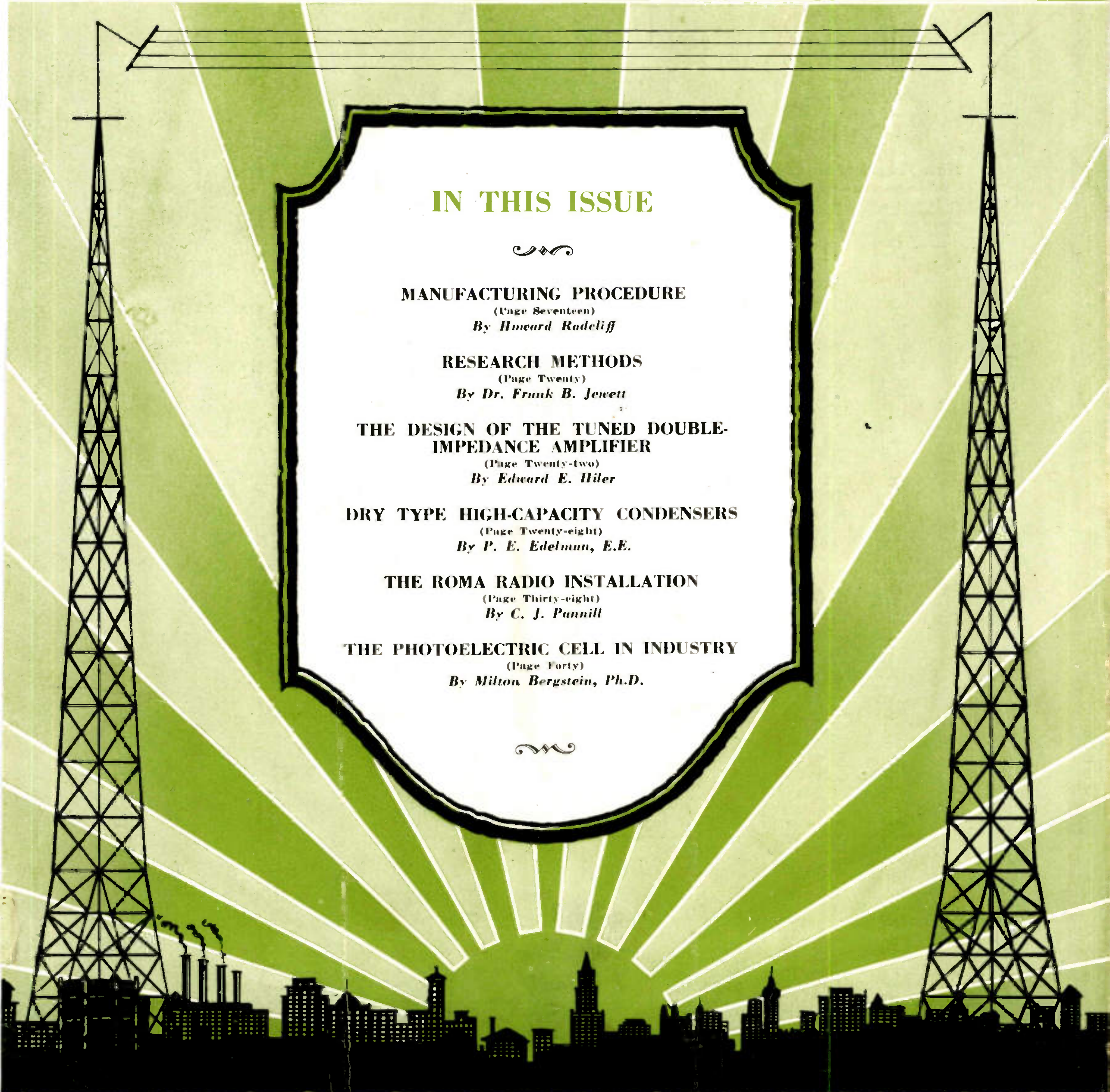
EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

Vol. VIII | AUGUST, 1928 | Number 8



IN THIS ISSUE

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Largest Ever Made

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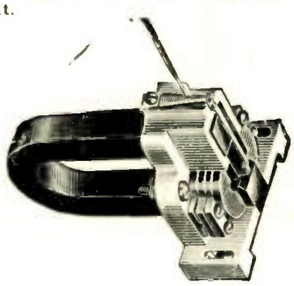

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Rugged in Construction yet Extremely Sensitive

No. C-104—Amplion Cone Unit represents an ideal combination of improvements that are the result of years of Amplion research work.

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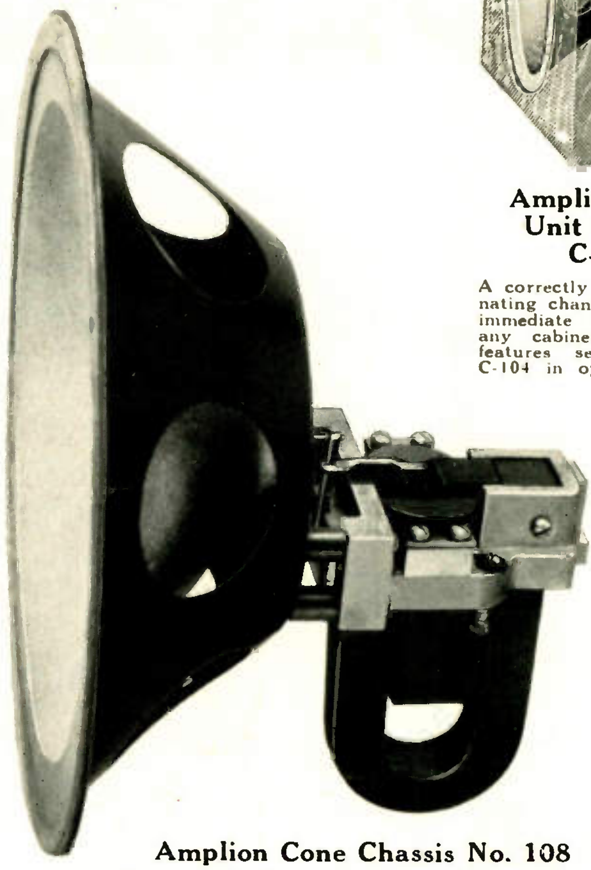
A correctly designed resonating chamber, ready for immediate installation in any cabinet. For other features see Cone Unit C-104 in opposite corner.



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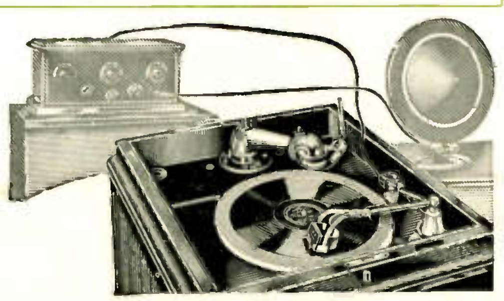

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RADIO ENGINEERING

for AUGUST 1928

Edited by M. L. Muhleman

52 Vanderbilt Avenue
New York, N. Y.

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VOLUME VIII NUMBER 8

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 33⅓ 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 is it 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*.

Contents

Departments

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QUALITY AND PERFECTION

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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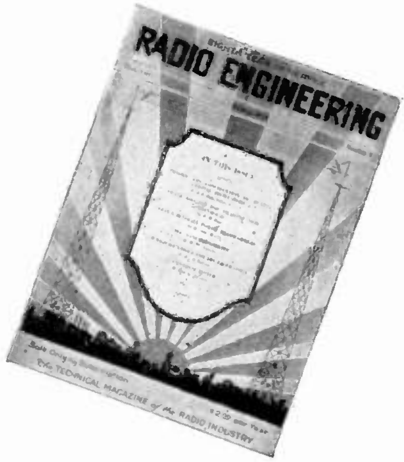


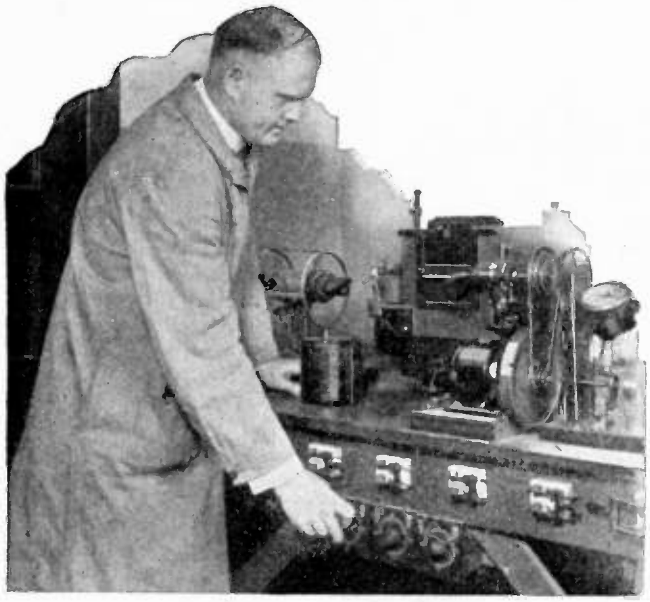
AUTUMN CONSTRUCTION REVIEW NUMBER

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.



Faithfully reproducing every note in the register — from the lowest to the highest — with all the accidentals. Any instrument — any volume.

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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.

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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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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.

SHAKEPROOF Locking Terminals *Stay Locked!*

MULTIPLE LOCKING
SPREADPROOF
TANGLEPROOF

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 rapidlv growing preference for Shakeproof—together with the fact that these locking terminals simplify assembly and make neater work.

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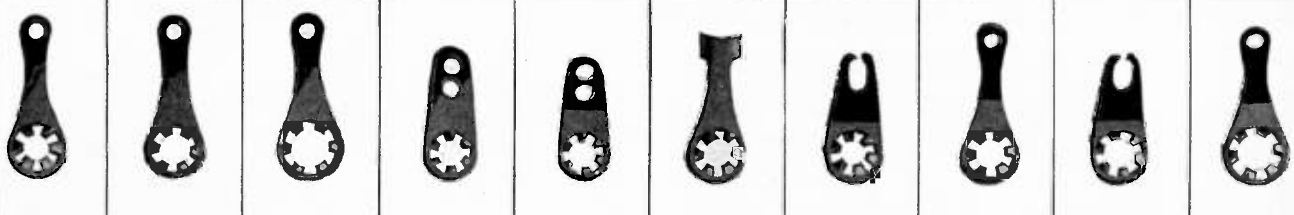
—eliminating one assembly

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.

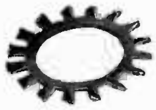
SHAKEPROOF'S "Two in One" Locking Terminals.....(Type 20)



2006	2008	2010	20061	20062	20064	20066	20067	20082	20102

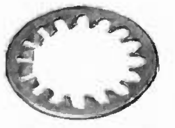
SHAKEPROOF LOCK WASHERS

In Sizes for Radio Work



Type 11...External

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).



Type 12...Internal

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LOCK WASHER COMPANY

(Division Illinois Tool Works)

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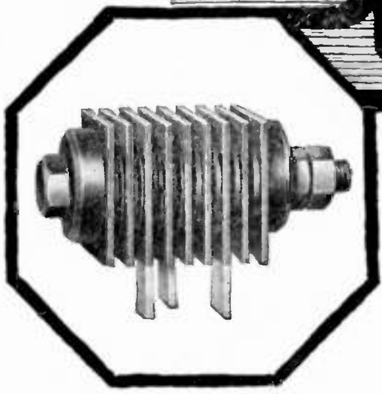
Please send me samples of your Locking Terminals and Lock Washers as follows:—

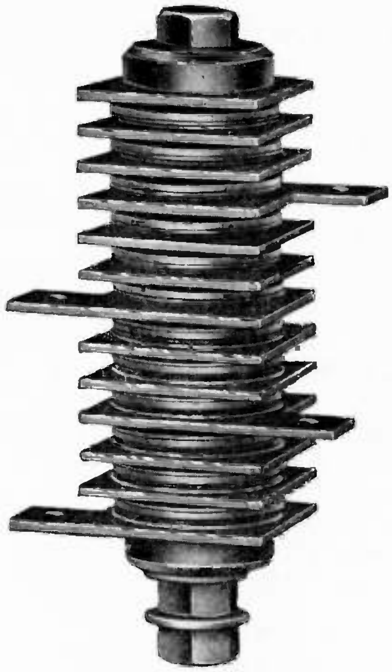
Locking Terminals ______________________

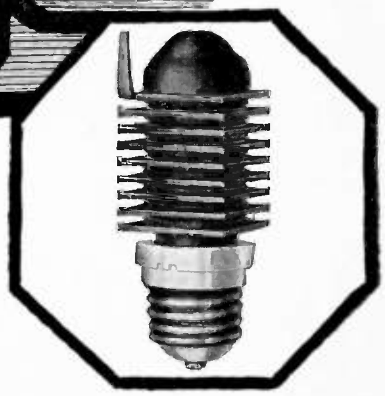
Lock Washers (sizes) ______________________

Firm Name ______________________ By ______________________

City & State ______________________ Title ______________________







Type B-12, B-L 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 2-½ 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.

