containing an inductance usually contain another component, the D.C. resistance of the inductance. Calculation of the impedance of such a circuit requires cognizance of the D.C. resistance and the impedance of the circuit is equal to

\[ Z = \sqrt{R^2 + X_L^2} \]

For example, we have an inductance of 10 henrys with a resistance of 10 ohms across a 60-cycle line. The impedance is equal to 6.283 \times 60 or 370 ohms. The impedance is equal to

\[ Z = \sqrt{10^2 + 370^2} \]

It is evident from the above that when the resistance is negligible in comparison with the reactance, the effect of the resistance upon the total impedance is very small and the impedance can be considered as equal to the reactance. A more comprehensive illustration of the above is the following: Let us suppose an inductance of .1 henry and 1 ohm resistance, and a frequency of 60 cycles.

\[ Z = \sqrt{1^2 + 37} = 37.7 \text{ ohms plus ohms} \]

The low value of D. C. resistance has very little effect upon the total impedance. Now let us suppose that the D.C. resistance is 10 ohms instead of 1 ohm.

\[ Z \text{ will then equal } \sqrt{10^2 + 37^2} = 39 \text{ ohms} \]

Such instances where the D.C. resistance has little effect upon the total impedance is found in the case of audio-frequency transformers utilizing alloy cores to obtain high values of inductance with small windings so as to keep the D.C. resistance low. It is evident that the higher the value of frequency, the less the effect of the D.C. resistance upon the total impedance. One should not construe from the above that the resistance component should always be neglected. In accurate design consideration of the resistance component in impedance calculations is essential, but in our case and in general receiver considerations such as are of interest to us, it is not essential.

**R.F. and A.F. Chokes**

Practically every one who has had occasion to construct a receiver or to read a constructional article, undoubtedly noted reference to radio-frequency and audio-frequency choke
THE ENGINEERING RISE IN RADIO

(Continued from page 34)

thought out in the way of a selective system of operation, assurably had not been incorporated as elements of the equipment used on these occasions; or, if tuning systems were being employed, they were consciously unsuccessively. The interference was so confusing that the performance was not a success—in fact, was far from it.

Factors Involved

The trained engineer of a later day will sense that the trouble with the first days is at having in actual wire-and less signaling was lack of sharpness.

7. The situation here referred to as existing in 1901, may be thought to have been identical with that existing in the broadcast field 1925-1928. But, the difference is that in 1901 the desire was to operate two transmitters in one area, while today's systems are designed to operate within the interference twenty or more transmitters in one Field. It is a matter of degree. The pictures reflect the state of the art at each of these periods.

In the writings of Hertz, Lodge, Thomson, Heaviside, Poplin, Tesla, Overbeck, Bjerknes, Braum, Zenneck, and others, there was much of suggestion pointing to the advantages of exact sympathy. That is, the condition where two tuned oscillating circuits have identical natural frequencies; one circuit responding efficiently to free oscillations in the other.

Resonance, as engineers came to understand it, occurs in a circuit when a sustained alternating voltage the frequency of which is equal to the natural frequency of the circuit is applied to its ends. Resonance exists in a circuit which possesses the proper balance of capacity and inductance. Going a step further, it may be stated that complete resonance obtains when the frequency is such that the inductive reactance equals exactly the capacitive reactance. The electrical properties of a circuit tuned to resonance are dependent upon whether the inductance and capacity are connected in series or parallel.

In the case of series resonance the current is a maximum when a single lumped capacity and a single lumped inductance are connected in series between the terminals to which an alternating voltage is applied, and the energy absorbed is not altered as the frequency is varied. In other words, series resonance obtains when the supply voltage and supply current are in phase. Parallel resonance obtains in a circuit having inductance and capacity connected in parallel, when the supply current and supply voltage are in phase.

And, to continue, sharpness of resonance, to sustained alternating current, is a quantity expressing the measure of change of current value in a simple series circuit for a given alteration in either the capacity or inductive reactance when resonance obtains. If a small change in the frequency of the applied alternating voltage results in the induced current falling off rapidly on both sides of the resonant point, the tuning is then sharp.
The WRCA Radio Installation

A Description of the Transmitter and Receiver on Board the New York-Rome Airplane, Roma

By C. J. Pannill *

NEWLY developed aircraft apparatus, which is said to be the most complete and modern of its kind has been installed on the giant Bellanca sesquiplane Roma. The apparatus includes a special 75-watt transmitter designed to operate on 45 meters for ordinary messages and on 600 meters for communication with ships at sea. Its power is derived from a wind-driven generator installed on the outside of the streamline with a retractable mount so that it can be swung into the fuselage to reduce wind resistance when not in use. The five tube receiver is for use on a wavelength of 550—850 meters.

Transmitter Equipment

The transmitter equipment consists of a transmitter box, containing the transmitters proper; a send-receive switch; a flame-proof key; a Fair Lead; antenna equipment and the double-current wind-driven generator.

The transmitter box encloses the essential parts of two transmitters, one being used for the 45-meter wavelength and the other for 600 meters. The short-wave transmitter is of the crystal controlled, master oscillator and frequency doubling power amplifier type. Two meters are in this circuit—a grid current meter in the power amplifier indicates the amount of excitation and an antenna ammeter shows the power amplifier output. A simple wavemeter, consisting of a coil, condenser and small lamp, is also included. The keying of this circuit is accomplished by a potentiometer scheme, which inserts a high resistance in series with the plate supply of the crystal tube.

The circuit used in the long-wave transmitter is relatively simple. It consists of a Hartley Oscillator inductively coupled to the antenna circuit. Keying in this transmitter is accomplished by changes in a resistance network, which increases the grid bias to the point where the oscillator plate current is reduced to zero. The transmitter can be used on ICW by employing a 210-type tube as an audio-frequency oscillator coupled to the grid of the radio oscillator, a switch being provided to cut out this audio oscillator

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* Vice-pres. & Gen. Manager, Radio Marine Corporation of America.
when it is not in use. A generator field rheostat and filament voltmeter are provided for adjusting the applied voltages to the proper values.

The transmitter has been installed in the center of the fuselage behind a 500-gallon gasoline tank and suspended from its eight corners by rubber shock-absorber cord. This is to eliminate the danger of shock when landing and to protect the mechanism from any harmful vibration, although each unit is extremely rugged and is housed in a duraluminum cabinet.

Accessories

The wind-driven generator is designed to rotate 4000 R.P.M. and is driven by a 500-watt Deslauriers air fan. The rated output is 4½ amperes at 11 volts for the low voltage commutator and 3 amperes at 150 volts for the plate supply. As may be seen from the accompanying illustration the generator can be swung into the cabin when the transmitters are not being used and thus reduce the wind resistance.

The antenna wire, which is wound on the reel shown in Fig. 1, is 41063 inches in diameter and of copper clad steel, which is said to give high conductivity and great strength for a light weight. Two or more antenna fish weights are used and can be drawn up into the plane through the Fair Lead. The antenna reel is of the metal type, having an insulated handle. The Fair Lead—shown above the transmitter in Fig. 1—is so arranged that connection to the antenna wire is made by means of a metal flange at the lower end. 250 feet of antenna wire is used and the two fish weights each weigh approximately ten ounces.

The switch for changing from transmitter to receiver is flame-proof, as is also the transmitting key. These are absolutely air tight and can not ignite gasoline vapor even if it is present in proportions such as to be explosive.

Receiving Equipment

The five small tubes used in the receiver are of low power consumption and are mounted on sponge-rubber to protect the delicate filaments. The single controlled set employs two stages of radio-frequency amplification, a detector and two stages of audio amplification. The wavelength range of the receiver is from 550 to 850 meters, thus insuring no interference from the lower wave channels. The weight of the receiver is approximately 12 pounds.

There is no doubt that radio communication has become an essential to airplanes. With the rapid extension of the radio beacons and direction-finders along our coasts pilots will become more and more dependent upon radio as a guide. For example, Major J. C. Pitzmair, co-pilot of the Braun, said in a recent interview, "We consider wireless absolutely essential for all future undertakings of this nature", referring to the transatlantic flight he had just completed. "As we now realize," he continued, "had we a wireless set on board, upon our estimated arrival in the neighborhood of Newfoundland we could have been given almost our exact position by direction finding stations along the coast, have been informed of the precise direction and velocity of the wind over the sea, and would have made New York easily with our objective accomplished."

It has been estimated that if a pilot flying at the height of 10,000 feet found it necessary to make a forced landing, he could, by capable management, maneuver his plane so that it would be fully twenty minutes before it reached the surface of the water. When it is considered that the full twenty minutes might be utilized in sending out radio calls for assistance some idea of the value of radio in such an undertaking may be had. Vessels carrying a radio compass could determine the position of the disabled plane, if no position had been given, relay the appeal to other ships and speed to the rescue.
Applications of the Photoelectric Cell in Industry

Covering the Various Uses of the Alkali Metal Photoelectric Cell and the Most Desirable Circuits

By Milton Bergstein, Ph.D.

PART I

In the photoelectric cell, industry has at its hand in a practical and economic form a new coordinating device of which the barest possibilities have only yet been realized. An indication of the extent of employment of the photoelectric cell may be gleaned from the statement that visual coordination may now replace mechanical coordination, that chemical processes involving nice regulation may be made automatic, that the human element may be entirely eliminated from the process of seeing, in short—that an additional sense (machines are already endowed with a sense of touch) has been added to mechanical devices to enable them more early to replace the human and fallible factor.

It is the purpose of this article to give detailed information of the manner of employment of the photoelectric cell itself. The machines used in conjunction with the cell may be of familiar or of special types. Mechanically they are no mystery and their construction is not the province of this paper.

Photoelectric cells and their properties will be first described and then the various devices will be classified as to purpose and as to photoelectric properties.

General Information

(1.) The photoelectric cell we are considering is an alkali metal cell in which the surface of the metal has been highly activated by treatment with hydrogen and the output increased by addition of a rare gas. Fig. 1 illustrates such a cell, which has been employed in most of the circuits herein described. An alkali metal cell properly handled will last indefinitely, but there are certain precautions which must be taken.

(2.) Ionization of the gas in the cell to the point of luminosity does it no good. There is the possibility of high current flow which may wreck a meter and vaporize the alkali metal in the tube. Even when the glow is reduced to a minimum it is harmful; the sensitivity of the cell is changed by such treatment and it is some hours before the cell again behaves normally.

(3.) In order to prevent such glow, it is necessary to operate the cell, when used in series with a battery, at a voltage below a certain maximum allowable potential. In the notation used herein, a battery in series with an alkali metal cell or other photoelectric cell is always called a "D" battery. Adjustment of the potential of the "D" battery is discussed hereafter.