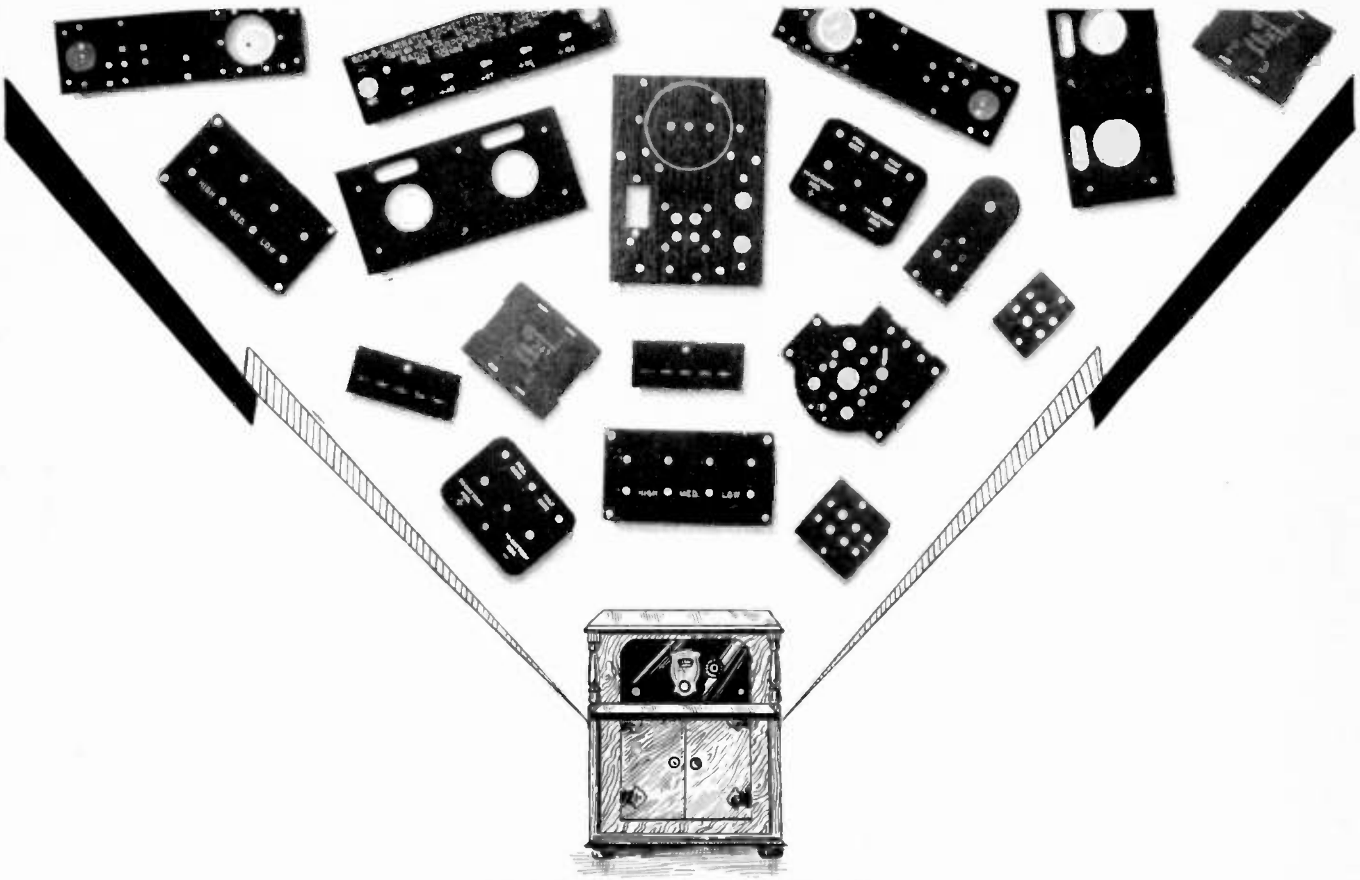
B-L Rectifying Units are Bone Dry—Noiseless—Durable—Compact. An interesting booklet, explaining their characteristics and some of the many applications, is yours for the asking.

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

Bone Dry **Durable**

B-L RECTIFIERS

Noiseless **Compact**



MICARTA

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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—

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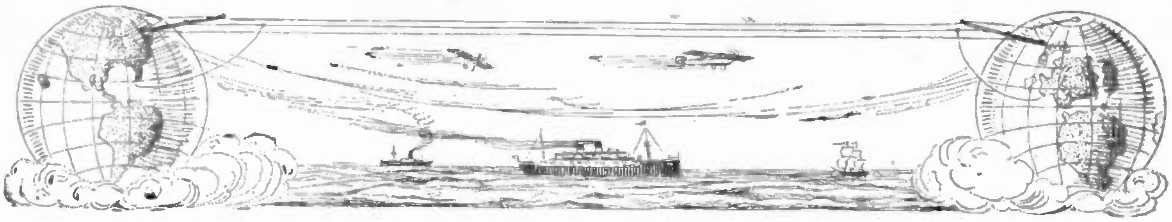


Manufacturing Procedure

History and Fundamentals of an Unusual Form of Production Structure

By Howard Radcliff

PRODUCTION is a prize 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.

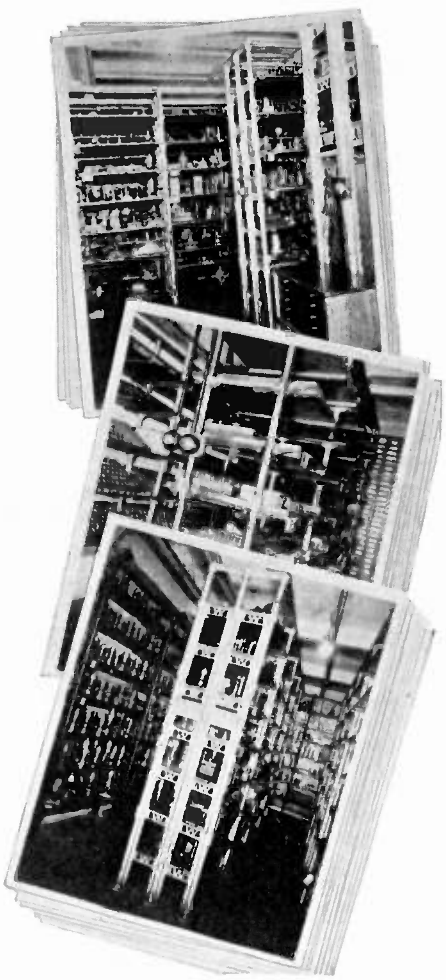
Production structures differ. Since production depends a great deal on the character of the factory, the character evolving from the company executives and the nature of the products, it is obvious that an entirely different form of factory procedure will maintain in, say, The National Biscuit Co. and 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 huge 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 bold 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.



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

(Courtesy of Weston Electrical Instrument Corp.)

Factory Procedure

Most of us associate production with a very highly standardized product with no outstanding variance 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

(Courtesy of Weston Electrical Instrument Corp.)

A view of the General Inspection Department where parts are measured by reference to definite standards reduced to a series of "instruction cards."

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 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.

Were 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 took 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 also been carried out to a state of perfection. Many of the operators are females, as they are better equipped to handle the delicate manufacturing and assembling work. All operations possible are done by machines irrespective of their nature and each operation is predetermined by the engineering personnel. In other words, the engineering intelligence is focused on the special machines for performing the various operations and on the plans and schedules provided the workers.

A notable example of this is the 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 the operators 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 cooperatively 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 maintains uniform standards throughout a highly organized plant of conscientious 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 "instruction 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, microscopic examinations and especially 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,

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 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 .0135 in. drill, the flats milled and the pivot base threaded—.030 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 .0135 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.

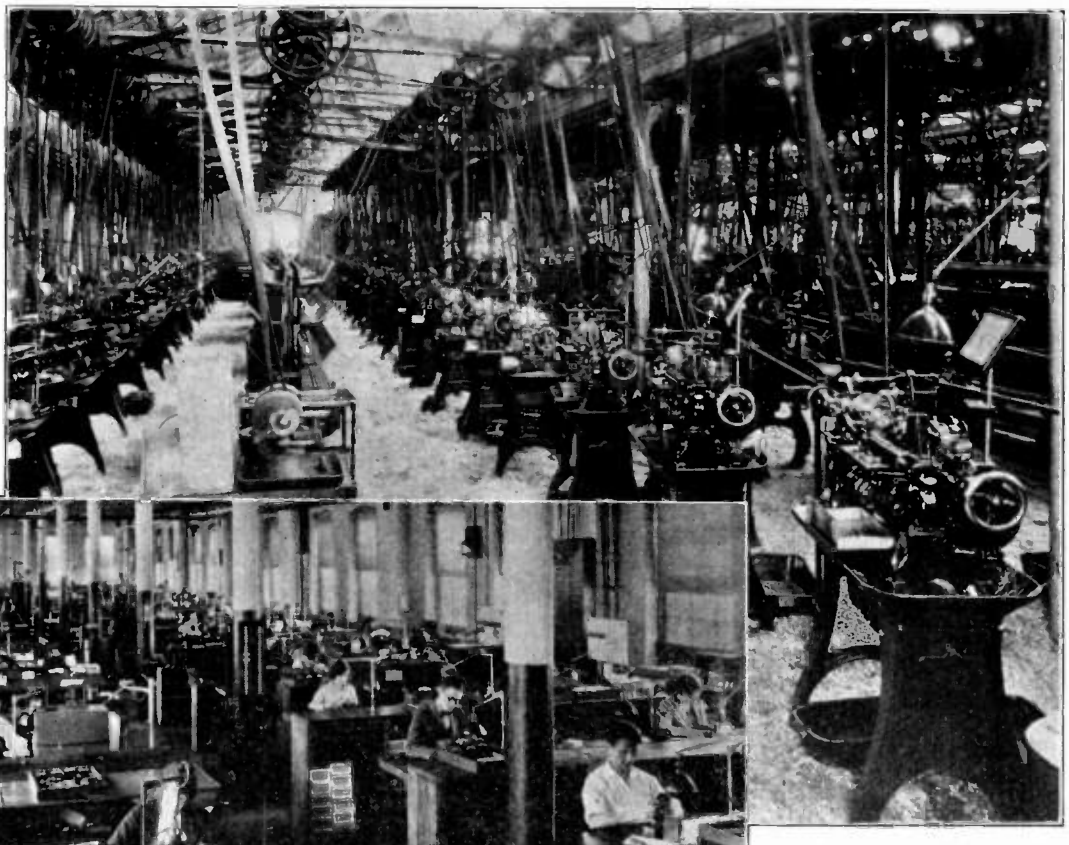
Standardized Reconditioning

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 faculties. 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.



Right: A view of a bank of automatic machines in the plant of a testing instrument manufacturer. These machines are employed for making pivot bases, instrument springs and other small parts.

(*Courtesy of Weston Electrical Instrument Corp.*)

Partial view of the Reconditioning and Repair Department, a "factory within a factory." A permanent technical record is kept of instruments leaving the factory, which facilitates the work and eliminates the possibility of error.

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 authoritative 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

DR. F. B. JEWETT
President, Bell Telephone Laboratories

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 out 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 supposition—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 ten 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

* *President of Bell Telephone Laboratories.*

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 huge 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 per cent or a hundredth of a per cent 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 cements 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 ingredients 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, swung 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.

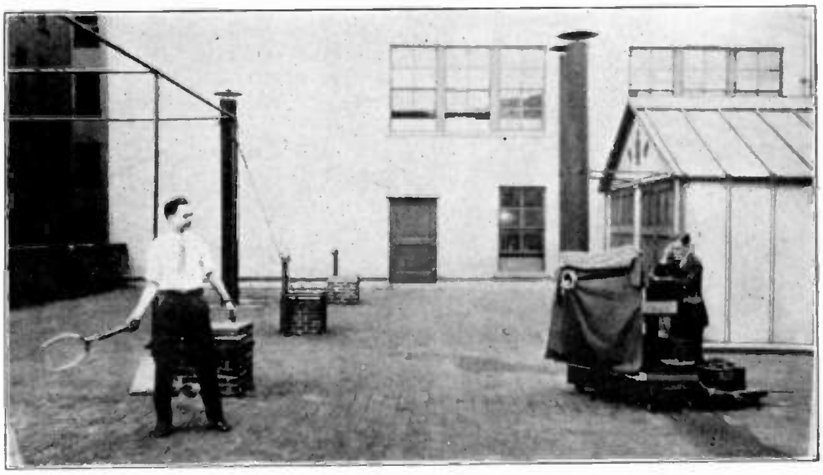
In the first form of apparatus demonstrated in April of last year, the scene was illuminated by a rapidly oscillating beam from a powerful arc light and that limited the scene to be transmitted to a very small area. The new development frees television from one of its most serious limitations.

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 pick-up apparatus consists of a lens behind which are the revolving scanning disc, photo-electric cells and amplifier. The disc and cells are under the light-proof covering.

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 appellation. 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 preponderance of amplification upon a predetermined frequency. Generally speaking and considering the operating characteristics of associated equipment, the modern radio receiver installation of conventional design is deficient upon the lower audio register, between 30 and 200 cycles. Satisfactory low-frequency 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.

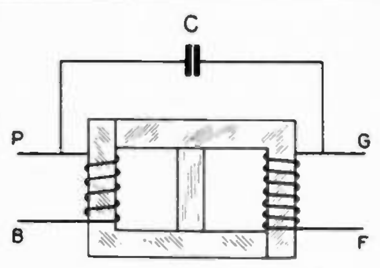


FIG.1

General design of a tuned double impedance unit.

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 band, 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 this 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.

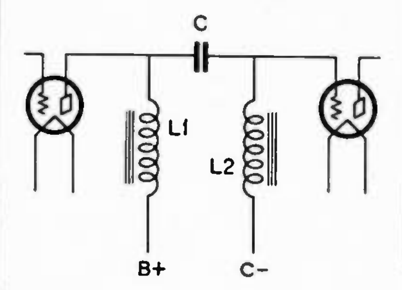


FIG.2

Circuit diagram of single stage tuned double impedance amplifier.

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 maximum 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-freqency 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 respect to 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. Emperical 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.

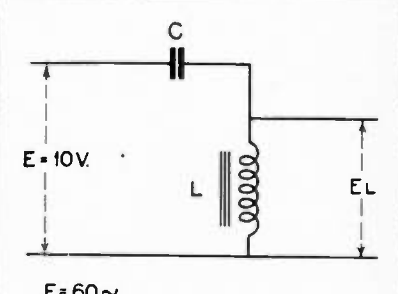


FIG.3

Series circuit containing a capacity and impedance.

Elimination of Leakage Reactance

The presence of leakage reactance in an audio coupling unit is detrimental

* Hiler Audio Corporation.

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 controls 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, L1 being the plate coil, C is the coupling condenser and L2 is the grid coil.

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 C 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 10 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 1,000 ohms. The current I in the circuit is equal to

$$I = \frac{E}{\sqrt{R^2 + \left(6.28 \times F \times L - \dfrac{1}{6.28 \times F \times C}\right)^2}}$$

$$I = \frac{10}{\sqrt{(1{,}000)^2 + (50{,}240 - 50{,}240)^2}}$$

$$I = .01 \text{ of an ampere}$$

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

$$6.28 \times 40 \times 200 \times .01 = 502.4 \text{ volts.}$$

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 lead of the grid choke for the purpose of controlling the height of the resonance peak in circuits where regeneration is very pronounced. The effect of this resistance can be gleaned by a study of the above formulae.

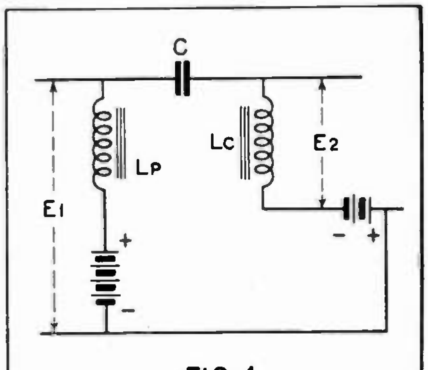


FIG.4

Circuit which serves to demonstrate series resonance phenomenon.

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.

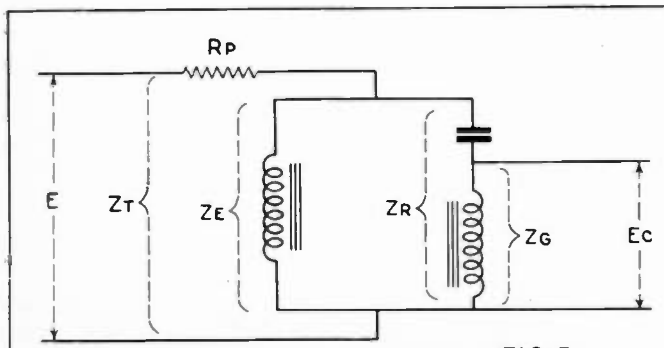


FIG.5

Generalized circuit of a single stage of tuned double impedance amplification; an analization of the electrical properties.

Circuit Analysis

A simple analysis of a single stage, such as shown in Fig. 2, would result in an analytical circuit similar to Fig.

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

$$Eg = \frac{Ze}{Zt} \times \frac{Zg}{Zr}$$

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. Zr can be classified as being equal to "e", a very small quantity approaching 0 as a limit at resonance. Zg is equal to $2\pi fL$. At a frequency approximating resonance, Ze is equal to "e", since the circuit constituting Zr is a practical short across the plate choke. Zt being equal to Ze + Rp it is therefore equal e plus rp. Substituting in the formula for Eg we obtain

$$Eg = \frac{e}{e + rp} \times \frac{2\pi fL}{e}$$

where L is the inductance of the grid choke.

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

$$Eg = \frac{2\pi fL}{e + rp}$$

therefore $Eg = \dfrac{2\pi fL}{rp}$ 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.

Fig. 7 shows the resonant frequency for various values of coupling capacity and grid choke.

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.*

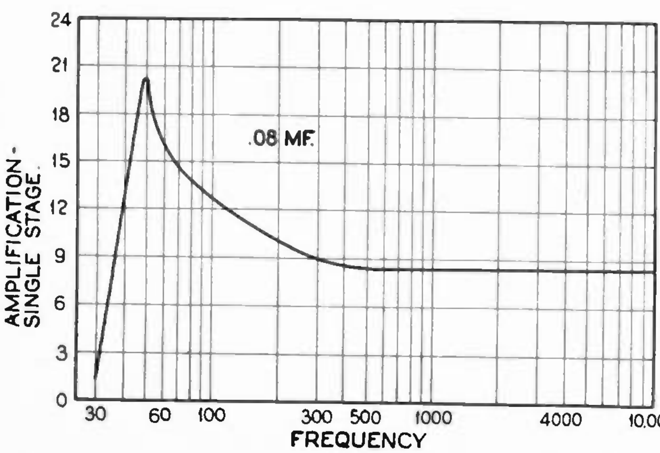


FIG.7

Typical frequency characteristic curve of a single stage of tuned double impedance amplification.

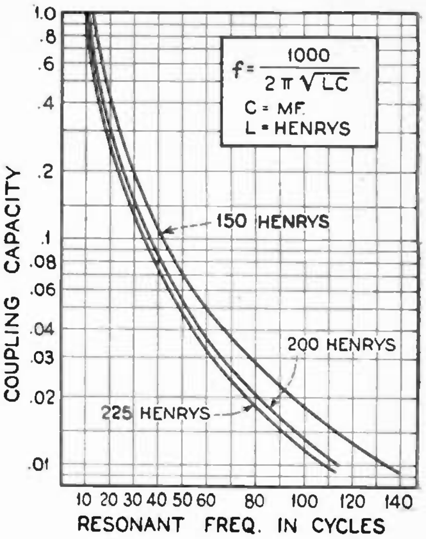


FIG.6

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

The development of the "B" 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 power supply is the source of plate voltage and filament voltage, and 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

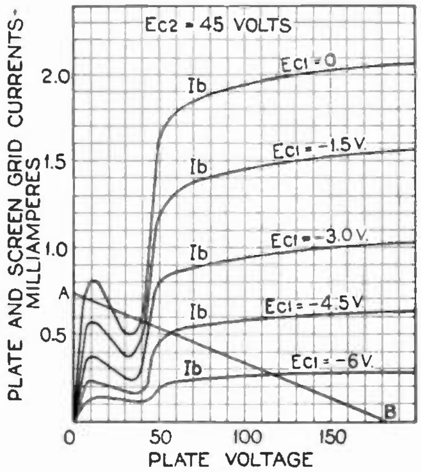


FIG. 15

Group of plate characteristic curves of the UX-222, with 45 volts on the screen-grid.

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 135 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 1.5 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 curves 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

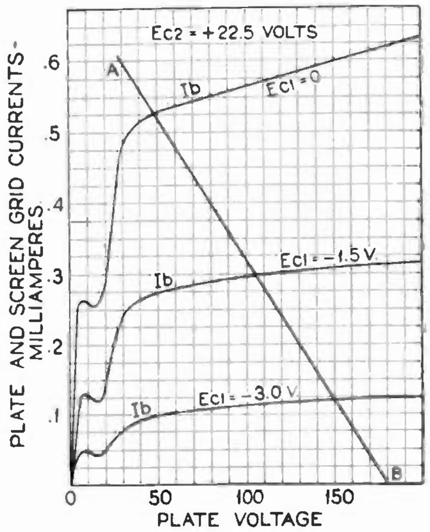


FIG. 16

Group of plate characteristic curves of the UX-222, with 22.5 volts on screen-grid.

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. 16 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. 17 shows an equivalent circuit for a resistance-coupled amplifier. Here:

$$C_p = C_{pg} + C_{pf} + C_{ps}$$

when C_{pg} is the plate-grid capacity of

* *Research Laboratory, General Electric Co.*
From a Paper Delivered before the Radio Club of America, February 8, 1928.

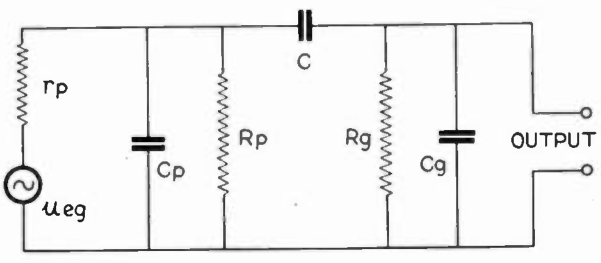


FIG. 17

Generalized circuit of a resistance-coupled amplifier serving to indicate the advantages of the UX-222 as a coupling tube.

the tube, C_{ps} the plate-screen capacity, and C_{pf} the plate-filament capacity, all including wiring capacities. Also:

$$C_g = C'_{gs} + C'_{gf} + C'_{gp}\ (A_v + 1)$$

where C'_{gs} is the capacity between grid and screen of the *next* tube in the amplifier, C'_{gf} the grid-filament capacity, C'_{gp} the grid-plate capacity, and A_v the voltage amplification, all of the next tube. C is the blocking condenser, while R_p and R_g are the plate and grid coupling resistors. The value C_g 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

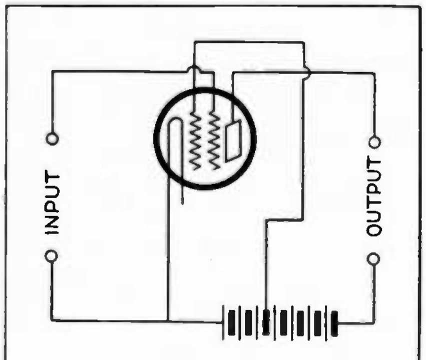


FIG. 20

Double grid tube connected so as to function as a space-charge-grid tube.

fidelity due to the reduction of the effective grid-plate capacity of the amplifier tubes will be appreciable. The UX-222, for example ($C_{pg} = 0.025$ mmfd. max.) will have a value for C_g of 9 mmfd. as compared with that of 200 mmfd. for the UX-240 ($C_{pg} = 9$ mmfd.)

It must be understood that these capacity values neglect the external portion of C_{pg} 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 mmfd. as a result of a C_{pg} of approximately 1 mmfd. 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

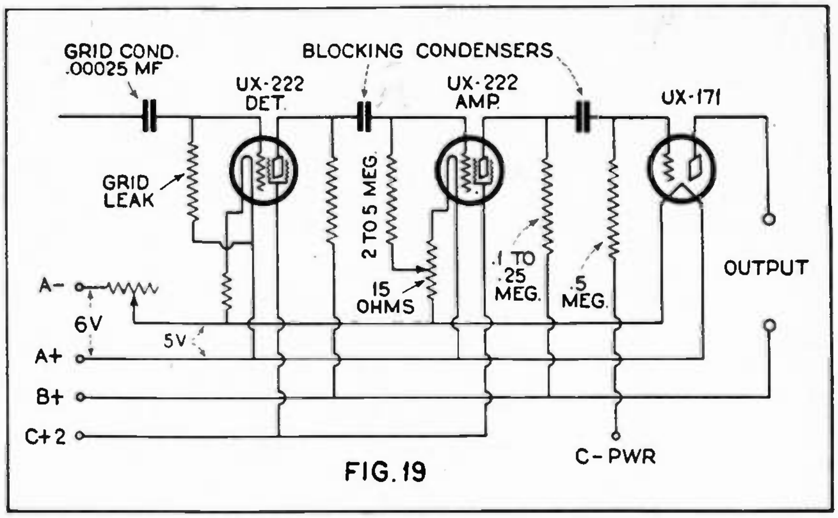


FIG. 19

Circuit diagram of resistance-coupled A. F. amplifier, using UX-222 tubes with a 171 tube in the output. Voltages and constants are given in Table No. 2, below.

Table No. 2

Screen-Grid Resistance-Coupled ux-222

Filament Voltage	(E_f)	3.3	
B Supply Voltage	(E_b)	180	
Series Load Resistance	(R_p)	250,000	Ohms
Control-Grid Voltage	(E_{c1})	−1.5	
Screen-Grid Voltage	(E_{c2})	+22.5	
Plate Current	(I_p)	0.3	mA.
Plate Resistance	(r_p)	2	Megohms
Mutual Conductance	(g_m)	175	Micromhos
Amplification Factor	(u)	350	

Table No. 3

Space-Charge-Grid ux-222

Filament Voltage	(E_f)	3.3	
B Supply Voltage	(E_b)	180	
Series Load Resistance	(R_p)	250,000	Ohms
Control-Grid Voltage	(E_{c2})	0–$\frac{3}{4}$–$1\frac{1}{2}$	
Space-Charge-Grid Voltage	(E_{c1})	+22.5	
Plate Current	(I_p)	0.3	mA.
Plate Resistance	(r_p)	150,000	Ohms
Mutual Conductance	(g_m)	400	Micromhos
Amplification Factor	(u)	60	

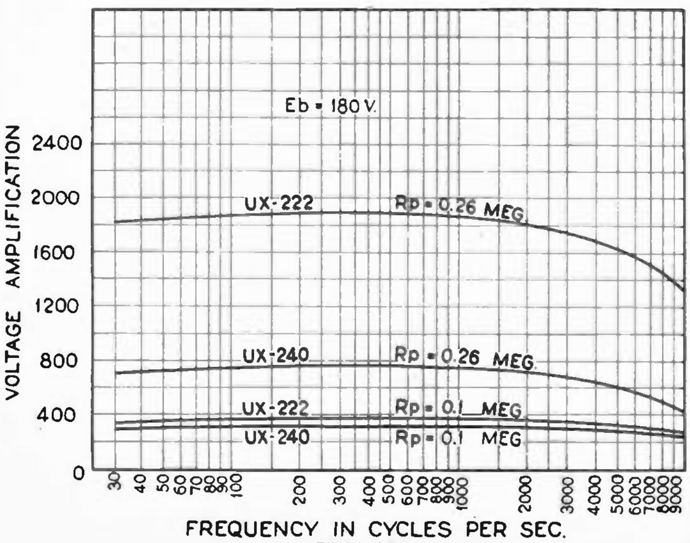


FIG. 18

Relative characteristics of a resistance-coupled amplifier (Fig. 17) employing a UX-222 tube, with two different values of load resistance compared to relative characteristics when employing a UX-240 under identical circuit conditions.

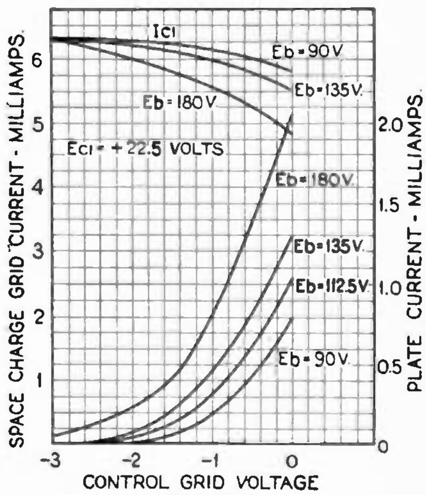


FIG. 21

Static characteristics of the UX-222 used as a space-charge-grid tube.

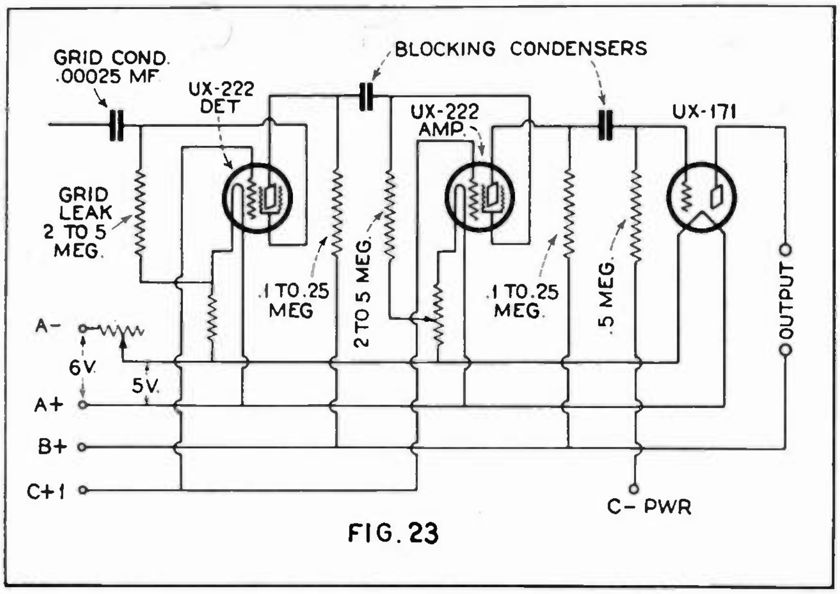


FIG. 23

Circuit of resistance-coupled A.F. amplifier employing space-charge connection. Voltage amplification is considerably increased (compare Figs. 18 and 24) but amplification falls off at high frequencies due to the influence of large capacity existing between plate and control grid.

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 Schottky 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 out 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 it. Its advantage is higher gain per stage than is practicable with three-electrode tubes, due to higher mutual conductance.