(4.) An inspection of Fig. 1 shows that the tube is equipped with a standard 201-A base. The active material is deposited on the plate, which is consequently the cathode; the grid serves as the anode. For simplicity plate and grid are connected to the usual prongs on the base, the other two prongs being dead. There are no other connections on the cell.

(5.) A "D" battery should never be used unless a resistance of at least 300,000 ohms is in series with it and the cell. In this way ionization intense enough to cause destruction of the cell is avoided. The resistance may be obtained in the form of a grid leak, or leaks of 0.1 megohm or more.

Applications

The circuit of Fig. 2 can be used for direct reading photometry, automatic electric light control, counting machines, color sorting machines, stencil cutting machines, control of mechanical processes, automatic titration, smoke detection. The preceding applications are quite general. Color sorting devices include such machines as equipment for the grading of beans and for the sorting of oranges, lemons, limes, and other commodities according to color. The application may be further extended to include in-

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Fig. 1. Phototron KN2, an alkali metal photoelectric cell that is well suited to requirements of industry in general.
spection of small devices for improper polish, for faulty finish, for departure from size and etc. The principal mechanical features of such devices are obvious. The first circuit indicated in Fig. 2 is intended for fine and delicate adjustment and is exclusively battery operated. It is to be used to obtain an increase of current with an increase of light.

(6) Maximum Allowable Voltage of "D" Battery. This paragraph is readable on any circuit in which a "D" battery and a relay operated from the first stage of amplification are used. To determine this value adjust the "B" battery to such voltage that the circuit N to 2 in Fig. 2 is open when the cell is disconnected. This will be known to be the case when a buzzer and battery in the line N to 2 do not operate. Now, insert the photoelectric in its socket and shield it carefully from light. Increase the voltage of "D" until the buzzer works. The maximum allowable voltage of "D" is 20 volts below this value.

(7) Working Voltage of "D" Battery. Under no circumstances operate above the maximum allowable voltage. It is usually possible to work conveniently at even lower voltages. This insures smooth, uninterrupted operation.

(8) "H" Battery. The "B" battery is the battery connected to the plate and filament of the amplifying tube. When using a relay adjust the voltage of the "B" battery so that the relay will operate on the light variation in which you are interested. This is readily determined by experiment. This paragraph is readable on any circuit in which a relay is employed.

(9) Adjustment of 30-ohm Rheostat. This paragraph is readable on any circuit in which such a rheostat is used to control the voltage on the filament. Adjust this rheostat so as to use the minimum possible voltage on the filament.

(10) The relay to be used should be determined by the particular application intended. Light-duty sensitive relays are designed for various current intensities and open and close on certain variations of current. In ordering such a relay one should specify the minimum limit of current intensity on which it should be operative and also whether it is to open or close (or do the same simultaneously or successively) on increase of current. Heavy-duty relays are operated by the light-duty relays. In ordering, one should specify whether they are for A.C. or D.C. use. All the figures are drawn to indicate that when light is shining on the cell the armature rests on point 2 of the relay. When no light is shining the armature rests on point 1.

The "C" battery may be adjusted so that the current flow from filament to plate, when the cell is not illuminated, is almost equal to zero. This is a very sensitive and adaptable circuit particularly applicable in extremely accurate work. In this circuit 1 to 70 megohms resistance at R is indicated. If it is desired to magnify the light effect to a considerably high value (i.e., if the light intensity is extremely low) it is necessary to increase the size of this resistance and the voltage of the "D" battery.

(11) In order to increase the range of operations a number of relays may
be used in cascade as indicated in Fig. 3. We may make the arbitrary assumption that relays 1, 2, 3, and 4 close on 1, 2, 3, and 4 milliamperes respectively. The condition when 3 milliamperes are flowing through the circuit, which is connected to the output terminals is illustrated in Fig. 3. Depending on the current flowing any one of four circuits is closed or they are all open and inoperative.

The circuit of Fig. 4 is the same as Fig. 3 but provided with heavy duty equipment. It is a practical circuit that can be used in large scale operations and can be applied to machinery designed for the purpose indicated in Fig. 3.

This circuit must be employed for actual power operation, because the points on the light-duty relay will not handle the amperage required. It is intended for operation from line currents. Batteries are eliminated except for the "C" batteries. It will be found that adjustments must be made of the resistance, R, and of the voltage of the "C" battery depending upon whether A.C. or D.C. is used.

The principle of a cascade of relays may be extended and applied to this circuit as well as to the previous one.

The circuit of Fig. 5 is also intended primarily for rough work. It cannot be used for fine adjustments. Such devices as counting machines, burglar alarms, smoke detection units, and rough light control equipment are adequately handled by this unit but otherwise its applications are limited.

No "C" battery is used in this arrangement. The voltage on the amplifying tube is adjusted by means of the 500 to 50,000 ohm variable resistance R. The circuit is not limited to 201-A tubes. However, if a tube such as the 100 or the 120 is substituted for the 201-A the resistance R must be varied accordingly so that the filament current should not exceed that prescribed by the manufacturer. In case the change is made it will be necessary to vary also the large resistance R so that the relay should work satisfactorily with the output of the new tube.

Fig. 6 is similar to Fig. 5. This is the practical unit used in control of power equipment. In ordering the heavy duty relay as indicated in paragraph 11, it is absolutely necessary to state whether it is for A.C. or D.C. operation.

(Fig 6 continued)

Fifth Annual Radio World's Fair

Consumer Show Opens September 17 in Madison Square Garden.

Radio Industries Banquet Is Announced for September 18

T he Fifth Annual Radio World's Fair in Madison Square Garden, New York City is announced and take place Sept. 17 to 22, inclusive.

Many new models which were not quite ready for display at the Chicago Trade Show at the Stevens in June are to be shown at the New York show for the first time. It is rumored that the exhibition will also contain a number of models which have been developed since June.

The entire exhibition space in Madison Square Garden with its 60,000 square feet will be filled with receivers and accessories from the factories of two hundred and fifty of the country's leading radio manufacturers. This vast exhibition space is exactly 100 per cent greater than the combined space in the Grand Ball room and the Exhibition Hall at the Stevens Hotel which was required for the Trade Show just over.

Show Hours

The opportunity which the exhibitions provide dealers and jobbers, the country over, to inspect new lines, all under one roof, is an important advantage gained by those attending. To facilitate such contacts the management has arranged at considerable extra expense for special trade show hours, from 11 to 1 P.M. on each day, excepting the opening day, at which time the public is not admitted.

During these two hours dealers and jobbers may leisurely inspect and compare feature for feature, the respective receivers, speakers and accessories that the manufacturers are offering.

Each dealer or jobber wishing to inspect exhibits before the doors are thrown open to the public at one o'clock may obtain credentials for two company representatives by making the request in writing to G. Chayton Irwin, Jr., Show Manager, 1900 Times Building, New York City.

Radio Industries Banquet

The Fifth Annual Radio Industries Banquet, sponsored by the three great groups composing the radio industry, is announced for Tuesday, Sept. 18, at Hotel Astor, New York City. These groups are: the National Association of Broadcasters, the Radio Manufacturers Association and the Federated Radio Trade Association.

What is significant to the radio listeners of the country is that the radio men have deliberately set out, on the night of their banquet, to entertain more radio listeners than have ever been entertained at one time before. Linked together, from 10 to 12 o'clock, Eastern Daylight Saving Time, on this occasion, will be all of the stations of the Red, Blue and Pacific Coast networks of the National Broadcasting Company, the Columbia Broadcasting System, and, in addition, a large number of other stations not included in either chain, but members of the National Association of Broadcasters. The most popular announcer from each of the four networks taking part in the history-making broadcast will officiate before the microphone one fourth of the time.

The general chairman of the Radio Industries Banquet is Paul B. Klucz of Chicago, vice president and general manager of Zenith.

Radio Engineering, August, 1928
NEW OF THE INDUSTRY

ZENITH GAINS MORE AUTOMATIC PATENTS

In addition to the Marvin and Vasselli patents pending the Zenith Radio Corporation, in further strengthening its position, in the central area of Ford Field, 12 Patent No. 1,493,184, British Patent No. 297,158, Canadian Patent No. 361,351, French Patent No. 351,166, and United States Patent Re. 17,954. There are also seven other patents controlled by Zenith, pending in the patent office.

HILER AUDIO TO EXPAND

The successful adjudication and the dedication of the majority of the most important patents, by the Hiler Audio Corp., for the use of the patent, February 15, in the Second District Court of New Jersey, was the opening gun in the program held for the acquisition of the patent holding and manufacturing organization.

Edward E. Hiler, inventor of the tuned double impedance system of audio amplification, has successfully negotiated with various manufacturers and has issued letters of agreement. Negotiations are pending with several others and in the pursuit of the patent organization to license some of the reputable radio receive-manufacturing concerns.

Very successful tests have been recently completed and incorporation of the Hiler system into some of the most popular receivers is only a matter of a short time. The licensees of the Hiler Audio Corp. at this time are Zenith Radio Corp., General Radio Co., American Specialties Mfg. Co., the Conrad Company, Kennedure Laboratories, Inc. and Leslie F. Mott Co.

ACTIVITIES OF THE FEDERATED RADIO TRADE ASSOCIATION

The past Convention of the Federated Radio Trade Associations, held June 11-13 in Chicago marked the beginning of one of the most important steps ever undertaken by any association in any industry. The first step referred to is the re-organization of the Federated R.T.A.'s to provide individual branches for the manufacturers, for the radio wholesaler, for the radio retailer and for the true manufacturers, combining the entire distribution side of the radio industry.

The Federated Radio Trade Association was organized in Minneapolis in 1926. It was originally composed of four associations, namely the Northwest Radio Trade Association, the Wisconsin Radio Trade Association, the Michigan Radio Trade Association and the St. Louis Radio Trade Association. These associations combined for their mutual benefit and through their exclusive and identical interests hoped to benefit the entire radio industry. Other associations, feeling the need for national cooperation and realizing the benefits which they could obtain from the opinions and experiences of other associations, joined this movement to make it truly a nationwide project.

During the year of 1927, the Federated Trade Association has secured many new members and established executive offices at 22 W. Jackson Bldg., Chicago.

As the industry had become more stabilized, the individuals engaged in the distribution of radio apparatus expressed themselves as wanting an organization of their own, whereby they could work on problems affecting their particular division of the industry and yet cooperate with the other branches in the development of the industry. In accordance with this request and suggestions, the Federated R.T.A. started a re-organization program which resulted in the selection of the 1928 Annual Convention. This organization developed through a special re-organization committee that investigated the needs of the various sections and was submitted for approval and adoption during the past Convention. The radio manufacturers were provided for, in the Federated, the first being that of the original local trade associations which is headed by Mr. Michael Re, President of the Wisconsin Radio Trade Association. Then follows the Radio Dealers Association, headed by Peter Simpson, a national organization of radio wholesalers working for the interests of their members. The National Radio Dealers Association, headed by Julian Simpson, working for the benefit of the radio dealers; and the Manufacturers' Representatives Association, headed by Geo. Bueschel, composed of radio manufacturers' representatives, working in an endeavor to better the conditions within the industry. The Federation elects six members to the board of Directors of the Federated which governs the activities of that organization throughout the year. They are in turn governed by their own President and two others and all committed cooperating on their individual problems. These groups, however, through their close connection with the Federated cooperate with each other and are many of the most valuable disputes concerning differences of opinion which take place between associations which have no common meeting ground.