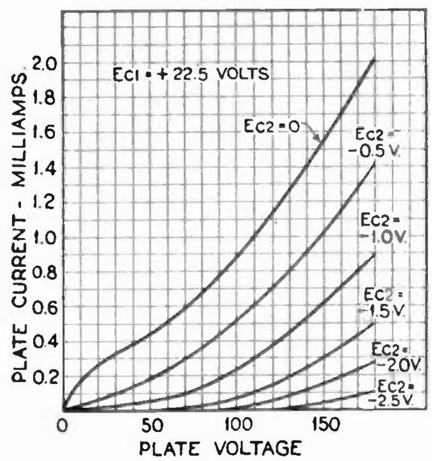


FIG. 22

Static chara[illegible] of the UX-222 used as a space-charge-grid tube.

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 26).

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]

Relative characteristics of space-charge resistance-coupled amplifier, shown in Fig. 23, using UX-222 tubes — and characteristics as a straight amplifier using UX-240 tubes.

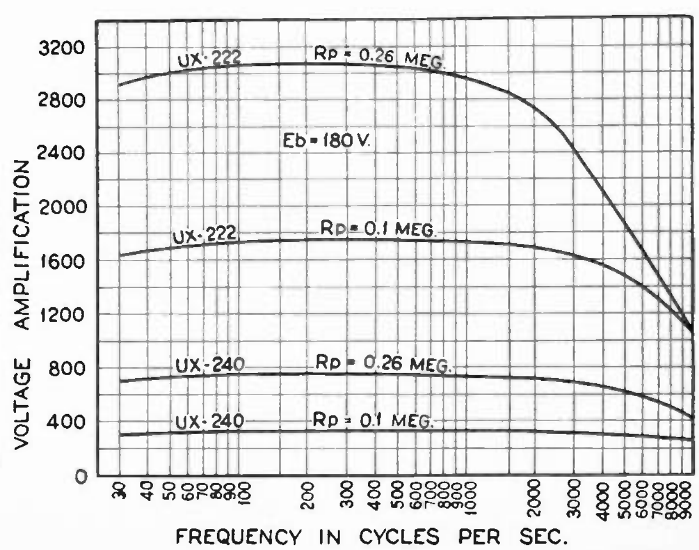


FIG. 24

"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.*

AN "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 Pawlowski type (*U. S. Patent No. 830924*). 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. 1658976*) are shunt connected in combination with series inductances, as shown by Fig. 1. The condensers have effective capacity of the order of 1,500 mfds. and the chokes need not be larger than .2 henry each. Outputs may be had at 6 volts up to 3¼ amperes or 4 volts, 1 ampere.

Comparative costs with other methods of filament excitation show decided

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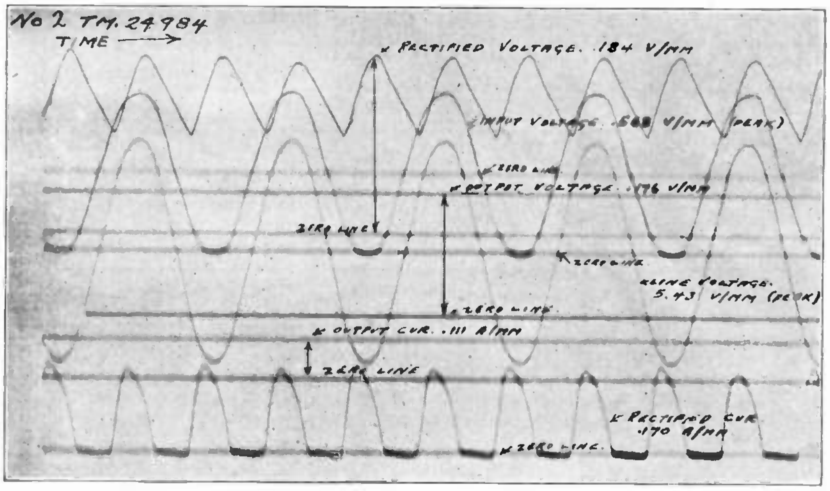


Fig. 2. Output voltage and current connected to non-inductive load: line, rectifier and input voltages to rectifier. D.C. unit output, 6 volts, 1.3 amps.

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.

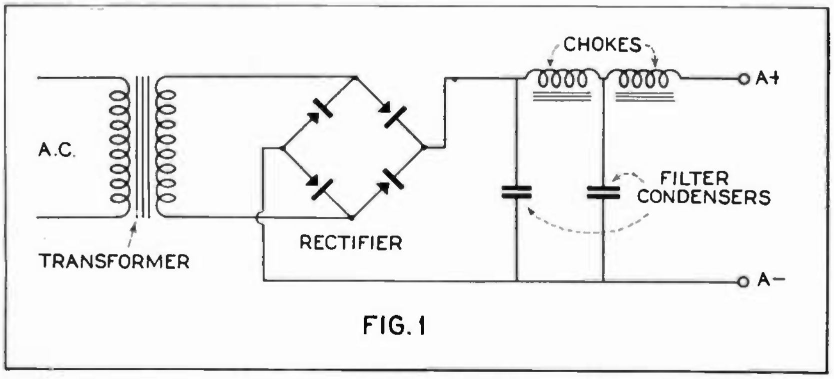
Outstanding Advantages

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 watering 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 thermic 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



Rectifiers connected in Wheatstone bridge form with 1500 mfd. condensers and .2 henry chokes used as a power supply for parallel connected tube filaments.

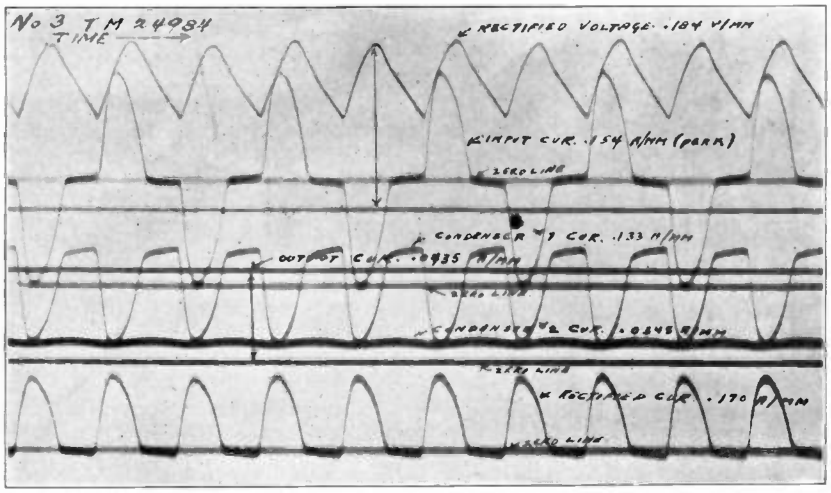


Fig. 3. Rectified current; current flowing through condensers; output current; rectifier voltage and input current. Load on unit, 6 volts and 1.15 amp.

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, 1.3 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 *Im* flowing between first choke coil and second condenser; current through first condenser, rectified voltage; input current; operating conditions.

Fig. 5. Transient conditions immediately upon energizing unit with output adjusted for 6 volts. Rectified 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

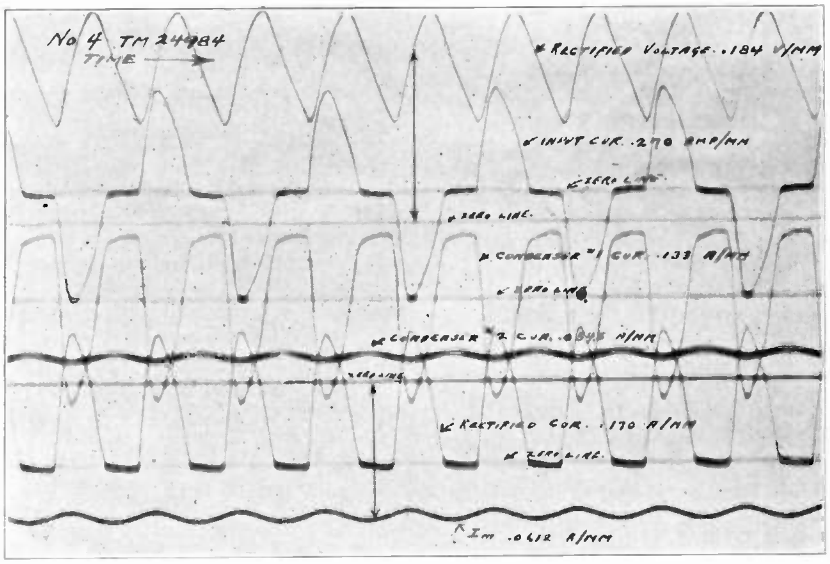


Fig. 4. Rectifier current: current through No. 2 condenser, current In between No. 1 choke and No. 2 condenser, current through No. 1 condenser; rectified voltage; input current. Output voltage kept at 6 volts. Operating conditions.

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.

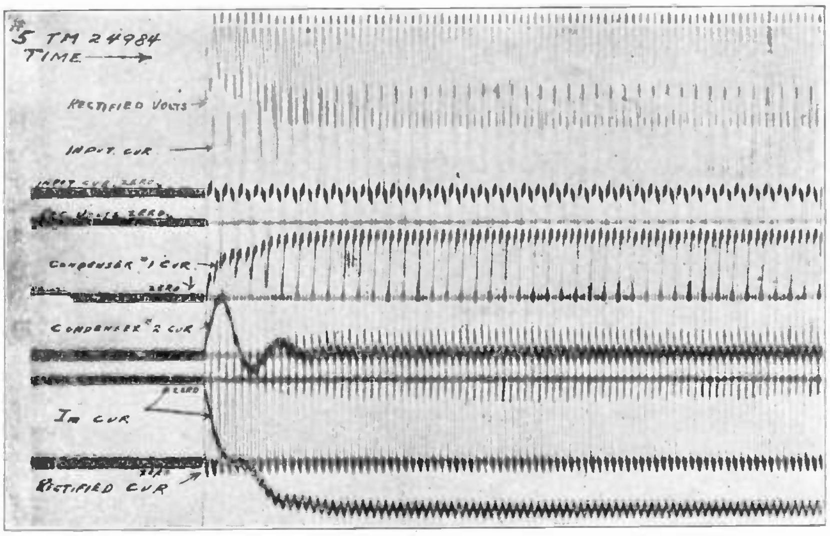


Fig. 5. Transient conditions immediately upon energizing unit with output adjusted to 6 volts. Rectified current; current through condenser No. 2; Im, current between No. 1 choke and No. 2 condenser; current through No. 1 condenser; rectifier voltage and input current.

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 the 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 (charged 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 1891 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—through its literature—there is no avoiding the conclusion that Marconi possessed the type of mind which seeks to apply principles to utilitarian purposes: the type of mind possessed by Morse, Bell, Edison, Westinghouse, Preece and Rathnau.

Progress in Russia, Germany and France

At about the time that Marconi was carrying on his elementary experiments in Italy, Professor A. S. Popoff, in Russia, was engaged in experiments with Hertzian wave phenomena. His first communication on the subject was sent to the Russian Physical Society, in April 1895, being published in the January, 1896, *Journal* of that society.

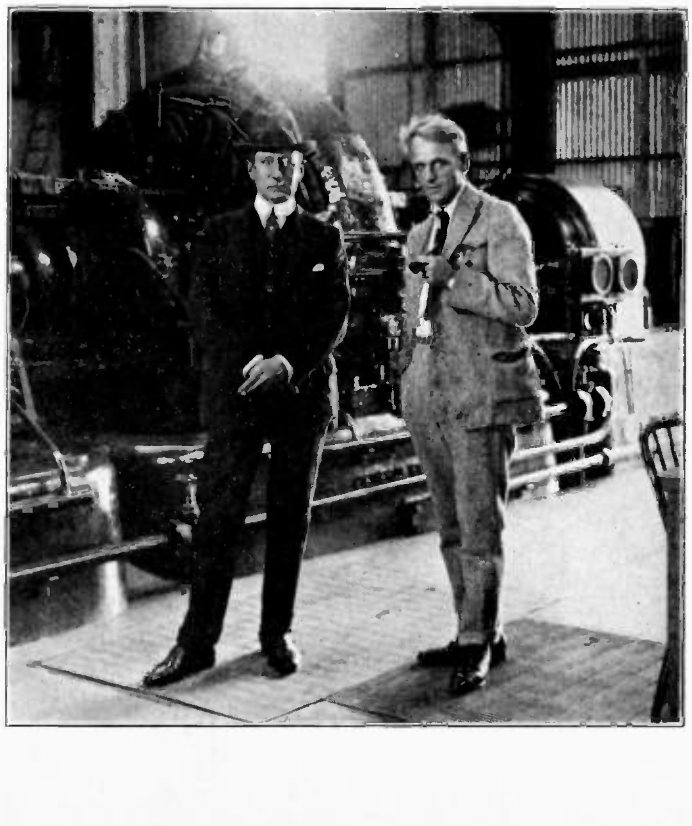
Popoff reasoned that as an electric-wave detector of the Branly type responded to Hertzian radiation it should also respond to waves of the same nature produced by flashes of lightning. He designed a device and circuit arrangement almost identical with that at first employed by Marconi—detector, tapper and relay—and set this up at the Meteorological Observatory at St. Petersburg in July, 1895.

The receiver was attached to a previously installed lightning rod. Thus he employed an elevated conductor for receiving, as had Marconi at the same time or a little later. In seeking a use for this apparatus it occurred to Popoff that it might serve as a warning of approaching lightning storms, or at least as a recorder of distant lightning discharges.

In his early work Popoff apparently did not employ an elevated conductor in connection with the Hertz oscillator used to transmit impulses to his receiving station. At the secondary terminals of the induction coil the spark gap was between metal spheres from thirty to ninety centimeters in diameter. No elevated wire or ground connection was utilized in these experiments, although he reported covering a range of five kilometres.

The publication of Popoff's paper in January, 1896, together with the wide publicity given Mr. Marconi's demonstrations in England in March, 1896, at once made the subject of wireless telegraphy popular in colleges, electrical work-shops and attic laboratories the world over.

It was in the year 1895 that Professor Röntgen, in Germany, discovered X-rays, having characteristics similar to those of Hertzian waves, in that they penetrate certain substances which are opaque to light rays. X-rays may be produced by apparatus similar to the induction coil equipment used in radio experiments, in connec-



Guglielmo Marconi and Roy A. Weagant in 1920, before one of the Alexanderson alternators at the Rocky Point transmitting station of the Radio Corporation of America.

[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 as an evidence that in Germany the physicists were losing little time in contributing materially to advances in knowledge made possible by Maxwell and Hertz.

With reference to wireless telegraphy, however, the Germans appear to have been a little slow in getting started. One of the earliest of the German scientists to take up the study was Dr. A. Slaby, of Charlottenburg. Dr. Slaby was aware of what Marconi had done 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 novelties introduced by Marconi and fell back upon methods previously known."

It is recorded that Dr. Slaby was present on May 13, 1897, at tests carried on in the British Channel by Mr. Marconi and upon his return to Germany Slaby engaged in the task of considerably extending the signaling range of the instruments he had devised for wireless-telegraph experiments. In a statement Dr. Slaby conceded that the young Italian inventor had "devised for the process an ingenius apparatus which by the simplest means attains certain results."

In Germany early wireless progress was aided by valuable contributions made by Ferdinand Braun, Count Arco, E. Marx, G. Seibt, and especially by the mathematical skill of Professor J. Zenneck. In the year 1899, when the latter was twenty-eight years of age, he was assigned the undertaking of conducting a series of practical tests of wireless-telegraph signaling in the North Sea, and thenceforward his contributions to the theoretical and practical sides of the subject were of great value in Germany and in other countries.

In France H. Poincare, A. Turpain, G. Ferrie, A. E. Blondel and Commandant Tissot were early workers in the field, the results of their investigations having the form of practical signaling systems, useful, but not of great range.

The Beginning in America

Following Joseph Henry's announcement in 1842 of the oscillatory nature of the Leyden jar discharge, and continuing up to Hertz's time (1888) there were in America several brilliant philosophers who prosecuted research into the phenomena of science, as uncovered from time to time, but out of none of these inquiries came anything in the nature of a contribution toward the solution of the mysteries laid bare by Maxwell, Heaviside, Thomson and Hertz. It is true that from the time of Morse's introduction of the telegraph in 1844 until the beginning of the developments by Gray, Bell, Berliner and others, which brought forth wire telephony in the seventies of the nineteenth century, many of those who had a knowledge of electricity devoted their efforts to improvements in telegraphy.

The introduction of the telephone in America, in 1876, brought in its train a maze of problems, mechanical and electrical. In the beginning of that art the mechanical problems were perhaps the more pressing, as by solving these the telephone as invented could immediately be put to work to produce revenue.

It was natural that because of the large size of the country and the great distances involved that the United States should offer a profitable field for systems of telegraphic and telephonic communication. The introduction of these services found the country poorly staffed with men who possessed theoretical knowledge of electricity and electric circuits. That this was so is evident from the fact that in 1867 Cromwell F. Varley was brought over from England to make a study of and report on the electrical condition of the telegraph system. Georges de Infraville was brought from France, in 1871, because he was something of a mathematician and had theoretical knowledge of electrical circuits. F. B. Badt was brought from Germany, in 1882, by the early electric-light interests. S. P. Freir came over from England to set up improved telegraph apparatus on American lines. He was accompanied by William Finn. In 1885, Van Rysselberghe came over from Belgium to introduce the first system of combined telegraph and telephone operation on American lines.

It must not be thought that the small group of American electricians was not accomplishing big things. The situation was that they were in need of aid of a theoretical and mathematical nature. Mr. Edison introduced the phonograph in 1877, and shortly thereafter was at work on the incandescent lamp. At the same time C. F. Brush introduced the arc lamp, and Edward Weston was, in 1877, engaged in electric-light experiments.

It has been stated herein that very likely from Henry's time forward—after the introduction of electromagnets—experimenters on many occasions inadvertently set up electro-magnetic radiation while carrying on investigations with other objectives in view, and that while radiation continued small sparking effects were observed in wire or other metallic systems in the neighborhood of the source of the waves. Up to Hertz's time (1888) these manifestations were ignored, or were not recognized as having any practical significance. They were not understood. An explanation of their cause seemed to be beyond human ken.

Thomas A. Edison's Experiment

A particularly noteworthy instance of this was the experience of Mr. Edison, in the year 1875. Sparks were observed in metallic systems located in the neighborhood of a vibrating armature of the make-and-break electric bell type.[2] The succession of sparks at the contact points generated feeble electro-magnetic waves which were broadcast throughout the room. Although Mr. Edison, with the aid of his assistants, Charles Batchelor and James Adams, continued to investigate the phenomena over a period of a month nothing conclusive was learned as to the cause or the effect.

Mr. Edison gave the phenomenon the name *Etheric Force*. He was, in fact, not far from the truth. A communication which appeared in a scientific journal at the time, written by Dr. G. M. Beard,[3] who had witnessed Edison's demonstrations, read in part: "At the present time the weight of evidence in my mind is in favor of the theory that this is a radiant force, somewhere between light and heat on the one hand and magnetism and electricity on the other, with some of the features of all these forces. If it be, as I have suggested, a kind of electricity which, after the manner of the shuttle, returns to its source by rapid forward and backward movements, it would yet be electricity under very different conditions from those under which we are wont to consider it, and would be practically a new force. The more I experiment in this department, and the more closely I reflect on the results of experiments, the farther I seem to be driven from the electrical toward the radiant theory of this force: and there would appear to be no ready escape from the conclusion that we have here something radically different from what has before been observed by science."

Maxwell's main treatise was published about two years before the Edison experience, and it will at once occur to the student of history that had Mr. Edison read and understood Maxwell's proposals, very likely the investigation would have been continued until the truth was known, and Hertz anticipated.

The final experiment by Mr. Edison recorded in this series (December 26, 1875) 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 those years of work and worry, when the quadruplex telegraph, the acoustic telegraph, the phonograph, the telephone, the dynamo, the incandescent lamp, the feeder-and-main system, the underground system and the three-wire system were born and nurtured, when men were to be taught and inspired, it is no wonder that the interesting 'Etheric Force' should have

[2] *Scientific American*, January 8, 1876.

[3] *Scientific American*, January 22, 1876.

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 the twenty-one year old Italian youth, Marconi, reaped the harvest harrowed and sown by others. He wrote:[4] ". . . . but so far as the present author was concerned he did not realize that there would be any particular practical advantage in thus with difficulty telegraphing across space instead of with ease by the highly developed and simple telegraphic and telephonic methods rendered possible by the use of connecting wires."

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

In the year 1889, Elihu 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.[5]

In tracing American thought in the period following Maxwell's disclosures reference should be made to the work of Amos E. Dolbear, in the year 1883, professor of physics at Tufts College.

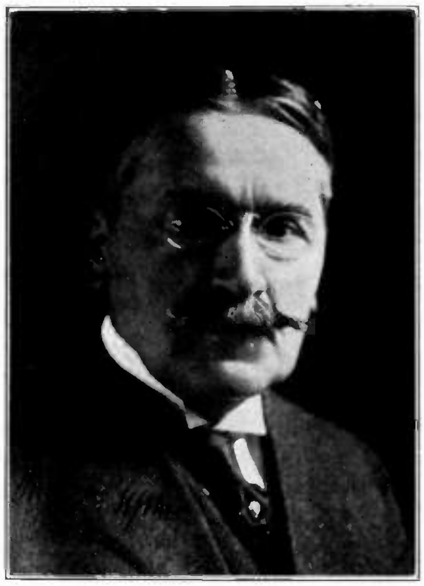
Dolbear at first proposed a system of communication without continuous conductors, by connecting a telephone transmitter in the primary circuit of an induction coil in series with the battery. His proposal contemplated the use of an elevated conductor attached to one terminal of the secondary of the coil, the opposite terminal being earthed. In 1886 he proposed the substitution of a telegraph key in the primary circuit in place of the telephone transmitter, but still no spark-gap was introduced.[6]

This was one more investigation which the history of the art shows was not carried far enough to attract attention at the time, or to demonstrate what might be done with the idea. Of course, it was not until eight years later that the experiments with detectors of the coherer type were carried on in Europe, so that without a practical means of detecting electric waves an experimenter was no further ahead than was Maxwell in 1873.

In the seven years between Hertz and Marconi (1888-1895) the foremost American science professors carried on in the college laboratories experiments which in the main were designed to confirm, or check, results reported from European centers of learning.

Of those who were at least keeping abreast of the times one of the most eminent was Professor John Trowbridge, of Harvard University.

In America at that time the great material expansion of the country was such that the electric light, electric railways, the telegraph, the wire telephone, the dynamo and motor, had at hand immediate fields of usefulness on a profitable scale. The limited group of scientists aided by the growing number of practical electricians witnessed the birth of the great electrical industry, which was destined to play a stellar role in the commercial and industrial development of the continent.



DR. M. I. PUPIN

In addition to Professor Trowbridge, others who were in positions to maintain places on the fringe of scientific advance were Elihu 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 were to revolutionize 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 electrical waves 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 telephone voice-currents over long lines. The solution was to place carefully balanced inductance coils at intervals in the long lines.[7]

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 was of 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 oscillator 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 radiator system.

Professor Trowbridge, it would seem, did not envisage the prospect suggested by Maxwell and presented by Hertz. Possibly in viewpoint 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 the fore in America just prior to and

[4] "Signaling Through Space Without Wires." By Oliver J. Lodge, page 45.
[5] U. S. Patents 707,000, 707,008.
[6] United States Patents 350,299 and 355,149.
[7] This invention was acquired by the American Telephone and Telegraph Company, in January, 1901.
[8] "What Is Electricity?" By John Trowbridge. D. Appleton & Co., N. Y., 1896.

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. Martin'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 electro-static conditions of the earth* and thus transmit intelligible signals and perhaps power."

It might be supposed that the prior experiments of Morse, Lindsay, Preece, 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 June, 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 1896 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 1899, 1900 and 1901, several additional patents were taken out covering variations of connections and valves.

As stated in the chapter on Transmitters, 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.

NIKOLA TESLA

CHAPTER 3

Syntony, Tuning, Selectivity

THESE terms are practically synonomous, 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 toy 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 found to be. 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 two 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, the 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

[1] *"Philosophical Magazine," August* 1888, *p.* 228; *"The Electrician," Vol.* 21, *pp.* 607-8.

waves through space. Heaviside used the terms *inductance, reluctance, reactance, permeance* and *permittance*, all of which were in time to become household words in the terminology employed 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 submarine cables, planted seeds of thought 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 of capacity are associated, the resistance of the circuit being small in comparison with the inductance—clearly pointed out by Thomson.

In 1895, Mr. Marconi studied the reports of Hertz's experiments, performed seven years previously, and he has stated that he realized if Hertz's oscillator was to actuate efficiently a receiving system that these would have to be *tuned* together—the sending 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 system parabolic reflectors of the Hertz type were used, radiation being directed 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 obtained 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 had opportunity to study the results of the early Marconi trials, with respect to the factors involved in increasing the distance of operation. These observations supplementing his own laboratory work led to the invention[2] of a radiator system employing an inductance with 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 of ether wave telegraphy was Marconi's grant No. 12,039, of 1896, the important claim of which was for the use of an elevated antenna conductor. The method covered was elementary and suffered from the limitation pointed out by Lodge as stated above.

In Germany, in 1895, Oberbeck,[3] and V. Bjerknes,[4] had sensed that the problem of the utility of electric waves was bound up with the necessity for syntonic balancing of associated circuits, the principles of which were explained in their technical papers. In Germany, also, Ferdinand Braun[5] proposed a transmitting system to be designed for the purpose of producing electric waves of greater length than those radiated by the simple Righi oscillator at first employed by Marconi. Braun suggested for a transmitting system a closed oscillatory circuit, containing condensers and induction 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 the transmitting system would have been novel in 1899, had they been availed of.

The technique of tuning in electric wave telegraphy may seem to have been slow in developing, but the fact is 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 delving into theoretical considerations had not at hand the experimental means with which to check theory. Also, it is well known that there have been, and still are, physicists gifted with ability to prosecute pure research who are but little inclined toward experimental 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 experimental workers, and the engineers, which 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 importance, around which there shall always be no end of disagreement and dispute as to priority.

Practical Considerations

At this point we are engaged in tracing the growth of ideas bearing on the problems involved in attempting 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 on the situation as it existed at that time we may recognize that the next step, that taken by Marconi, in 1900, constituted a distinct advance along the line which held a promise of improvement.

For the purpose of increasing the efficiency of transmission and of securing selectivity, Marconi, in 1900, employed 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 frequency and its harmonics. An examination of the wiring arrangements covered in this development shows that advantage was taken of the 1897 improvements of Lodge, and also of those suggested by Braun, previously referred to. Marconi, however, had advanced ideas of practical tuning, and these he applied in a very creditable manner.[6]

In the year 1900 the need for a workable system of tuning was a subject of the utmost importance. Considerable 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; November, 1897, eighteen miles; July, 1898, twenty-five miles, and 1899, one hundred and fifty miles.

So long as but one operating company or organization maintained service in a given area the difficulties of interference were under that degree of control which suppresses competitive transmissions. But the art had to advance and it was 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 off the Navasink Highlands, near New York. In 1901, when the *Shamrock* was pitted against the *Columbia*, the same service was undertaken by the Marconi company, but in the meantime in the United States the American DeForest Wireless Telegraph Company had made some progress in the development of a workable system, as also had the American Wireless Telephone and Telegraph Company, so it followed that in reporting 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 apparent that whatever had been

(*Continued on page 37*)

2. *British patent* 11,575, 1897.
3. *Wiedemann's Annalen, Vol.* XXV, *p.* 63.
4. *Wiedemann's Annalen, Vol.* LV, *p.* 21.
5. *Br. Patents* 1,862 *and* 22,020, 1899.
6. *British Pat.* 7,777, 1900, *U. S. Pat.* 763,772, 1900.

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, audio-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.

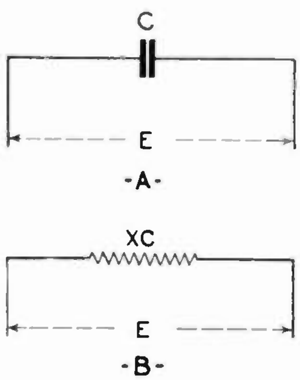


FIG. 48

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.

These two considerations are of extreme import 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 formulae 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 resistance; 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 how to calculate 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. Impedance, too, since it is expressed in ohms, is illustrated by means of a resistance. In circuits containing a condenser only, the ratio between the reactance and resistance is usually very high, so that the effect of the resistance is very small and the only opposition considered is that of the reactance.

A pure resistance, that is one without capacity and inductance, has but one value, namely, resistance. Being free of capacity, it has no capacity reactance and being free of inductance, it has no inductive rectance. Therefore its resistance value is equal to its reactance and impedance values.

The reactance of a condenser is determined by means of the formula

$$Xc = \frac{1{,}000{,}000}{6.283 \times F \times C}$$

The numerator 1,000,000 and the portion of the denominator, 6.283, which in reality is 2π, are constants. F and C are variables depending upon the frequency and the capacity. As is evident from the formula, the higher the value of F or frequency, the lower the value of reactance with a constant capacity. With a constant frequency,

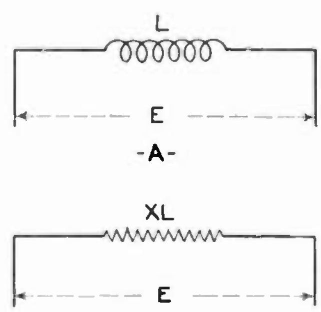


FIG. 49

The reactance of an inductance in an electrical circuit (A) is expressed in ohms and carries the symbol of resistance (B) if expressed as XL, inferring inductive reactance.