This reorganization represents the first time that the entire distributing side of any industry has been organized and committed in an endeavor to benefit the conditions of the entire industry. The Federated Radio Trade Association has been very active in securing the passage of the Federal Radio Act of 1927, and acting in the passage of the Act of 1927. They have cooperated with the Radio Manufacturers and the National Association of Broadcasters in advising the Federal Radio Commission concerning the interpretation of the present Federal Radio Act. They have been very active in the promotion of schools for radio service men and many of the local associations have established a plan for the examination and certification of all licensees thereby insuring the public of increased service and the dealer of increased profit for the proper servicing of all apparatus. They have been very active in the promotion of local radio trade shows thereby increasing the public's familiarity with radio equipment and providing the dealer with an opportunity for sales henceforth never presented. They have been very active in the solution of interference problems and in the promotion of interest for the boards of directors and clubs as well as doing much throughout the country to strengthen the conditions of the distributors and the radio manufacturers.

The officers and members of the Federated Radio Trade Association are very actively in the interest of the entire radio industry and many of their activities are not mentioned in this brief resume. Their services have been given whole heartedly for the benefit of the industry and they feel themselves entirely compensated for their efforts.

H. R. FLETCHER ELECTED VICE-PRESIDENT OF RACON

The Racoon Electric Company takes pleasure in announcing the appointment of Mr. H. R. Fletcher as Vice-President and Director of Sales of that company.

Mr. Fletcher joined the Racoon Electric Company as Sales Manager, in early days of the Racoon Electric Company, which has been in operation for 18 years.

The production of metalized film has increased largely this year, and shipments to American licensees and to foreign countries has grown very rapidly in the last eighteen months it is stated.

INTERNATIONAL RESISTANCE CO. IN PHILADELPHIA

The International Resistance Company has moved its factory to 135 North 22nd Street, Philadelphia, and is equipped for the manufacture of metalized film and for laboratory facilities.

The production of metalized film has increased largely this year, and shipments to American licensees and to foreign countries has grown very rapidly in the last eighteen months it is stated.

AEROVOLX INCREASES PLANT SPACE

According to R. C. Moore, general manager of the AeroVox Wireless Corporation, the increased demand for his products is such that he is forced to enlarge his plant in the second quarter of this year, and has cut his plant to 35,000 square feet of floor space. He plans to increase his installation to 50,000 square feet of floor space at the AeroVox plant at 70 Washington Avenue, New York. This leaves the total floor space occupied by this pioneer capacitors and vacuum manufacturers up to 35,000 square feet or seven times the space occupied only four years ago.

NEW BELDEN REPRESENTATIVE

The Belden Manufacturing Company, 2500 South Western Ave, Chicago, announces that Wallace R. Lynn, with offices in San Francisco, California, has recently been appointed as their Pacific Coast representative. Mr. Lynn will handle the sale of the company's entire line of electrical insulation which are marketed exclusively through jobbers and dealers.

HAROLD J. WRAPE

President, Federated Radio Trade Association

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H. R. FLETCHER ELECTED VICE-PRESIDENT OF RACON

The Racoon Electric Company takes pleasure in announcing the appointment of Mr. H. R. Fletcher as Vice-President and Director of Sales of that company.

Mr. Fletcher joined the Racoon Electric Company as Sales Manager, in early days of the Racoon Electric Company, which has been in operation for 18 years.

The production of metalized film has increased largely this year, and shipments to American licensees and to foreign countries has grown very rapidly in the last eighteen months it is stated.

INTERNATIONAL RESISTANCE CO. IN PHILADELPHIA

The International Resistance Company has moved its factory to 135 North 22nd Street, Philadelphia, and is equipped for the manufacture of metalized film and for laboratory facilities.

The production of metalized film has increased largely this year, and shipments to American licensees and to foreign countries has grown very rapidly in the last eighteen months it is stated.
KSTP AND WJIB ON RF SCHEDULE

The Radio Corporation of America, 62 West 39 Street, announces that stations KSTP, of St. Paul, Minn., and WJIB, of Newton, Mass., have joined in a national selling arrangement and will devote their schedules to carrying a list of stations broadcasting pictures through the Harison process on their radio schedules. Among the other stations on this list are WMCA, Hotel McAlpin, New York city, which broadcasts a television Wednesday-night special each week; WPMH, Providence, R. I.; WOR, New York city; WIP, Philadelphia; KXOS, Voice of St. Louis, St. Louis; WOKO, Hudson Valley Broadcasting, Rensselaer, N. Y.; WDEL, Wilmington Electric Specialty Company, Wilmington, Del.; WREO, Scranton; WPS, Rochester; WAPI, Bridgeport; and CROW, Detroit.

NEWTON, ILL., IS THE NEW HOME OF THE X-L RADIO LABORATORIES

Here they will be in a ultra-modern plant, built seven years ago by a group of bankers and Brockton business men.

The announcement was made at the annual meeting of the company, at which the following directors were elected: Milton Alden, President and Treasurer; John Pauly, Clerk; Lincoln Davis, Vice President; Charles W. Holland and Marsland A. Davis—the last named from Brooklyn.

X-L RADIO LABORATORIES MOVE TO LARGER QUARTERS

A substantial addition to the capital has been made by Lincoln Davis and the Plymouth County Development Corporation, an interest of Edgar B. Davis of New York, Brockton, and Loilling, Texas. The new building will be in an ultra-modern day-light factory, known as the Plymouth County Development Corporation, and built seven years ago by a group of bankers and Brockton business men.

NAT GREENE NO LONGER MARRIAGE MONIAL PROSPECT

Mr. Nat Greene, Vice-President of the People's Electric Manufacturing Company, was married to Dr. Esther Tuttle of Boston, on Wednesday, the 13th of July, at the Hotel Baltimore.

Mr. Greene, the bride was left for a honeymoon at Lake Placid in the Adirondack Mountains. On their return, they will reside in New York City.

EDelman Receives Single Control Patent

The United States Patent Office has just issued Patent No. 168226 to F. E. Edelman, a Chicago electrical engineer, for a basic single control stabilized radio receiver. The patent claims "A radio amplifier having a series of transformer coupled stages with tuned secondaries included in the grid circuits thereof and adjustable primaries in the plate circuits thereof, means to simultaneously vary said primaries and changes in the tuning of said secondaries in relation to each other for efficient electromagnetic coupling, without undesired feedback effects; a common control circuit for said grid circuits corresponding, varying said electromagnetic coupling, the minimum setting of said secondaries from minimum adjustment thereof."

The patent describes a radio set which effectuates a single control over all broadcast wave lengths and is regarded as an important development. Introducing a series of transformer coupled stages with tuned secondaries included in the grid circuits thereof and adjustable primaries in the plate circuits thereof, means to simultaneously vary said primaries and changes in the tuning of said secondaries in relation to each other for efficient electromagnetic coupling, without undesired feedback effects; a common control circuit for said grid circuits corresponding, varying said electromagnetic coupling, the minimum setting of said secondaries from minimum adjustment thereof."

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NEW WEST COAST REPRESENTATIVES OF DURHAM


New home of Tope in Canton, N. Y., has a floor space of 92,000 ft. and covers six buildings.

NEW MAJESTIC REPRESENTATIVE

The radio trade will be interested in the announcement that Mr. H. E. Bishop, formerly sales manager of Blackman Distributing Company, has joined the firm of Grigsby-Grunow Co., in capacity as special sales representative for the Metropolitan District of New York City, and has been associated with the Blackman Distributing Co. for seven years.

INTERNATIONAL RESISTANCE CO. APPOINTS KILLAN, IN WESTERN SATISFACIY

The International Resistance Co. of 2 1/2 S. 20th St., Philadelphia, Pa., have announced the appointment of Michael Killan, of Portland and Seattle as their representatives in Oregon and Washington.

Supplied stocks of material will be carried at both offices.
ALL-AMERICAN MOHAWK SHOW INCREASE

E. N. Ranland, President. All-American Mohawk Corporation, announces to its stockholders that it has increased its present annual Mohawk Show from 6 to 10,000 face tickets for the benefit of the proceeds of the show will be donated to the company. A new Mohawk Show will be held at the company's Mohawk Theatre in New York City on the evening of June 30, 1928. The show will feature a variety of talent, including dancers, singers, and comedians. The proceeds will be used to support the company's charitable and educational programs.

WUNDERLICH JOINS CARTER

S. E. Wunderlich has been appointed general sales manager of the Carter Radio Company in St. Paul, Minn. He will be responsible for the company's sales efforts in the region.

FOUR NEW KELLOGG DISTRIBUTORS

Recently the Kellogg Switchboard and Supply Company, of Chicago, secured the following four new distributors for Kellogg Radio products: Central Iowa, Moines, Iowa, will represent Kellogg in the state of Iowa. Eastern Ohio, Cleveland, Ohio, will represent Kellogg in the eastern portion of Ohio. Central Missouri, Columbia, Missouri, will represent Kellogg in the central portion of Missouri. Northwest Illinois, Rockford, Illinois, will represent Kellogg in the northwest portion of Illinois.

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C. F. COPELAND, EAGLE SALES

The Eagle Electric Mfg. Co., of Brooklyn, N. Y., wishes to announce to the trade that Mr. Charles F. Copeland has joined the active selling force of this company. Mr. Copeland will act as district office representative in all territories east of the Mississippi—working with the large force of representatives and help build up electrical jobbers business. Mr. Copeland is well known to the trade, having traveled for the Orstetter Electric Company.

GREBE LEASE LARGE FLORIDA BUILDING

Space totaling 13,000 square feet has been leased for a large space building to be operated, of New York City and Los Angeles, in May, 1928, at 1200 South Western Boulevard, Long Island City, New York. The building is designed to be used to consolidate the present shipping and storing of the various departments of the Tele- phone building and will be used exclusively as a shipping house.

By acquiring this new space a large section of the factory at Richmond Hill, Long Island, will be available for the manufacturer of new apparatus. The Ford building is conveniently located, having its own railroad siding and in a close proximity to other transportation facilities.