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.

Capacity		Reactance in ohms at various frequencies			
	60	250	500	1000	1,000,000
.001	2,666,000	640,000	320,000	160,000	160
.01	266,600	64,000	32,000	16,000	16
.1	26,660	6,400	3,200	1,600	1.6
1.0	2,666	640	320	160	.16
2.0	1,333	320	160	80	,08
4.0	666	160	80	40	.04
8.0	333	80	40	20	.02

(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

$$I = \frac{E}{Xc}$$

Capacitative 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 Xc, the value in ohms is 1325. In other words a 2 Mfd. condenser across a 60-cycle line will offer opposition or will have a reactance equal to 1325 ohms. Now let us suppose, as in Fig. 51, that this condenser C2 is connected across a resistance R2 which is a section of the voltage distributing system in a half-wave "B" eliminator. The function of this condenser is to by-pass the 60-cycle ripple remaining in the system. The other functions of this condenser at this time are immaterial. If the value of R2 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

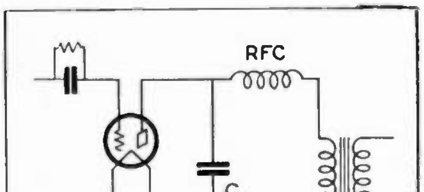


FIG. 50

The function of the capacity C is to by-pass the R.F. currents normally retarded by the radio frequency choke RFC. The capacity value of the condenser is an important factor and is covered in the text

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 by-passed. 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

$$XL = 6.283 \times F \times L$$

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 capacitative 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

$$I = \frac{E}{XL}$$

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 consideration, 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

$$Z = \sqrt{R^2 \times XL^2}$$

For example, we have an inductance of 10 henrys with a resistance of 10 ohms across a 60-cycle line. The reactance is equal to 6.283 × 60 or 3770 ohms. The impedance is equal to

$$Z = \sqrt{10^2 \times 3770^2}$$

$Z = 3770 +$ ohms (slide rule calculation)

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 comprehensible 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.

$$XL = 6.283 \times 60 \times .1 = 37.7 \text{ ohms}$$

$$Z = \sqrt{1^2 \times 37.7^2} = 37.7 \text{ plus ohms}$$

The low value of D. C. resistance has very little effect upon the total

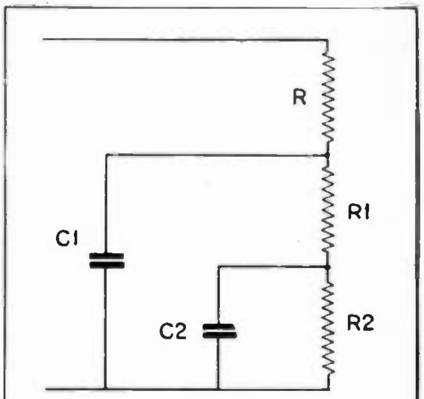


FIG. 51

By-pass condensers shunting the resistors of a "B" eliminator voltage divider network.

impedance. Now let us suppose that the D. C. resistance is 10 ohms instead of 1 ohm.

Z will then equal $\sqrt{10^2 \times 37.7^2} = 39$ 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 coils. The function of the choke oil, as its name implies, is to choke or retard the flow of certain currents through certain parts of the receiver. For example, the radio-frequency choke coil employed in conjunction with a by-pass capacity, as in the plate circuit of a detector tube, is incorporated to retard the flow of radio-frequency currents through the audio-frequency transformer winding. The function of the choke is to retard the flow of this current and cause it to flow through the capacity to the ground. This arrangement is illustrated in Fig. 50. The selection of the choke RFC and the capacity C is governed by the reactance values of the individual units. The reactance of the radio-frequency choke, which is usually of 80 or 90 millihenrys, is very low for audio frequencies but comparatively high for radio frequencies. With a known value of reactance for the lowest radio frequency in the circuit, the reactance of capacity C must be of such value as to permit the easy flow of the radio-frequency currents retarded by the choke RFC, through the capacity C to the ground. At the same time, the reactance of the condenser C must be sufficiently high to prevent appreciable loss of the audio-frequency component in the plate circuit. With a known value of impedance for the audio-frequency transformer primary or the plate load, it is a simple matter to select a by-pass condenser C which will have a low reactance for the radio-frequency component in the plate circuit, and fairly high reactance to audio frequencies.

A different state exists when an audio-frequency choke with its associated condenser is employed in the battery lead of a stage of audio-frequency amplification. Here the choke must have a high impedance to audio frequencies and the condenser used must have a low reactance. The design of these chokes is usually such that the D. C. resistance is very low, in order to minimize the D. C. voltage drop, since the chokes are carrying direct current. Consequently, the impedance of the choke is usually equal to its reactance. The reactance and impedance for all such condensers and chokes is determined in the manner described. By determining the relative reactance values of the choke and its associated condenser, one can decide if the units selected are of the correct values, and if they will be effective. In the case of the radio-frequency choke and its associated condenser, the lowest value of radio frequency need not be considered, since the reactance of the choke will increase with frequency, making it more effective, and the reactance of the condenser will decrease with applied frequency, making its function more effective. The same is true of the audio-frequency choke and its capacity.

With respect to the audio-frequency choke and its associated capacity, the following will give an idea of the relation between the capacity and the inductive reactances of the condenser and the choke, respectively. We are desirous of keeping the audio-frequency signals out of the battery circuit and incorporate into our receiver a 3 henry choke and a 1.0 Mfd. condenser as the audio-frequency choke and by-pass condenser, respectively. The lowest frequency is approximately 60 cycles. Let us consider the D. C. resistance of the choke as negligible.

Choke reactance at 60 cycles $= 6.283 \times 60 \times 3 = 1131$ ohms.

Capacity reactance at

$$60 \text{ cycles} = \frac{1{,}000{,}000}{6.283 \times 40 \times 1} = 2660 \text{ ohms}$$

It is evident that our by-pass capacity will not be very effective at 60 cycles, since the choke will offer less resistance to the flow of the 60-cycle current than the condenser. At 250 cycles, however, the reactance of the choke is 4710 ohms and that of the condenser only 640 ohms. To obtain greater efficiency at the low frequency we should increase the choke inductance or increase the capacity.

A calculation of the relative reactance values of chokes and condensers employed in radio receivers in the illustrations mentioned, will aid materially in the solution of enigmatical problems, in the determination of why certain phenomena are or are not taking place. More of this anon.

Tube and Load Impedances

The calculation of impedances plays a very important rôle in the audio amplifying system, i. e., in the determination of the probable energy transfer between the vacuum tube and the audio coupling units. The energy transfer from the tube to the coupling units is governed by the impedance relation between the tube and the coupling units.

A knowledge of the methods employed to calculate reactance and impedance is therefore necessary. Tube output impedance values are not uniform for the various types of tubes available on the present market. Without an understanding of reactance and impedance of chokes and condensers, correct selection of audio coupling units for the various tubes is impossible. Solution of the impedance relation between vacuum tubes and plate loads will explain many puzzling experiences, and the reason for disappointing experiences.

(*To be continued*)

THE ENGINEERING RISE IN RADIO

(*Continued from page* 34)

thought out in the way of a selective system of operation, assuredly had not been incorporated as elements of the equipment used on these occasions; or, if tuning systems were being employed, they were conspicuously unsuccessful. The interference was so confusing that the performance was not a success—in fact, was far from it.[7]

Factors Involved

The trained engineer of a later day will sense that the trouble with the first attempts at *tuning* in actual wireless signaling was lack of *sharpness*. In the writings of Hertz, Lodge, Thomson, Heaviside, Pupin, Tesla, Oberbeck, Bjerknes, Braun, Zenneck, and others, there was much of suggestion pointing to the advantages of exact *syntony*. 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 either the inductance or capacity or 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.

(*To be continued*)

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 1899 the desire was to operate two transmitters in one area, where today the desire is to operate without interference twenty or more transmitters in one field. It is a matter of degree. The two pictures reflect the state of the art at each of these periods.

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 sesqui-plane *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 waveband of 550—850 meters.

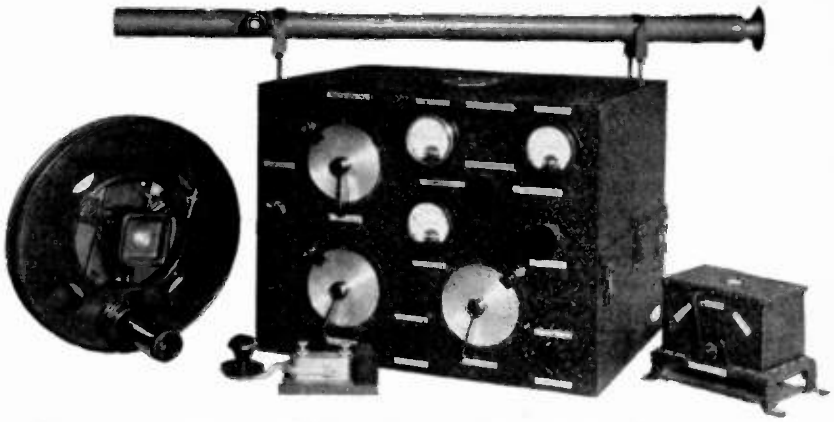


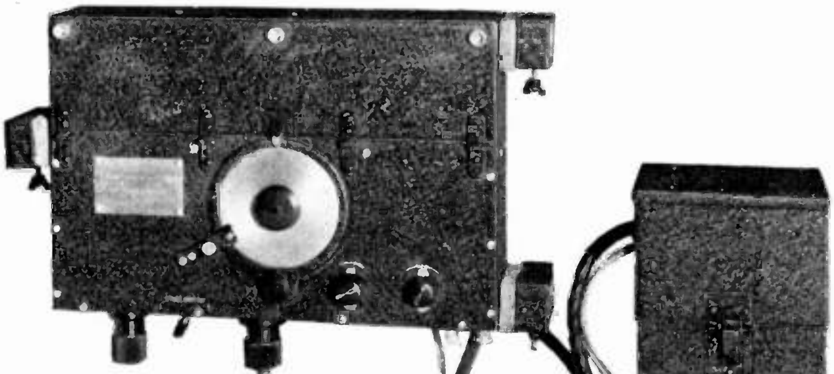
Fig. 1. The transmitting equipment of WRCA. The antenna reel; the flame-proof key in front of the transmitter over which is the Fair Lead, and the send-receive switch.

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



WRCA's 550-850 meter receiving equipment. The case on the right houses the batteries. Note the suspension blocks on the receiver cabinet.

* *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 ampere at 750 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 .0403 inches in diameter and of copperclad 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. I—is so arranged that connection to the antenna wire is made by means of a metal flange at the lower end. 350 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.

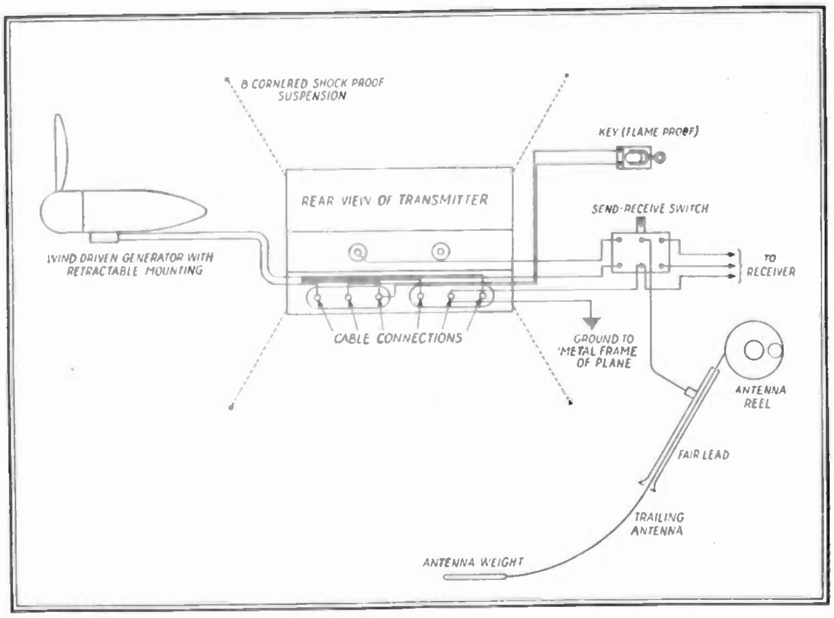
The wind-driven generator swung out of the cabin to operating position. This generator supplies both high and low voltages for operation of the transmitter. It may be drawn into the cabin when not in use thus reducing wind resistance.

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. Fitzmaurice, co-pilot of the *Bremen*, 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.



How the various units of the transmitter are connected. Note that the antenna is connected to the set through contact with the Fair-Lead.

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.

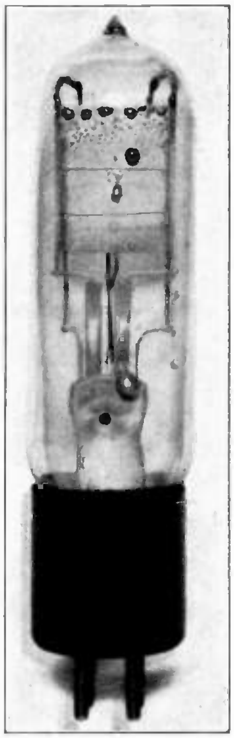


Fig. 1. Phototron KN2, is an alkali-metal photoelectric cell that is well suited to requirements of industry in general.

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.

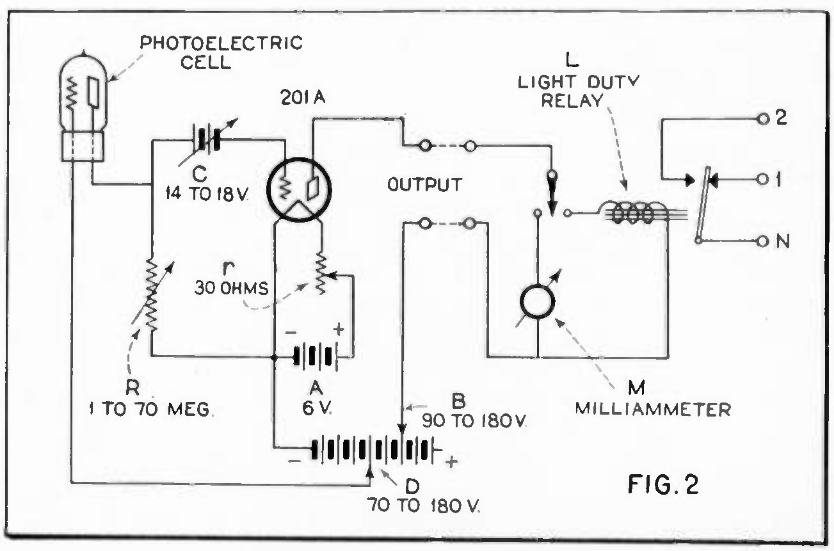
(3.) In order to prevent such glow, it is necessary to operate the cell, when used in series with a battery, at a voltage below a certain maximum allowable potential. In the notation used herein, *a battery in series with an alkali metal cell* or other photoelectric cell is always called a "D" battery. 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 100,000 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, cigars, and other commodities according to color. The application may be further extended to include in-



A circuit which is excellent for color sorting machines, automatic titration, smoke detection or for the control of light-duty machinery.