GREBE JOBBER ON COST CHANGES FIRM NAME

Weinberg-Nichols Company, distributor of A. G. Grebe and Company, incorporated, of New York and Los Angeles, in the Richmond Hill, Long Island City, New York. The firm has been acquired to consolidate the present shipping and storing of the various departments of the Telephone building and will be used exclusively as a shipping house.

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K. W. RADIO CO. HAS NEW TRAFFIC CONTROLLER

To facilitate the handling of the increased volume of telephone traffic at the company's main office building, the company has installed a new traffic controller, which is a high-speed telephone switchboard. The switchboard can handle up to 4,000 calls simultaneously, and is housed in a 10,000 sq. ft. warehouse, which occupies the entire northern corner of Hudson and Clinton streets.

For the delivery of Majestic sets, two more trucks have been ordered.

HILER LICENSES GENERAL RADIO CORP.

Announcement is made that the General Radio Co., of Cleveland, Ohio, has taken out a license to manufacture tuned double-impedance audio couplers under United States patents granted to Mr. Edwin H. Hiler and assigned to the General Radio Co. The new line of general audio Co. parts will include tuned double-impedance couplers for use with conventional tubes and also tuned double-impedance audio couplers for use with the 222-type of screen tubes.

BLINN AND MERRITHEW TO CALL FOR TRADE FOR JENSEN RADIO

Two additional appointments to the sales-organization of the Jensen Radio Manufacturing Co., New York, have been made. They are: F. M. White, general sales manager of the company. These follow-up appointments were made a short time ago by Mr. White, and practically complete the sales organization, which is to call on the jobbing trade and manufacturers in the United States for this company.

ERNST E. YAXLEY PASSES AWAY

Manufacturers, of telephone and radio equipment, throughout the entire country, will be saddened at the news of the death of Mr. Ernst E. Yaxley, President of the Yaxley Manufacturing Co., 29 South Clinton St., Chicago, III., who passed away, July 27th, at his summer home at Port Huron, Michigan, after an illness of several months. Mr. Yaxley was born August 20th, 1860, on a farm near Hillsdale, Mich., and of English parentage. He went to Chicago in 1882, starting his mechanical career in the machine shops of the Thor Wash- Machine Co. From here he went to the Western Electric Company. At both these places his inventive ideas and genius were rapidly recognized, as he designed and perfected many devices in the manufacture of their various products.

Later on his appointments were to the Victor Telephone Company as superintendent for the shops where he developed the present telephone bell now found on every telephone receiver.

In May 1921 when the then existing patents on the receiver took away the profits, Mr. Yaxley, H. C. Hubac- ker, and A. D. Snavely organized the Monarch Telephone Manufac- turing Company at Canal and Randolph Streets. The independency of Mr. Yaxley's receiver proved to be a fateful step, and the company sold out this part of their business and the name was changed to Yaxley Manufacturing Company, which continues promoting and manufacturing their line of time recording systems now found in many of the largest institutions throughout the country.

Mr. Yaxley's experience of the telephony business gave him the knowledge necessary for designing and manufacturing radio parts and apparatus, and the company is one of the leaders in this country today.

According to Mr. White, James H. Blin- n, U. S. National Radio, Denver, Colo., has been assigned to the job of covering the states of Colorado, Utah, and Wyoming, while Harry M. Moore, Krell & Rustic Electric Co., Dallas, Texas, will represent the Jensen Radio Manufacturing Co. in Texas and New Mexico.

Both Mr. Blinn and Mr. Merrithee are well known in the territories which have been assigned to them, and have been identified with the radio trade for a number of years.

SPLITDORF APPOINTMENTS

Spofford Radio Corporation continues to intensify its distributorships throughout the country. The following appointments have just been announced by Hal P. Sweeney, general manager and secretary. At St. Joseph, Missouri—Weeth Hard- man, in charge of the territory in Missouri and Iowa. At Hutchinson, Kansas—Auto Supply Co., a division of D. A. Ellis Company. At Dallas, Texas—Paulcott Bros, whose territory will cover for Spofford central Texas.

RAYTHEON ABSORBS Q. R. S. RADIO TUBE DIVISION

Raytheon Manufacturing Company of Cambridge, Mass., announces that they have absorbed the Q. R. S. Radio Tube Division of the Raytheon Company, in part settlement of the dispute between the latter company and Mr. Ray concerning the infringement of the gaseous rectifying tube patents.

A BULLETIN ON DESIGN OF IRON FUSE ELEMENTS

Ever since smoke power I supply devices first became an important factor in the radio industry several years ago, and especially since the more recent trend of design toward controlled intermediate stages, there has been a very great increase, in the use of a method of designing iron core filters through the use of a chart which must pass both alternating and direct current. Realizing the need of such a chart, before available much of which is applied to technical subjects generally rather than to radio manufacturers, the Raytheon Laboratories prepared the chart and it is now commercially available grades of aluminum sheet.

The results of these studies are now made available in Raytheon Technical Bulletin No. 39, entitled "Design of Iron Core Resistances." This bulletin contains the necessary mathematical data for the calculation of iron core resistances, including permeability curves, incremental permeability curves, design charts in design ranges of direct current, flux density, and a diagram used to obtain the required iron for a given core in direct current.

A copy of the foregoing described bulle- tin is available for the asking by address- ing the Technical Service Department, Ray- theon Manufacturing Company, Cambridge, Mass.

A BULLETIN ON CONSTANT POTENTIAL REGULATION

An ingenious method of automatic compensation for line voltage variations, based on obtaining a uniform output from the primary voltages of two transformers connected in parallel, one only to perform as a capacitive reactance and the other a reactive reactance. This method has resulted from extensive research work by Mr. W. C. Pottier of the Raytheon Laboratories.

A complete review of these research efforts are now published in Raytheon Technical Bulletin No. 38, entitled the "Constant Potential Regulator," by D. E. Replique. Copies of this bulletin may be obtained free by addressing the Technical Service Department, Ray- theon Manufacturing Company, Cambridge, Mass.

WELL KNOWN RADIO MEN JOIN AMRAD SALES FORCE

The following men have recently joined the Amrad sales force, according to Mr. J. A. Lyon, general sales manager. Mr. T. G. Tryfflef will work in the New York territory for Amrad. Mr. H. C. Hubacker will be a radio dealer and for that reason knows the problems of the man who he will contract. Prior to becoming a dealer, he spent several years at sea as a radio operator and has been in the radio busi- ness for over 20 years.

Mr. E. R. Tran, formerly announcer at WGN and the broadcasting station in South- er, New York, and prior to that associa- ting with the Barber Manufacturing Co. Mr. Tran will cover New York City for the Barber Manufacturing Co.

Mr. Edgar K. James has recently joined the sales force of the Maratha Salesman company. Mr. James is well known in the radio manufacturing business and is promised for its value and for the reason of his past experience and know- edge of radio engineering.
The 350 Power Amplifier and B Supply

By Robert Frank Goodwin

In the amplifier to be described one of the new CX-350 power tubes is incorporated. This tube is capable of supplying ample undistorted power for the operation of a heavy duty speaker. It is considered a 25-watt tube, having characteristics quite similar to those of the 371 type, but is much larger and is designed for operation at higher voltages.

Equipment designed for the 350 tube must be capable of supplying the high plate current and the necessary grid bias, which is from -45 to -84 volts as shown in the tabulation:

<table>
<thead>
<tr>
<th>Plate Volts</th>
<th>Grid Bias</th>
<th>Plate Current</th>
<th>Power Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>-45</td>
<td>1500</td>
<td>3500</td>
</tr>
<tr>
<td>300</td>
<td>-48</td>
<td>1400</td>
<td>2500</td>
</tr>
<tr>
<td>250</td>
<td>-68</td>
<td>1250</td>
<td>2250</td>
</tr>
<tr>
<td>200</td>
<td>-84</td>
<td>1100</td>
<td>4000</td>
</tr>
</tbody>
</table>

The filament rating is 7.5 volts, 1.25 amperes. The material used is of the rugged coated ribbon type, similar to that used in the 381 rectifier. This filament operates at a dull red heat. The current required is supplied from the 7.5 volt winding of the power transformer. The low operating temperature and the increased size of this type of filament results in minimum ripple voltage or "hum" when operated from such a source. It is important that the transformer be so designed that the filament voltage at the tube terminal does not exceed 7.9 volts (rated voltage less 3%). The coated filament is not affected by traces of gas, and a slight blue glow will not impair or affect the performance of the tube, provided the resistance in the grid circuit is kept low, so as to avoid a decrease in bias which may otherwise result from a flow of gas current to the grid. The tube is not intended for use in a resistance-coupled amplifier circuit.

A special power transformer is here employed, having two low-voltage secondaries as well as a high-voltage winding for the plate supply current.

It is desirable that the bias required by the tube be supplied from a drop across a resistor in series with the "—B" return, as shown in the schematic drawing. It will be found that this connection compensates almost completely for changes in plate voltage, which may occur as a result of line voltage variations. An increase in plate voltage causes a small increase in plate current which in turn raises the applied "C" bias sufficiently to compensate for the new value of plate voltage, thus maintaining the proper operating condition at all times. If a decrease in voltage occurs, the reverse action takes place. This desirable operating condition is sacrificed if a fixed "C" bias derived from a battery or other source is provided. In such cases a decrease in plate voltage will cause a large decrease in plate current which will greatly decrease the power output obtainable from the tube, while an increase in plate voltage will overload the tube.

Construction

For those who are interested we shall attempt to describe the construction of the unit. The baseboard on which the parts are mounted measures 10 inches in width, 15 inches in length, being one-half inch thick. It should be of well-seasoned hard wood to prevent warping.

The exact specifications for the layout out of the parts is illustrated in the layout drawing. The transformer T-2099 is mounted to the left back of the board, with the double choke unit T-2090 just to the right of it, leaving one-eighth of an inch space between
them. To the right of the choke the condenser block is situated. Before mounting this unit four pieces of solid wire about 6 inches long should be soldered, one to each of the four lugs on the block. It will be noticed that there is a one-half inch space between this unit and the choke. Now the output choke may be mounted to the rear end of the board approximately one-quarter of an inch from its edges. At the front right corner the audio transformer is situated, and between this and the choke coil socket is to be secured. Just to the left of the audio transformer the 1-mfd. by-pass condenser is to be placed, and to the left of this condenser just in front of the large condenser block, the 2-mfd. 1,000 working volt output condenser is to be mounted. It will be noticed that this condenser is mounted close to the large condenser block in order to give the milliammeter sufficient space when the control panel is secured in place.

In mounting the 8,000-ohm fixed resistor unit two or three washers should be placed beneath it to raise it from the baseboard, thereby allowing for air circulation. The two sockets used for the rectifier tubes are mounted in front of the power transformer and choke units, spaced according to the specification given in the layout drawing. In mounting these sockets the prongs are bent upward and the bakelite stamping furnished with them is placed over the prongs, thereby insulating it from the baseboard. With the variable resistances, binding posts, and meter secured to the control panel, the builder may commence with the wiring.

The 4½ volt "C" bias required by the first stage may be procured from the supply portion of this unit. To do this it will be merely necessary to connect a 225-ohm resistor unit at the point marked (X) in the schematic drawing.

In connecting the unit to the rear of the chassis, connecting the plate of the first audio-stage socket to P on the audio transformer should be removed and a flexible lead connecting to the socket is to be brought down to the input post on the eliminator. The rest of the B leads are connected to their respective binding posts on the control panel.

With the tubes inserted vary the 2,000-ohm resistance until the milliammeter reads approximately 50 to 60 mids. The filament of the rectifier tubes should burn at a dull red heat. The plate should not be red, as such will indicate a defective condenser or a short circuit elsewhere.

LIST OF PARTS REQUIRED

Thordarson Power Transformer (type T-2069)
1—Thordarson Choke Coil (type T-2069)
1—Thordarson Audio Transformer (type B-200 or F-300)
1—Thordarson Choke Coil (type B-30)
1—Polymet Condenser Block (type F-1001)
1—Polymet 2-mfd. By-Pass Condenser (type C-2001)
1—Polymet 1-mfd. By-Pass Condenser (type C-906)
6—Ry Binding Posts marked as follows:

The “Advanced Ultra-Six” Super-Heterodyne

By H. G. Cisin

The correct application of the screen grid tube to the super-heterodyne circuit represents a decided advance in receiver design. In the “Advanced Ultra-Six,” the new four element tube is utilized in the intermediate frequency stage with very satisfactory results. The “Ultra-Six” is an improved modification of the “Advanced Ultra-Five.” In the newer circuit, the use of the screen grid tube results in a much more powerful receiver. This gain is especially noticeable on distant stations.

The schematic wiring diagram of the “Advanced Ultra-Six” is shown in the accompanying illustration. An antenna coupling coil (4) is used, thus permitting operation from an outdoor aerial, indoor aerial, or lamp socket antenna. The receiver is tuned to the desired signal by means of a 0.005 mfd. variable condenser. The first tube (6), called the “mixing” tube, has its grid coupled directly to the antenna, no grid condenser or grid leak being used. These are unnecessary, since the plate of the mixing tube is connected through the primary of the intermediate coupler (10) to the grid of the oscillator tube (37) and not to any positive point of the "B" unit.

As a result, the plate potential of the mixing tube is alternately positive and negative, since it varies in unison with the potential of the oscillator grid. Therefore, the plate current flows only at intermittent intervals in the mixing tube and it is possible to regulate the frequency of the positive potential application to the plate by tuning the grid circuit of the oscillator tube. This is done by means of a 0.005 mfd. variable condenser. In this way, the incoming signal is caused to beat with the intermittent surges of current through the mixing tube. As a result, the plate current flowing through the mixing tube is modulated by the incoming signal at any desired frequency.

Volume is controlled by means of a 200 ohm potentiometer (2) shunted across the primary of the antenna coupler.

The intermediate stage, using the screen grid tube, is coupled to the detector by means of a long wave impedance coil (17). The 69 turn rotor is used as a tickler coil. Regeneration is controlled by means of a variable resistance, shunted across the tickler.

Three 250 millihenry chokes are used in this circuit, as indicated on the schematic diagram at (14, 14-a) and (24). Chokes (14) and (14-a) are by-passed by 0.5 mfd. fixed condensers, while choke (24) is by-passed by a .001 mfd. fixed condenser.

The audio frequency portion of the circuit is identical with that of the "Advanced Ultra-Five" except as to volume control. Two stages of transformer coupled audio frequency are...
The top view illustrates the symmetry of the front panel. The middle view is the best arrangement of the apparatus on the base board and panel. Notice that the intermediate frequency tube in the schematic diagram is a screen-grid type.

used. As a speaker filter, an output choke is used, in connection with a 2 mfd. fixed condenser.

Five amperites are specified in this circuit, as shown in the diagrams at (7), (22), (28), (31), and (36). These give automatic filament control and are indispensable in the modern receiver. A cable mounting is shown at (40). This provides a convenient means of making connections to battery and eliminators.

The dotted lines shown on the schematic diagram indicate the apparatus enclosed within shields. Two new style Hammerlund "Hi-Q" type shields are used. Each shield contains two compartments, as shown in the top view of the receiver.

**Tubes Required**

The mixing tube (6), the detector (21), the oscillator (37), and the first audio tube (27), are all type 201-A. The last audio tube (30) is a type 171 power tube. A type 112 tube may be used in this stage, if desired, but of course with the proper grid bias of 9 volts instead of 40 volts as required for the 171 tube. A 222-type screen grid tube is used at (12). Since this tube requires a filament voltage of only 3.3 volts, it is necessary to use a resistor (13) in the circuit, to cut down the battery voltage the required amount. "C" bias of 1.5 volts is obtained by utilizing the voltage drop in a part of the resistor, a tap being provided for this purpose.

**LIST OF PARTS REQUIRED**

6. 1000 mfd. Hammondlund "Mid-Line" Variable Condenser (5).
7. 1000 mfd. Hammondlund "Mid-Line" Variable Condenser (38).
11. Eho Sockets, new style UX type, (6, 12, 21, 27, 30, 37).
12. X-L Variodenser, type G-10 (9).

**Radio Engineering, August, 1928**

2. Thorndarson R-200 Transformers (6, 20).
4. Royalty Variable Resistor, Electroad, type "F" (23).
5. 200 Ohm Yaxley Potentiometer, No. 5200 P (2).
6. 0.5 meg. Duram Metallized Resistor Grid Lead, with Single Duram Vertical Mounting (30).
8. Carter Tip Jacks (34, 35).
10. Amperite No. 112, with M'tg (31).
15. Carter Filament Resistor, type CC-5-15 for Screen Grid Tube (13).
17. Yaxley 12-Conductor Cable complete with Connector Plug & M'tg (40).
18. Can Rester Radio Solder (Iosos Core).
20. Composition Panel, 7" x 20" x 3/16".
21. Sub-Panel, 10" x 25" x 3/16".
22. Brackets, low type.
23. X-L "Push-Pulls" (1, 3).
24. Hammerlund new "HI-Q" type Shields.
27. Shield Grid Tube, 222-type (12).

**Airplane Radio beacon Variations Overcome**

In the work which the Bureau of Standards is carrying on to develop radio aids to air navigation, it was necessary to determine the reliability of the crossed-coil radio-beacons which are used to guide aircraft. Experience has shown that the famous are very reliable in the daytime up to the limit of their distance range. There has been, however, very little information on night reliability.

A series of night flights between Cleveland and New York was made, observing principally the beacon at Bellefonte, Pa., in the middle of the Allegheny Mountains. These flights showed that the beacon was very reliable at night up to a distance of 25 miles and gave accurate bearings most of the time up to 50 miles. Beyond 100 miles bearings observed in this series of flights were usually of questionable value.

Observations made on the ground and in the air indicate that the cause of this shifting of the radio course is a distortion that is introduced in the radio waves as they travel through the upper atmosphere. The nature of this distortion has been carefully studied and analyzed. It is especially pronounced in mountainous regions. By using special antenna arrangements for receiving, it has been found that these shifts can be practically eliminated.
Radio Engineering, August, 1928

N four short years Silver-Marshall, Inc. has forged up from obscurity to the position of dominant leadership in the radio parts and kit field—interesting, you say, just what does that mean to you?

S-M leadership means just one thing—better radio for less money. Ask any one of the thousands of listeners and experimenters who have used and recommended S-M into supremacy. They'll all tell you that S-M leadership means better radio at less cost. And S-M will lead again in 1928 and 1929 by giving you new developments that enable you to enjoy or home-built radio to equal in external finish the finest factory productions, parts that place the performance of such sets utterly beyond competition, and, thru knock-down kits, radio sets that will consistently outperform all ready-made sets at anywhere their amazingly low prices.

New S-M Offerings Now Ready

Never has there been a design which so perfectly fulfills the requirements of the setbuilder as does the new Silver-Marshall 720 Screen Grid Six—successor to the famous Shielded Grid Six of such unparalleled popularity during early 1928. The 720 Screen Grid Six is a six-tube dual control screen grid receiver using three screen grid tubes in individually copper-shielded r. f. stages and two audio stages with the marvelous new S-M transformers—a set absolutely unequaled at the price.

On a summer evening test in Chicago, 41 stations (two on West Coast) were logged, 5 of which (in N. Y., N. J., Fla., Ga., and La. respectively) were on adjacent channels (only 10 kc. apart) to locals then on the air. The 720 Kit, complete without cabinet, is priced at $72.50. Custom-built complete in cabinet as illustrated, it costs $102.00.

And at $51.00 S-M offers the 740 "Coast to Coast" Screen Grid Four—a kit that is a revolution in four-tube results. The 740 Screen Grid Four is the wonder set of the season, and S-M, exclusively, the approved kit at $120.00. It is complete with aluminum shielding cabinet and will bring in 100 stations on any average evening.

The S-M "Round the World" Short Wave sets are the trimmest, most efficient short wave sets yet, priced from $36.00 to $51.00 complete with shielding cabinet. New S-M condensers are marvels of rigidity and flexibility in Universal single, and triple types. The 685 Public Address Unit—the first really high-powered amplifier yet offered—is priced at only $160 wired, or $125 for the kit. It will turn out music or voice that can be heard by 1000 to 10,000 people. Other Unipac and Power Supplies take care of every power need.

Of course, the most startling audio development of the last two years would logically come from S-M laboratories, as it did two years ago. The new Clough audio transformers were deservedly the sensation of the June radio trade show. In open comparative tests, S-M 225 and 226 ($6.00 transformers) have excelled the performance of all competitive types tested, regardless of cost. The 225 and 226 transformers at $9.00 each simply leave the most skeptical marveling.

These and many other startling new S-M parts leave small wonder at S-M leadership. They prove that you can get the best radio for the least cost from S-M.

If you don't want to build, yet want your radio to be supreme, with all the advantages that this implies, S-M, will gladly refer your inquiry to an Authorized Silver-Marshall Service Station near you. If, on the other hand, you build sets professionally, and are interested in learning whether there are valuable Service Station franchises yet open in your territory, please write us. SILVER-MARSHALL, Inc. 854 W. Jackson Blvd., Chicago, U. S. A.

Are you receiving "The Radiobuilder" regularly? Published every month, this little magazine provides you with the earliest information on forthcoming S-M developments and with operating hints and kits that will help you to get the most out of radio.

You can't afford to be without "The Radiobuilder." For besides general news of interest to every builder, it gives advance notice and previews of new products and detailed constructional and operating data on new apparatus before the information appears in the S-M DATA SHEETS.