* Photion Instrument Corp.

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, uncritical operation.

(8) **"B" 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.

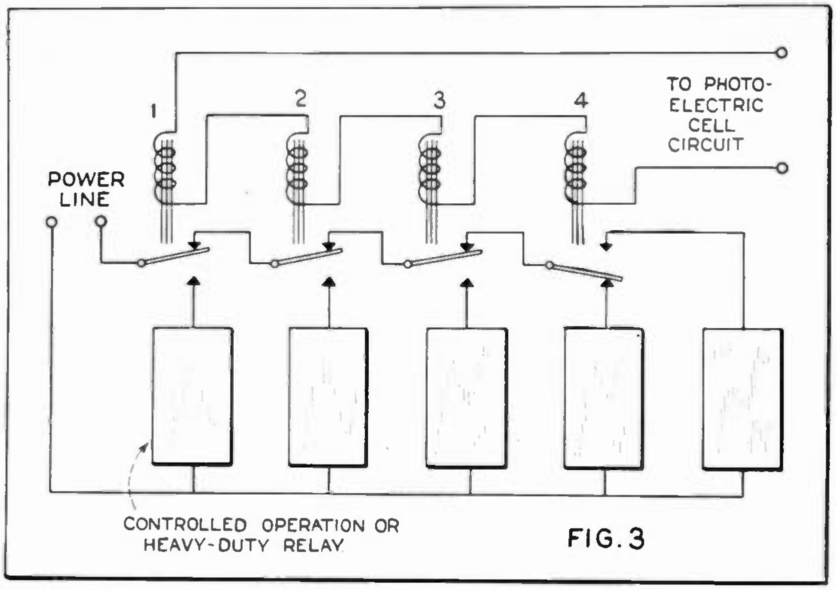


FIG. 3

A number of light-duty relays operating on slightly different currents may be controlled by one photoelectric cell.

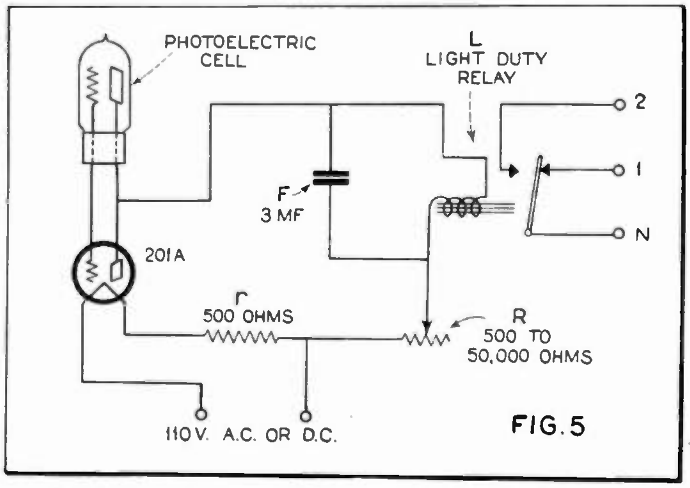


FIG. 5

Rough work is the main function of this light-duty circuit.

(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

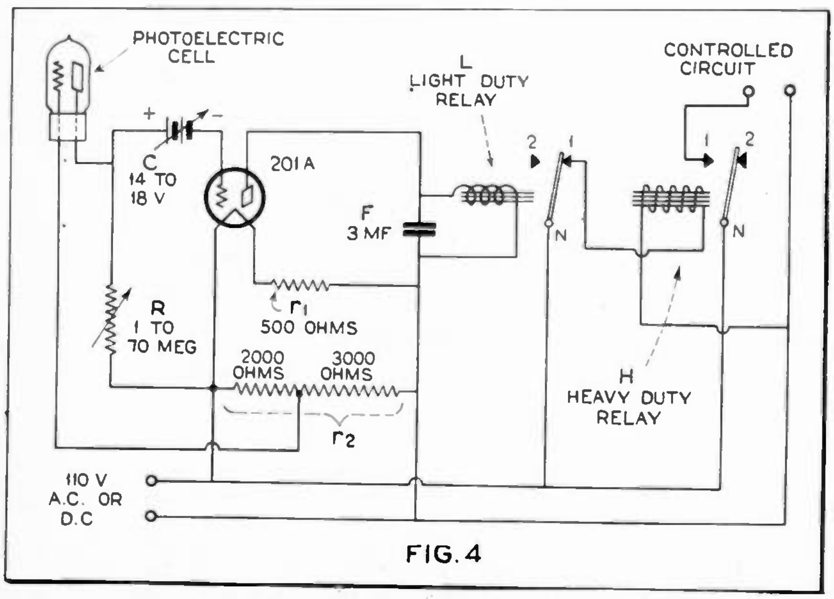


FIG. 4

This control circuit is for heavy-duty work and is intended for operation from line currents.

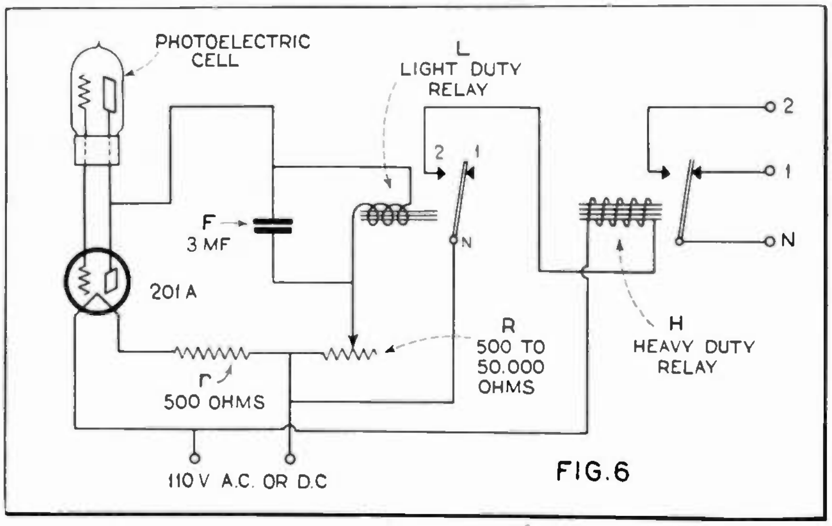


FIG. 6

A practical circuit for the control of either A.C. or D.C. power equipment.

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 "B" 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 199 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.

(To be continued)

Fifth Annual Radio World's Fair

Consumer Show Opens September 17 in Madison Square Garden. Radio Industries Banquet Is Announced for September 18

THE Fifth Annual Radio World's Fair in Madison Square Garden, New York City is announced to 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. Clayon Irwin, Jr., Show Manager, 1800 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. Klugh, of Chicago, vice president and general manager of Zenith.

ZENITH GAINS MORE AUTOMATIC PATENTS

In addition to the Marvin and Vasselli patents, the Zenith Radio Corporation, in further strengthening its position, in the control of automatic radio, has purchased Heath Patent No. 1,638,734, British Patent No. 257,138, Canadian Patent No. 264,391, French Patent No. 607,436, Belgium Patent No. 331,166, and United States Patent Re No. 17,002.

There are also seven other patents controlled by Zenith, pending in the patent office.

HILER AUDIO TO EXPAND

The successful adjudication and the declaration of validity of the tuned double impedance patents held by the Hiler Audio Corp. in the U. S. District Court of Massachusetts, was the opening gun in the program of expansion instituted by this 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 licenses to these manufacturers. Negotiations are pending with several others and it is the purpose of this patent organization to license some of the reputable radio receiver manufacturing concerns.

Very succcessful tests have been recently completed and incorporation of the Hiler system into some of the most popular receivers is only a matter of a very short time. The licensees of the Hiler Audio Corp. at the present time are Zenith Radio Corp., General Radio Co., American Specialty Co., Ford Mica & Radio Co., Kenneth Harkness Laboratories, Inc., and Leslie F. Muter Co.

ACTIVITIES OF THE FEDERATED RADIO TRADE ASSOCIATION

The past Convention of the Federated Radio Trade Association held June 11-15 in Chicago marked the beginning of one of the most important steps ever undertaken by any association in any industry. The important step referred to is the reorganization of the Federated to provide for individual branches for the manufacturers' representatives, for the radio wholesalers, for the radio retailers and for local radio trade associations, thus 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 Michigan Radio Trade Association, the Wisconsin Radio Trade Association and the St. Louis Radio Trade Association. These associations combined for their mutual benefit and through their exchange of ideas and experiences 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 with this movement to make it a nationwide project. During the year of 1927, the Federated secured many new members and established executive offices at 32 W. Randolph St., Chicago.

As the industry had become more stabilized, the individuals engaged in the distributing of radio apparatus expressed themselves as wanting an organization of their own whereby they could work on problems affecting their particular phase of the industry and yet cooperate with the other branches in the development of the industry. In accordance with their request and suggestions, the Federated started a re-organization program in Milwaukee, February 15, at their Second Annual Convention. This re-organization scheme was 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. This new set-up provided for four component groups within the Federated. The first being that of the original local trade associations which is headed by Mr. Michael Ert, President of the Wisconsin Radio Trade Association. Then follows the Radio Wholesalers Association, headed by Peter Sampson, a national organization of radio wholesalers working for the interests of their members. The National Radio Retailers association, headed by Julian Sampson, working for the benefit of the radio dealers; and the Manufacturers' Representatives Section headed by Geo. Riebeth, composed of radio manufacturers' representatives, all cooperating in an endeavor to better the conditions within the industry.

Each of these groups elect six men 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 own officers and all committees working on their individual problems. These four groups, however, through their close connection with the Federated cooperate with each other and save many of the needless disputes concerning differences of opinion which take place frequently in associations which have no common meeting ground.

This re-organization represents the first time that the entire distributing side of any industry has been organized and correlated 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 again in the passage of the Act of 1928. They have cooperated with the Radio Manufacturers Association and the National Association of Broadcasters in advising the the Federal Radio Commission concerning the interpretation of the present Federal Radio Act. They have been very active in the promotion of training schools for radio service men and many of the local associations have established a plan for the examination and registry of all service men thereby insuring the public of increased satisfaction 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 merchandise and providing the dealer with an opportunity for sales heretofore never presented. They have been very active in the solution of interference problems and in the formation of Listeners Clubs as well as doing much throughout the entire country to benefit the conditions of the distributors and the radio public.

The officers and members of the Federated Radio Trade Association are working 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 wholeheartedly for the benefit of the industry and they feel themselves entirely compensated for their efforts.

HAROLD J. WRAPE

President, Federated Radio Trade Association.

H. R. FLETCHER ELECTED VICE-PRESIDENT OF RACON

The Racon Electric Company takes pleasure in announcing the appointment of Mr. H. R. Fletcher as Vive-president and Director of Sales of that company.

Mr. Fletcher joined the Racon Electric Co., as Sales Director, in February of this year. He was previously connected as an executive with Amsco Products, Inc., Algonquin Electric Co. and the Apco Mfg. Co.

INTERNATIONAL RESISTANCE CO. MOVES IN PHILADELPHIA

The International Resistance Company has moved its factory to 135 North 22d Street, and is equipped in most modern fashion for the manufacture of metallized filament and for laboratory facilities.

The production of metallized filament 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.

H. C. HOLMES APPOINTED DE FOREST SALES MANAGER

The DeForest Radio Company of Jersey City, N. J., announces the appointment of H. C. Holmes as general sales manager, with headquarters in the main office at the plant.

For many years back Mr. Holmes has been closely identified with the radio industry, particularly in the production end. Prior to his present appointment, he was vice-president of Henry L. Crowley & Company, manufacturers of synthetic ceramic products widely employed in the production of vacuum tubes, and secretary and general manager of the Isolantite Company of America before that time.

AEROVOX INCREASES PLANT SPACE

According to S. I. Cole, general manager of the Aerovox Wireless Corporation, the increased demand for Aerovox condensers and resistors this year has made necessary the addition of 10,000 square feet of floor space to the Aerovox plant at 70 Washington Street, Brooklyn, N. Y. This brings the total floor space occupied by this pioneer condenser and resistor manufacturer up to 30,000 square feet or seven times the space occupied only four years ago.

NEW BELDEN REPRESENTATIVE

The Belden Manufacturing Company, 2300 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 automotive, electrical and radio lines which are merchandised exclusively through jobbers and dealers.

KSTP AND WJBI ON RAFOTO SCHEDULE

The Radiovision Corporation, 62 West 39 Street, announces that stations KSTP, of the National Battery Broadcasting Company, St Paul, Minn., and WJBI, of Scranton, Pa., have joined the growing list of stations broadcasting pictures through the Cooley Rayfoto process on their radio schedules. Among the other stations in the chain are WMCA, Hotel McAlpin, New York city, which broadcasts a picture playlet every Wednesday night and pictures three mornings each week; WTMJ, Milwaukee Journal, Milwaukee; KMOX, Voice of St Louis, St Louis; WOKO, Hudson Valley Broadcasting Company, Mt Beacon, N. Y.; WDEL, Wilmington Electric Specialty Company, Wilmington; WWJ, W. R. Hoffman, Detroit; WFI, Strawbridge & Clothier, Philadelphia; CKNC, Canadian National Carbon Company, Toronto; and CJRN, D. R. P. Coats, Grain Exchange Building, Winnipeg.

NAT GREENE NO LONGER MATRIMONIAL PROSPECT

Mr. Nat Greene, Vice-President of the Polymet Manufacturing Company, was married to Dr. Esther Tuttle of Boston, on Wednesday, the 11th of July, at the Hotel Biltmore.

After the ceremony, the bridal couple 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. 1676256 to P. 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 for tuning said grid circuits and correspondingly varying said electromagnetic couplings, the minimum setting of said electromagnetic coupling being proportioned at a predetermined amount of the maximum setting thereof and progressively varied for each change of tuning of said secondaries from minimum to maximum adjustment thereof."