To S-M Authorized Service Stations, "The Radiobuilder" is mailed each month, free of charge, together with all new Data Sheets and Service Bulletins as they come from press. To all others a nominal charge is made; see coupon.

If you want to keep abreast of the very newest and most practical in radio building developments, be sure to mail the coupon today.

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Silver-Marshall, Inc. 854 W. Jackson Blvd., Chicago, U. S. A.

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Please send me, free of charge, the complete S-M Catalog.

For enclosed... (1 cent) in stamps, send me the following:

SM DATA SHEETS as follows, at 5c each:

No. 1 6750 ABC Reserve Power Unit
No. 2 6751 Public Address Unit
No. 3 6752 "Round-the-World" Short Wave Sets
No. 4 225, 226, 255, 256, 251 Audio Transformers
No. 5 720 Screen Grid Six Receiver
No. 6 "Coast to Coast" Screen Grid Four
No. 7 675ABC Power Supply and 675 Dynamic Speaker Amplifier

(SM) Sargent-Rayment Instruction Booklet

Name

Address
SAMSON MICROPHONE INPUT AMPLIFIER

The Samson Electric Company, of Canton, Mass., have announced the MIN I microphone input amplifier. This unit is designed for use with the EAM series of power amplifiers or wherever it is desired to transmit the pickup of a two-button microphone for public address purposes. The unit consists of a microphone input transformer, type 227 coupling tube, enter-

at forty or fifty feet from the radio set, and at the same time will have complete remote control of the radio set, switching the current supply on and off.

The Hololyke Company is pleased to announce having acquired the Deluxe Manufacturing Company, whose plant was formerly located in New York City. This arrangement will increase their production considerably.

DUBLER DRY "A" CONDENSERS

The Dumbler Condenser Corporation of New York City now announce the Dumbler Dry "A" Condensers designed for use in A-power circuits. These polarized condensers are designed for use in all circuits employing unidirectional or direct currents up to 15 volts, where high capacities are required. The Dumbler PL 417-A Dry "A" Condenser units are rated at 7000 MFD. Dielectric is tantalum ware method of measurement and are especially designed for use in a-battery elimination work. These new condensers possess many desirable characteristics which are now in this branch of the condenser art. For example, it is claimed that the leakage of these condensers is less than 1 milliampere as compared with 9 to 18 milliampere and more for the usual "A" condensers now available. This feature insures a long life for these new condensers. An exceptionally rugged internal construction is employed, together with heavy electrodes, and a scientifically designed home dry electrochemical dielectric.

Dumbler Dry "A" condensers are available in three sizes of 2000, 4000 and 6000 MFD. capacity.

SILICON STEEL CORE LAMINATIONS

The Lamination Stamping Company, of 761 Windsor St., Hartford, Conn., have brought out a number of standard assembled transformer and choke core laminations to meet radio requirements.

The new Samson Microphone Input Amplifier. The unit is complete in itself, having its own A-B-C power supply.

HOLYOKO COMPANY ANNOUNCES NEW PRODUCTS

The Hololyke Company, of 621 Broadway, New York City, with Mills at Hololyke, Mass., manufacturers of high insulated weather-proof wire, also in high insulation radio wire, have incorporated their products into the manufacture of special forms and wiring harnesses for radio and electrical apparatus manufacturers who have completed wiring devices.

The progress and development of radio cells for a higher degree of insulation and more rigid specifications than heretofore, and the precision of manufacturing today must be accurate to meet with the high standard specifications. For example, twist cords, in which they are leaders require a much higher cutting power than formerly, mainly on account of the advent to the dynamic speaker.

AC Supply Cords. The specifications on these are extremely rigid on account of the precision in alternating current sets. A badly constructed cord in this connection would produce hum, which would be entirely unsatisfactory.

Hook-up Wire. In this the Hololyke Company have prided themselves for many years, and as radio has progressed specifications have become more rigid. The Engineering Department of the Hololyke Company after experimentation have been successful in producing a material with a higher insulating value than the ordinary bee wax and the dielectric contained in the new Hololyke Hook-up Wire is equivalent to that of Bakelite. It is claimed.

An interesting item which the Hololyke Company is marketing for the consumer trade on which patents have been applied for is what is known as an electric control cord, which enables a speaker to operate...
In Most of The Better Radio Receivers

Watch dogs of tone quality safeguarding the musical reproduction of broadcast programs, Thordarson Audio Transformers do their part in making real musical instruments of hundreds of thousands of receiving sets annually.

Among leading set manufacturers, Thordarson transformers have long been recognized for their fidelity of reproduction. Today their use is so universal that it is difficult to find a dealer who does not sell at least one make of receiver so equipped.

Try this simple experiment. Ask your dealer for a demonstration of his receivers. Pick out the instrument with the most natural reproduction, and then look inside the cabinet. You will find, in the majority of cases, Thordarson amplifying and power supply transformers.

You will realize that it is wise to specify Thordarson amplification when buying your receiver, for the manufacturer who is far-seeing enough to equip his sets with Thordarson transformers, may be depended upon to have the balance of his instrument in keeping with this high standard.

THORDARSON RADIO TRANSFORMERS

Supreme in musical performance

THORDARSON ELECTRIC MANUFACTURING CO.

THORDARSON ELECTRIC MANUFACTURING CO.

THORDARSON ELECTRIC MANUFACTURING CO.

**new!**

THORDARSON

*R-300*

AUDIO TRANSFORMER

A superior audio transformer that will satisfy the most critical musical ear. The high impedance windings of the R-300 are wound on a core of D-X Metal, a recent development of the Thordarson laboratory. This new core material has an exceedingly high A.C. permeability, and an inductance that is 50% greater than that of the highest grade silicon steel.

In performance, this transformer responds exceptionally well to the lower frequencies and provides the same degree amplification to the diapason of the grand organ as to the note of the flute. Ratio 3:1. Dimensions, 2½" x 2½" x 3" high. Weight, 2 lbs. Price, $8.00.
The RCA Output Transformer, now available, is intended as an efficient coupling means for outputs in excess of 10 milliamperes of direct current. It serves to bypass the direct current component with minimum resistance so as to operate the power tube at highest efficiency while transferring the alternating current component to the loudspeaker. In this manner the delicate coil windings and mechanisms of the loudspeaker are protected from damage against excessive direct current, which might result in demagnetization and even burn-outs when the loudspeaker is connected directly to power tubes or multiple tube amplifiers.

When employing the RCA Radiola 300-A, with any of the present models of RCA Radiolas, the output transformer accessory is not required since loud-speaker coupling systems are incorporated in the receiver itself.

FLECHTHEIM 250 CONDENSER BLOCK

Supplementing their line of high grade bypass, filter and high voltage condensers, the A. M. Flechtheim & Co., Inc., of 136 Liberty St., New York City, have added a new condenser block designated as Type IX-250. This condenser pack is designed for use with the new 250 power tube, and of course, can also be used with the 210 tubes.

It is tapped as follows: 0, 2, 2, 4, 4, 1, 1 Mfd. The first 2 Mfd. unit which connects across the output of the oscillator tube, either a type 260 or 281, delivering about 500 volts of pulsating D.C., has been made to withstand a continuous operating potential of 1000 volts D.C. There is an excellent safety margin, which will protect valuable tubes and apparatus, if employed.

The Flechtheim Co. has recently issued a supplement to their catalogue which will be sent upon request.

"UNIVERSAL" FOUR COIL WINDING MACHINE

The "Universal" Four Coil Winding Machine, manufactured by the Universal Winding Co., of Boston, Mass., has been developed to economically produce paper insulated, meter, relay, ringer, controller, transformer and transformer coils of various types. This machine winds self-supporting circular or rectangular coils in which adjacent wire turns are laid parallel to one another with insulating paper automatically inserted between the layers of wire. If handles condensers, even to No. 29 and No. 44 B.W.G. sizes, the mechanism for inserting the paper will accommodate paper wide enough for coils sized by the use of two supplies and two wire guides on each side of the machine. The double coil is wound on each side of the single unit. To correct any porosity existing in a single layer of insulating paper, the machine can be set to insert and cut off as many as four layers of paper between layers of wire, without slowing down.

Attachments for small or large diameter coils can be supplied. Fitted with one component the machine will wind coils from 1/2 inch to 2 inches in diameter; other attachments are available to produce windings from 1 1/4 inches to 4 1/2 inches and from 3 inches to 9 inches in diameter.

ROLLEr-SMITH PORTABLE, DIRECT READING CIRCUIT TESTER

The Rollr-Smith Company, of Bethlehem, Pa., have introduced a portable, direct reading circuit tester, known as the HTD Circuit Tester. The uses of the HTD Circuit Tester are twofold. The instrument can be used to ascertain if there is an electrical circuit existing between conductors applied to the terminals of the instrument and, secondly, it enables the user to determine the resistance of the circuit under test. The HTD Circuit Tester is recommended for use in preference to magnetic A.C. tester, devices because of its accuracy of indications under all conditions and its lightness and compactness as well. The instrument measures a 1 1/2" x 1 1/2" x 1 1/2", which dimensions are obviously much less than those of the conventional magnetic outlet. Likewise, its light weight of 10 ounces commends it when compared with the bulkier and heavier magnetizers. Indications on the HTD Circuit Tester are never misleading, whereas, the alternating current and low initial cost. Its design is such as to make it an ideal instrument for the rapid measurement of coil and resistance units on a quantity production basis. The instrument is entirely self-contained—there are no loose parts that may become lost.

The instrument case is of black walnut. The overall dimensions are 2 1/2" wide, 9 1/2" long and 4 1/2" high. The net weight is 2 1/2 lbs. A stitched leather handle is attached to the upper end and heavy rubber feet are provided on bottom of instrument. There are four ranges as follows:

<table>
<thead>
<tr>
<th>Range</th>
<th>Value</th>
<th>Range</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>in Ohms</td>
<td>per Div.</td>
<td>in Ohms</td>
<td>per Div.</td>
</tr>
<tr>
<td>3-5</td>
<td>50 Ohms</td>
<td>200-500</td>
<td>10 Ohms</td>
</tr>
<tr>
<td>5-10</td>
<td>100</td>
<td>2000-5000</td>
<td>20 Ohms</td>
</tr>
<tr>
<td>10-20</td>
<td>200</td>
<td>20000</td>
<td>50 Ohms</td>
</tr>
<tr>
<td>20-50</td>
<td>500</td>
<td>200000</td>
<td>100 Ohms</td>
</tr>
<tr>
<td>50-100</td>
<td>1000</td>
<td>2000000</td>
<td>200 Ohms</td>
</tr>
</tbody>
</table>

The battery for this ohmmeter is self-contained, and consists of two standard cylindrical flash light cells each 1/2" in diameter. The capacity of the battery is such that the instrument will operate for at least one year on a single charge. The battery is easily replaceable by the use of an adapter. This adapter is a small metal plate which can be operated by two fingers of the hand. This plate is inserted in the mouth of the terminal in which the battery takes its place. The battery can be operated on a dry cell rendered accessible for replacement by the removal of this plate also gives access to the internal zero adjuster.

The scale reads directly in ohms from zero to 10,000 which enables resistance readings of the circuit under test.

The instrument is enclosed in a heavy sheet metal case with black finish and is equipped with nickel-plated binding posts. An etched metal instruction plate is attached to the front of the instrument giving instructions regarding replacement of the battery and 2 1/2" long magnet which can be operated by the removal of three screws the instruction plate can be taken off and the dry cell rendered accessible for replacement. The removal of this plate also gives access to the internal zero adjuster.
FOR LONG LIFE
USE

ACRACON

OIL PROCESSED
FILTER CONDENSERS

"Reckoned in Years—Not Hours"

Do not confuse ACRACON CONDENSERS with the ordinary wax impregnated type.
It is only by the use of our special oil process that such great life can be expected of them.

CONDENSER CORPORATION
OF AMERICA
259-271 Cornelison Ave., Jersey City, N. J.

Insure the ELECTRICAL RELIABILITY of your Products

I N no branch of industry do instruments serve a more important function than in the manufacture of electrical equipment. In the average industrial plant, switchboard and portable instruments are employed for economic power control and general maintenance tests. But the manufacturer of an electrical specialty has need not only for these types but for many others to meet his specific problems and to insure the quality of his product.
In thousands of factories throughout the entire world Weston instruments are shouldering the responsibility for the published claims of advertised products. In the realm of scientific research, in the routine testing of specification materials and in every production operation where measurements of the utmost reliability are essential to the maintenance of highest quality—there you will find "WESTONS."

With the Weston Direct-Reading Ohmmeter

The measurement of electrical resistance is a universal requirement in the manufacture of products employing resistance units or other parts required to have definite resistance.
The Model One Ohmmeter is especially designed for this class of work. It is direct reading, like an ordinary voltmeter and its speed of operation offers many advantages over other methods of measuring resistances.
The Model One Ohmmeter may be operated on ordinary dry cells. No auxiliary rheostat, voltmeter or other apparatus is required.
It is made in triple ranges and in convenient combinations from 0 to 10,000 ohms. It has a guaranteed accuracy of 1% of full scale value at temperatures from 10 deg. C to 30 deg. C.
Write for full particulars contained in Bulletin No. 501-G. We shall be pleased to assist you with any specific problem. It involves no obligation.

Weston Electrical Instrument Corp.
612 Frelinghuysen Ave. --- Newark, N. J.
Two fine wires can be connected or disconnected in a fraction of a second by the use of an adapter. The use of this pointer has proved of very great value in the quantity production of coils.

Resistances may be read to within an accuracy of approximately 1% of their value from the "5" mark to and including the "30" mark, at which latter point the operator should shift to the next higher ratio to get best results.

**RIDDLE "MEGGER" DIRECT-READING OHMMETERS**

"Megger" Ohmmeters comprise a complete line of direct-reading instruments for the rapid measurement of resistance, from as low as .01 ohms up to 3000 megohms (5,000,000,000 ohms). They are designed especially for factor production and laboratory use, being arranged for operation from an external source of direct current, and are used extensively by radio manufacturers for insulation tests of condensers, transformers, speakers, complex sets, etc., also for measuring grid-leaks and resistors.

"Megger" Ohmmeters are similar to the well-known "Megger" Testing Sets (used by Power Companies, Telephone Companies and electrical manufacturers, etc.) in that they contain a free ohmmeter of the differential moving coil, permanent magnet type, which indicates the results directly, with no adjustments whatever. They differ from the "Megger" Testing Sets in that the hand-generator is omitted in favor of external operating voltages which may be 120, 60, 12, 115 or 280 volts A.C. or 12, 60, 12, 115 or 280 volts D.C. The instrument is provided with a pointer which moves so that the resistance value can be read directly from the scale without the aid of an arithmetical calculation.

**JAGABI SLIDING-CONTACT TUBE RHEOSTATS**

These consist of resistance wire or strip, wound on porcelain-enameled iron tubes, with a slider which operates freely from one end of the winding to the other. Tubes 8", 16" and 20" long, together with various sizes of resistance wire or strip give a wide measurement of current capacities and resistance values—from as low as .01 ohm. 25 amperes up to 30,000 ohms. 1 ampere.

Non-inductively wound Rheostats, also Rheostats for operating at high voltages are available in tubes having thick walls of solid porcelain. The absence of all iron core makes these Rheostats suitable for very high frequencies as well as high voltages.

**EISLER ELECTRIC WELDING MACHINE**

The constant demand by manufacturers of radio tubes and allied industries for an efficient, fine welder has been met by the introduction of a new type electric welding machine, made by the Eislern Engineering Company.
Latest Additions to the

**POWERIZER**

Reg. U. S. Patent Office

Powerizer A—for filament supply and "C" bias 226, 227 and 171 tubes.

Powerizer 171—gives "A" and "B" supply, as well as "C" bias for 226, 227 and 171 tubes.

D-C Tube Powerizer for UX-199 and UX-222 Shielded Grid Tubes designed for use where AC Tubes cannot be used.

Radio Receptor Co.
106 Seventh Avenue
New York City

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**Quality Transformers**

The General Radio Company announces a new group of high quality transformers at a direct to the consumer price. This new group consists of two instruments, the type 585-D and the type 585-H, the characteristics of which are shown below.

**Type 585-D**
- Ratio: 1:2
- Price, either type: $7.00

**Type 585-H**
- Ratio: 1:3.5

**Specifications:**
- Type 585-D
  - Pri. Inductance: 79 H
  - D.C.R. Pri.: 2000 ohms
  - Sec. Inductance: 316 H
  - D.C.R. Sec.: 9300 ohms
  - Turns Ratio: 1:2

- Type 585-H
  - Pri. Inductance: 71 H
  - D.C.R. Pri.: 2000 ohms
  - Sec. Inductance: 866 H
  - D.C.R. Sec.: 11,000 ohms
  - Turns Ratio: 1:3.5

**NEW PRICES.** Write for new catalog No. 930 listing new low prices on all General Radio parts on a direct from the factory basis.

**GENERAL RADIO CO.**
30 State St., Cambridge, Mass.
274 Brannan St., San Francisco, Calif.

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A Good Circuit Deserves It!


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**Hammarlund's**

New "Battleship" Multiple Condenser

B RUTE strength and beauty of design characterize the new Hammarlund "Battleship" Multiple Condenser—leader of the gangs. Warpless, die-cast frame; plates permanently aligned; freemoving rotor. Terminals mounted on Bakelite strip beneath the frame.

The sections of this condenser are matched to within one-fourth of one per cent (plus or minus)—the closest precision obtainable. Recesses in the frame permit the direct attachment of Hammarlund Equalizing Condensers for exactly balancing each unit. The shaft is $\frac{3}{8}$" for strength, turned down at the end to fit $\frac{3}{4}$" dials.

Obtainable in two capacities (350 mmfd. and 500 mmfd.)—dual, triple and quadruple models—at prices of interest to the manufacturer and custom-set builder.

Write for Hammarlund literature and ask for quotations on your requirements.

**Hammarlund Manufacturing Co.**
424-438 W. 33rd St., New York, N. Y.
source of current, either 110 or 220 volts.

Two styles of transformers may be used. In 3/4 and 1/2 inch thicknesses of which depends entirely on the skill and the work in question. The machine as in Fig. 1, is directly connected to the

---

**Fil Fig. 1. Eister Electric Welding Machine**

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**NEW WILLIAMS-HUSKY COMBINATION ELECTRICAL SET**

Here is another new Williams-Husky Combination Wrench Set made possible by the recent reciprocal sales agreement between J. H. Williams & Co., Buffalo, N. Y., and the Husky Wrench Company, Milwauk e.

This arrangement enables each Company to merchandise Combina
tion Sets the other's quality Open-End, and Socket Wrenches. It is made for sales purposes only and is limited to the items which constitute these sets. For the other items see J. H. Williams, 655 Broadway, New York. The Husky Wrench Set is claimed to be the only complete assort
tment of Socket and Combination Wrenches. The Williams and Husky Wrenches are so designed that a variation of 10% will have practically no effect upon its operation or life. In other

---

**WILLIAMS MIDGET ELECTRICAL SET**

In order to care for a need, long felt by radio men, mechanics and electricians, J. H. Williams & Co. of Buffalo, have just placed on the market a set of special wrenches to facilitate the making of small adjustments such as occur most frequently in electrical work. The new kit, known as The Midget Electrical Set, contains seven 'Super wrenches', with openings running from 7/32 to 4 1/2 inches, which have two openings of the same size, but set at different angles, 15 and 75 degrees.

It is claimed that where one head cannot be used, the other head of the same wrench, an addition to Williams 'Superwrench' line, are drop-forge from Chrome-Molybdenum steel and finished in rust proof Chrome plate. In spite of their small size and extreme thinness, all are guaranteed against breakage.

Although designed primarily to handle the small, awkwardly placed nuts, bolts and capscrews so frequent in generators, motors, transmitters, radios and other electrical devices, this new kit is also handy for fine adjustments. Wherever: small wrenches are required it is sure to find innumerable uses. The seven Midget Super wrenches' are contained in a black leatherette carrying case which, when closed, measures only 5 1/2 x 3 x 3/4 inches. This convenient size for carrying in either side pocket and is also handy for the tool box or the side pocket of a coat.

---

**APMITE LIN-A-TROL**

The experience in operating radio re
covers from the circuits during the past year has clearly demonstrated the need for line voltage regulation. The regulating current tubes are so designed that a variation of 10% will have practically no effect upon its operation or life. In other

---

**NEW ACME WIRE PRODUCTS**

The Acme Wire Co. of New Haven, Conn., have brought out three new wire products for the radio field, as follows:

**TWISTED A.C. CELATITE**—This consists of one strand of each and one strand of red 16/30 flexible Celatite wire. The wire is designed to meet the requirements of testing practically all the other conductors consisted of 16 strands of 30 wire, which are ample for their purpose. The product is a universal hook-up wire for general purposes. The wire properties of each coil of wire are recorded and therefore easily worked. Being soft, it will not break easily. The most interesting part is the insulation which is a treated non-fiber. It is just loose-fitting enough so that it can be packed back from the wire and the wires the connection has been made the insulation can be drawn back, again, thus leaving no exposed wire.
CONDENSER TISSUES
OF UNIFORM QUALITY

Made of the highest grade materials

Mill at 182 Cornelison Ave., Jersey City, N. J.

PETER J. SCHWEITZER, INC.

200 Fifth Avenue

New York City

DEPENDABILITY

BROWN & CAINE
INC.

QUALITY

SERVICE

BEE CEE

FIXED CONDENSERS

2317-19-21-23 CALUMET AVENUE
CHICAGO, U. S. A.
Confidence in Polymet quality.
Confidence in Polymet service.
Confidence in Polymet dependability.
Confidence in Polymet to produce the best in every electric set essential led to the adoption of Polymet by two-thirds of the R.C.A. licensed radio manufacturers. It's the "little bit more" put into Polymet Products that brings the results which inspire this Confidence.

We don't ask your confidence 'till we've won it.

Send for our new catalogue showing the complete line of Polymet electric set essentials.

POLYMET MANUFACTURING CORP.
601 Broadway, New York City

POLYMET PRODUCTS

THE tremendous increase in popularity of powerful amplifiers and power units has brought with it an insistent demand for modern condensers and resistors, built to rigid standards and according to all improved methods.

Aerovox condensers and resistors are meeting the most rigorous tests imposed by modern power equipment. They are built to stand up under the severest service conditions.

Write for "The Research Worker" a free monthly publication that will keep you abreast of the latest developments in radio.

66 WASHINGTON ST., BROOKLYN, N. Y.

AMERTRAN DE LUXE

First Stage turn ratio 3 1/2 $10.00
Second Stage turn ratio 4 \ Each

Standard of Excellence in Audio Amplification

AmerTRAN De Luxe Transformers are but two of more than 30 quality Radio Products bearing the name AmerTRAN, including power transformers, choke coils, push-pull systems and allied products. Each AmerTRAN device is designed for a specific use. Full and authoritative information will be given on any audio or power problem.

AMERICAN TRANSFORMER COMPANY
Transformer Manufacturers for 28 Years
104 Emmet St., Newark, N. J.
There is but one A-BLOCK

3 units of 2500 Mfd. capacity assembled within a space of 2½” x 4” x 5”. Not 7500 Mfd. (mere words) but by actual measurements.
Guaranteed to operate faithfully when used in an approved unit and will not change its capacity. To be DRY CONDENSER (high capacity) made to any capacity or specifications.
Manufacturers submit specifications for quotations and sample TOBE A BLOCK (DRY High capacity Condensers).
Increased facilities in our new Canton Plant permit large production at low costs.

TOBE DEUTSCHMANN CO.
CANTON, MASSACHUSETTS

COIL FORMS
Made Round and Stay Round

“Coil-O-Form” Precision Tubing
This tubing can be supplied in all lengths and from 5/16 to 5 inches inside diameter with walls from .009 inches up in thickness. The tubing is especially treated so that it is moisture-proof, has a high dielectric strength and is exceptionally strong. Holes may be punched more cleanly than in any other forms and the breakage and spoilage has been reduced to a minimum. Forms may be obtained
punched to specifications if required.

<table>
<thead>
<tr>
<th>Tolerances</th>
<th>Inside diameter</th>
<th>Inside and outside</th>
<th>Outside diameter</th>
<th>Outside and inside</th>
<th>Length</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>± .001 inch</td>
<td>± .001 inch</td>
<td>± .002 inch</td>
<td>± .002 inch</td>
<td>± 1/128 inch</td>
<td>± 1/128 inch</td>
</tr>
</tbody>
</table>

Precision Moving Coil Forms for Dynamic Speakers
For this type of coil must have a minimum weight, maximum uniformity and rigidity. These forms have the same physical properties as the “Coil-O-Form”. A form may be obtained which has more than one outside diameter, greatly facilitating manufacturing operations.

Pilfer-Proof Mailing Cases
These mailers which can be mailed first, third or fourth class, are superior to the old screw-end mailing case in that the address label seals them against pilferage of the contents. They eliminate difficulty in removing the contents should the screw cap become damaged. They can be obtained in a wide range of diameters and lengths and in the following constructions: Fibre body and cover with metal bottom; fibre body with metal cover and bottom; all fibre. Properly labeled they make ideal containers for dry cells, grid leaks, resistance units, screw machine products, etc.

Engineers and manufacturers are invited to communicate with us. Samples on request.

CROSS PAPER PRODUCTS CORP.

Third Ave. at 140th St.
New York, N.Y.
Designed for Every Circuit
TONATROL
A Complete Line of Volume Controls

BY incorporating Tonatrol in the receiver you build, you can control the volume from your loudspeaker smoothly, from the faintest whisper to the resounding intensity of a brass band.

Tonatrol Volume Controls are designed in types to meet the specific requirements of all types of circuits. There are specialized volume controls for A.C. circuits as well as for the conventional battery type receivers. Can be had with filament switches or power switch attached. Eclatrol specializes in a full line of Controls for all Radio purposes.

Dept. L-8
175 Varick Street
New York

Guaranteed to Stay Accurate
It IS one thing to build a resistor that shows up well in a quick test and decidedly another to give it a month's trial carrying the work-a-day load before testing it. The difference in accuracy can be and often is surprising.

Test Har-field Resistors for a month or a year. Day after day they will carry the load they were built to carry, and maintain the accuracy your order specifies. For Hardwick, Field, Inc. have built the accuracy into their resistors that enables them to honestly make their guarantee.

Har-field Resistors are made in two types of coating—the vitreous enamel or specially processed cement. They come in a wide range of values to suit every need, and large quantities of any type or size can be quickly supplied. Prices are low enough to demand consideration from every careful purchasing agent and individual.

Tell us about the resistor you want and we will gladly make up samples for you with prices.

HARDWICK, FIELD, INC.

ALHAMBRA
CONE SPEAKER PAPER

ALHAMBRA PAPER gives ABSOLUTELY UNIFORM RESISTANCE and is also EXCELLENT for CONSTRUCTION and the small cloth and interleaf ribs of some do not equal in soft, natural tone the separate cone made of ALHAMBRA which is used by both class makers.

Core laminations are made to meet the requirements for the coming season. ALHAMBRA is furnished in sheets suitable for cone makers of 12 inches to 24 inches diameter—special sizes to order. Prompt shipment guaranteed.

The SEYMOUR CO., 332 W. 16th St., New York City

CORE LAMINATIONS
for Audio & Power Transformers — Chokes
A large variety of standard shapes carried in stock.
Special designs stamped to your order.

Our BOOKLET on LAMINATIONS (sent on request) gives specifications of Standard Shapes, and contains much data of value to the designer and buyer.

Lamination Stamping Company
764 Windsor Street, Hartford, Conn.

WIRE
STRAND—Antennae (plain or enameled)—Double Galvanized.
WIRE—Antennae (plain or enameled). Connecting and Ground (Rubber covered, braided or plain).
BUS BAR—Litze-Drift-Loop.
MAGNET (Cotton or Silk).

John A. Roebling's Sons Co., Trenton, N. J.

COPPER, BRASS, PHOSPHOR BRONZE
We specialize in the manufacture of rolled metals 001" thick and thicker, either plain or enameled, for RADIO MANUFACTURERS
Good deliveries; prices right; expert mill supervision.
THE BALTIMORE BRASS COMPANY
1206 Wicomico Street
Baltimore, Md.

CONDENSER PAPERS
OF
High Dielectric Strength
LINEN AND CELLULOSE
IN ALL CALIPERS
LIBERAL STOCKS CARRIED IN NEW YORK ROLLS FOR TESTING ON APPLICATION

FRED C. STRYPE
140 Lafayette St.
New York City
HEAT-proof
WARP-proof

For POWER Circuits

The Centralab Power Rheostat is constructed of heat proof materials with sufficient insulation to carry a continuous current load at a power dissipation of 35 watts or more.

An ideal unit to place in primary leads as a line voltage compensator. Has three terminals and is especially adapted to AC tubes and power circuits. Wire is wound on metal core, asbestos-insulated. Wire firmly held in position by reason of metal core and wire expanding to the same degree.

Diameter 2", 1" behind the panel. Single hole mounting. Bakelite knob.

Other products are Centralab Radiohms, Modulators, Potentiometers, and Standard Rheostats.

Central Radio Laboratories
25 Keefe Ave.
Milwaukee, Wis.

SEND
for Folder 126. It shows the correct application of resistances in receiver and power supply circuits.

ZINC-FOIL
(MIKROFOIL)

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Addresses of companies listed below, can be found in their advertisements—see index on page 70.

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Here's Television Simplified

YES, JUST THAT. Of course we are still struggling with the existing crude technique of neon lamp, scanning disk, and variable speed motor for the reception of television signals, but we have solved the two most difficult problems confronting the television experimenter, namely: how to control the luminosity of the neon lamp, so as to obtain the proper contrast between lights and shadows, and how to control the scanning disk, so as to keep in step with the transmitter. Both problems have been solved by our Engineering Staff, using the proper types of CLAROSTAT, as follows:

**HOW TO CONTROL LUMINOSITY**

The voltage applied to the kino-lamp or neon glow tube is of a critical value in assuring the desired contrast between lights and shadows. In fact, a satisfactory image, incorporating sufficient detail and luminosity, is largely a matter of having the proper direct-current voltage to assure the normal glow and yet low enough to permit of ample contrast with the increased brilliancy due to signal modulation. The above diagram presents an improved form of output circuit for the power tube operating the kino-lamp, in which the applied voltage is delicately adjusted by means of a Standard CLAROSTAT.

**HOW TO OBTAIN SYNCHRONISM**

Absolute synchronism is required between the receiving scanning disk and the transmitting scanning disk. For the present, the most satisfactory method of obtaining synchronism in television reception is manually. However, a precise motor speed control greatly aids in obtaining a minimum distortion of the image. The arrangement shown in the diagram below assures positive and precise control of the scanning disk by means of a special Power (100-watt) CLAROSTAT. A push-button short-circuits the resistance for momentary speeding up of motor for getting into proper step. The operation is as simple as keeping your ear on the road.

And for Every Other Radio Purpose—

Television, representing the most precise radio technique known today, can be materially simplified in other ways. The delicate screen-grid r.f. amplifier can best be controlled with the Volume Control CLAROSTAT; the short-wave detector is more sensitive if provided with the Grid Leak CLAROSTAT and the Volume Control CLAROSTAT for regeneration control; the resistance-coupled amplifier has a flatter curve if precise and silent resistance as provided by the Duplex CLAROSTAT is employed; and the power supply unit is more accurately matched to voltage requirements if Power, Standard and Duplex CLAROSTATS are used. In short, there is a CLAROSTAT for every radio purpose—when better radio is wanted.

ASK for our literature on the complete line of CLAROSTATS. Write on your firm letter-head and we shall be pleased to place your name on the mailing list to receive our monthly technical bulletins on better radio practices. And when you have special problems to solve, ask our engineering staff to give you a hand—without obligation, to be sure.

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