The patent describes a radio set which efficiently amplifies at all broadcast wavelengths and is regarded as an important departure in the art, introducing simplified automatic mechanical stabilization replacing complicated electrical circuits used in the past.

NEW WEST COAST REPRESENTATIVES OF DURHAM

The Henger-Seltzer Company of Los Angeles and San Francisco have been appointed as California representatives of the International Resistance Co., of Philadelphia, Pa.

Consigned stocks of material will be carried at both offices for prompt shipment to those dealers and jobbers who will stock the Durham products.

NEW MAJESTIC REPRESENTATIVE

The radio trade will be interested in the announcement that Mr. W. H. Bishop, formerly sales manager of Blackman Distributing Co., is now connected with Grigsby-Grunow Co., in capacity as special sales representative in the Metropolitan District of New York City. He will co-operate with Mr. Herbert E. Young, general sales manager, and work out of the 33 West 42nd St. Office, New York. Mr. Bishop has been associated with the Blackman Distributing Co. for seven years.

INTERNATIONAL RESISTANCE CO. APPOINTS KILLAN, INC. WESTERN REPRESENTATIVE

The International Resistance Co. of 2½ S. 20th St., Philadelphia, Pa., have announced the appointment of Killam, Inc., of Portland and Seattle as their representatives in Oregon and Washington. Consigned stocks of material will be carried at both offices.

X-L RADIO LABORATORIES MOVE TO LARGER QUARTERS

1124 Belmont Ave., Chicago, Ill., is the new home of the X-L Radio Laboratories. Here they have greater floor space than formerly, which with increased equipment, permits greater and more economical production.

ALDEN CO. MOVES TO NEW PLANT

It was announced recently at the annual meeting of the Alden Manufacturing Company that the business would be moved to Brockton, Mass.

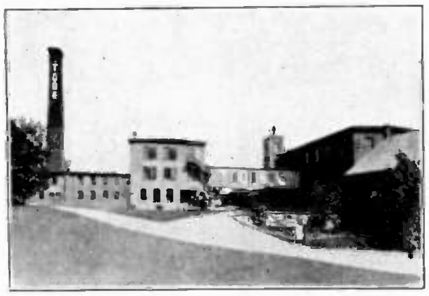
Their new home will be in an ultra modern daylight factory, known as the Plymouth County Ideal Factory, built several years ago by a group of bankers and Brockton business men.

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 Maynard A. Davis—the last three named all of Brockton.

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 Lulling, Texas.

HARDWICK, FIELD INC., OPEN NEW SALES OFFICES

Due to increased business Hardwick, Field, Inc., have been compelled to take



New home of Tobe in Canton, Mass. The plant has 92,000 ft. floor space and covers six buildings.

new and larger sales offices and are now located at 122 Greenwich Street. Several additional representatives have been appointed, which include:—

Albert L. Borkow, Jr., 1015 Chestnut St., Philadelphia, Pa.; J. A. McCaffry, 8656 Dumbarton Rd., Detroit, Mich.; H. B. Parke, 305 Seventh Avenue, Pittsburgh, Pa.

GRAY SALES CO. OPEN NEW YORK OFFICE

After operating in the New York territory for seven years from their Philadelphia Office the Gray Sales Co. have finally "broken out" and opened a New York office and show-room at 222 Fulton Street. Phone Cortlandt 6209 where Mr. Max Witz will be in constant charge.

The Gray Sales Co. also announce their appointment as metropolitan sales representatives for the following manufacturers: The Webster Company, Chicago; The Fidelity Radio Corporation, Salt Lake City, Utah; Gardiner & Hepburn, Inc., Philadelphia; R. B. M. Mfg. Co., Logansport, Ind.; Union Metal Products Co., Minneapolis, Minn.

DUBILIER OFFICES IN CHICAGO AND PHILADELPHIA

In order to co-operate more effectively with manufacturers and jobbers, the Dubilier Condenser Corporation of New York City has just opened its own branch office at 330 South Wells Street, Chicago. This branch office is managed by Fred Damarin, who is well known to the radio and electrical trades in the Middle West.

There is also announced at this time a Dubilier Philadelphia office in charge of Joseph H. Myers, at 1524 Chestnut Street, for the purpose of serving the radio and electrical trades in the Pennsylvania territory.

"RADIO ADVERTISING," NEW MONTHLY MAGAZINE

Radio Advertising is a new monthly magazine which will be published by Maxwell McArthur and Harry Schwarzschild at Flushing, N. Y. The first issue will appear in August and will be devoted to all phases of radio merchandising and selling.

NEW FEDERAL WHOLESALERS

The Metropolitan Electrical Supply Co., 180 West Lake St., Chicago, Ill., and the Swanson Electric & Manufacturing Co., Evansville, Ind., have been appointed wholesalers by the Federal Radio Corporation, Buffalo, N. Y. to serve Federal Orthosonic retailers in their respective territories.

D'ALMAINE JOINS BODINE ELECTRIC CO.

The Bodine Electric Company, 2254 West Ohio Street, Chicago, manufacturers of fractional horsepower electric motors and electric phonograph turntables, announce that Mr. H. D'Almaine has recently been appointed Assistant Sales Manager. Mr. D'Almaine was formerly advertising manager of Louis Allis Company of Milwaukee, Wisconsin, and previous to that, Assistant Sales Manager of Charles Cory & Son, Incorporated. He also was Assistant Manager of the fuse department of the Federal Electric Company, and was in charge of sales promotion work of jobbers and dealers.

FEDERAL RADIO CORP. OPERATES WHOLESALE DIVISION TO STUDY DEALER REQUIREMENTS

In its endeavor to give the best possible service to its dealer trade, the Federal Radio Corporation has established at the manufacturing plant in this city, what Lester E. Nobile, president of the company, terms a "laboratory for dealer problems". The so-called laboratory is taking the shape of a wholesale department for the Buffalo area, within the plant, under the direction of L. W. James, assistant to the president. Mr. James is maintaining a corps of salesmen and service men operating in direct touch with the dealers, giving them the benefit of the sales and service of a wholesaler.

NEW DUBILIER SOCKET-POWER CONDENSER CATALOG

An explicit catalog containing a complete line of condensers and condenser blocks for the "A" and "B" circuits of the socket-power set, as well as special interference elimination devices, has just been published by the Dubilier Condenser Corporation with sales offices at 10 East 43rd Street, New York City.

The Dubilier Socket-Power Condenser Catalog specifies condenser blocks for various standard radio power circuits and rectifiers. An analysis of each Dubilier condenser block is given, showing the capacity and the maximum D.C. working voltage of each section. The dimensions of the standardized cans in which Dubilier condensers and condenser blocks are enclosed, are also given, so that the mechanical quite as well as the electrical information is instantly available to the radio set builder.

A copy of this catalog, together with that dealing with Dubilier Micadons, Metaleaks, Light Socket Aerial and other devices, will be sent to anyone on request.

THOS. H. OWEN TO REPRESENT KELLOGG

Mr. Owen who recently joined the Radio Sales staff of the Owen Switchboard and Supply Company has had a successful career in the selling field, with two well known firms, extending over a period of more than twelve years.

He has been a sales representative for Roco Products Company of Cleveland, Ohio, for the past five years in the Ohio and Illinois territories.

Previous to his connection with that concern he was Chicago sales representative and manager of the Schulze Baking Company of Chicago for over seven years.

Mr. Owen has been spending the past few weeks at the Kellogg plant where he is studying the various manufacturing processes and attending sales meetings. He has been assigned to the New England states territory.

ALL-AMERICAN MOHAWK SHOW INCREASE

E. N. Rauland. President. All-American Mohawk Corporation, announces that the company, during the convention of its distributors, and during the Radio Trade Show, had closed contracts for sales running to $8,450,834. This compares with approximately four million dollars' worth of business transacted by the company for the entire year of 1927.

WUNDERLICH JOINS CARTER

N. E. Wunderlich has been appointed general sales manager of the Carter Radio Company, 300 S. Racine Ave., Chicago. Mr. Wunderlich during the past four years was associated with the Neutrowound Radio Mfg. Co. prior to which he was connected with the United Radio Corporation for a period of three years. He was formally publisher of Radio Topics.

FOUR NEW KELLOGG DISTRIBUTORS

Recently the Kellogg Switchboard and Supply Company, of Chicago, secured the following four new distributors for Kellogg Radio products:

The Kelvinator-Cleveland Company of Cleveland, Ohio, will provide outlets for Kellogg in North, Central and Northeastern Ohio. This concern is a large distributor of Kelvinator electric refrigerators and has a fine following of dealers who are able to merchandise radio.

The Fobes Electrical Supply Company of San Francisco, California, will distribute Kellogg Radio products in Northern California and Western Nevada. This old established electrical supply house has branches in Portland. Oregon; Seattle and Spokane, Washington.

The Collins Electric Company of Des Moines, Iowa, will represent Kellogg in Central Iowa.

Sickles & Preston Hardware Company, Davenport, Iowa, will feature Kellogg in part of Northwestern Illinois and Eastern Iowa.

C. F. COPELAND, EAGLE SALESMAN

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 direct 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 Ostrander Electric Company.

GREBE LEASES LARGE FLOOR SPACE IN FORD BUILDING

Space totaling 13,000 square feet has been leased by A. H. Grebe & Company, Incorporated, of New York City and Los Angeles, in the Ford Building on Northern Blvd., in Long Island City, New York.

This additional plant space will be used to consolidate the present shipping and storing facilities of the Grebe plant at Richmond Hill, and will be used exclusively as a shipping base and warehouse.

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

GREBE JOBBER ON COAST CHANGES FIRM NAME

Weinstock-Nichols Company, distributor of radio products of A. H. Grebe and Company, Incorporated, of New York and Los Angeles, has moved and changed its firm name to Robert Weinstock, Incorporated. The new address of the company is 643 Mission Street, San Francisco, California.

Newly appointed officers of the company are: Robert Weinstock, President and General Manager; W. A. Creelman, Vice President and Sales Manager, and Marshall Robinson, Secretary and Credit Manager.

K. W. RADIO CO. HAS NEW QUARTERS

To facilitate the handling of the increased business on the new Majestic electric receiver, K. W. RADIO CO., INC., have taken more extensive quarters in the *Evening Graphic* Building at 350 Hudson Street, New York City. They have over 4,000 sq. ft. for offices and 10,000 sq. ft. for warehouse, which occupies the entire northeast corner of Hudson and Charlton 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 Cambridge, Mass., has taken out a license to manufacture tuned double-impedance audio couplers under United States patents granted to Mr. Edwin E. Hiler and assigned to the Hiler Audio Corp.

The new line of general Radio Co. parts will include tuned double-impedence couplers for use with conventional tubes and also tuned double-impedance audio couplers for use with the 222-type of screen-grid tubes.

BLINN AND MERRITHEW TO CALL ON TRADE FOR JENSEN RADIO

Two additional appointments to the sales organization of the Jensen Radio Manufacturing Company, with manufacturing plants located in Chicago and Oakland, Cal., were announced recently by Thomas A. White, general sales manager of the company. These follow closely the five appointments 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.

ERNEST E. YAXLEY PASSES AWAY

Manufacturers of telephone and radio equipment throughout the country will be saddened at the news of the death of Ernest E. Yaxley, President of the Yaxley Manufacturing Company, 9 South Clinton St., Chicago, Ill., who passed away July 27th at his summer home at Wauconda, Ill., after an illness of several months.

Mr. Yaxley was born June 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 Washing Machine Company. From here he went to the Western Electric Company as a tool maker. At both these places his inventive ideas and genius was readily recognized, as he designed and perfected many devices in the manufacture of their various products. Later on he joined the Victor Telephone Company as superintendent of their shops where he developed the present telephone bell now found on every telephone receiver.

In May 1901 when the then existing patents on telephone receivers expired Mr. Yaxley, H. C. Hubacker and J. E. Norling organized the Monarch Telephone Manufacturing Company located at Canal and Randolph Streets. The independent manufacturer of telephone apparatus proved to be a failure so in 1912 this company sold out this part of their business and the name was changed to Yaxley Manufacturing Company, which continued 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 in which his company is one of the leaders in this country today.

According to Mr. White, James H. Blinn, U. S. National Bank Building, Denver, Col., has been assigned the territory comprising the states of Colorado, Utah and Wyoming, while Harry Merrithew, 713 South Ervay Street, Dallas, Texas, will represent the Jensen Radio Manufacturing Company in Texas and New Mexico.

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

SPLITDORF APPOINTMENTS

Splitdorf Radio Corporation continues to intensify its distributorships throughout the country. The following appointments have just been announced by Hal P. Shearer, general manager of the company:

At St. Joseph, Missouri—Wyeth Hardware Company, to cover eastern Kansas, and Missouri and Nebraska territory.

At Hutchinson, Kansas—Auto Supply Co., to cover central Kansas territory.

At Dallas, Texas—Padgitt Bros., whose salesmen will cover for Splitdorf central Texas.

RAYTHEON ABSORBS Q. R. S. RADIO TUBE DIVISION

Raytheon Manufacturing Company of Cambridge, Mass., radio tube specialists, announce that they have absorbed the Radio Tube Division of The Q.R.S. Company of Chicago, in part settlement of the suit against the latter company for infringement of the gaseous rectifying tube patents.

A BULLETIN ON DESIGN OF IRON CORE REACTANCES

Ever since socket power B supply devices first became an important factor in the radio industry several years ago, and especially since the more recent trend of design toward completely socket-power-operated radio sets, there has been a very apparent need for a simple yet reliable method of designing iron core filter reactors through the windings of which must pass both alternating and direct currents. Realizing the meagre data heretofore available much of which applied to steels not generally available to most radio manufacturers, the Raytheon Laboratories has undertaken extensive studies based on commercially available grades of silicon steel.

The results of these studies are now made available in Raytheon Technical Bulletin, Vol. 1, No. 1, under the title "Design of Iron Core Reactances." This bulletin contains the necessary mathematical data for the calculation of iron core reactances, including permeability curves, incremental permeability curves, design chart, procedure in design, chokes for large range of direct current, flux density, and a synopsis of method of calculation employed by Hanna in obtaining design charts for iron core reactances which carry direct current.

A copy of the foregoing described bulletin is available for the asking by addressing the Technical Service Department, Raytheon Manufacturing Company, Cambridge, Mass.

A BULLETIN ON CONSTANT POTENTIAL REGULATION

An ingenious method of automatic compensation for line voltage variations, based on obtaining a phase shift between the primary voltages of two transformers connected in series, one of the transformers to perform as a capacitive reactance and the other as a straight inductive reactance, has resulted from extensive research work on power unit design conducted in the Raytheon Laboratories.

The practical results of these research efforts are now published in Raytheon Technical Bulletin, Vol. 1, No. 2, under the title of "Constant Potential Regulator," by D. E. Replogle. Copies of this bulletin may be obtained free by addressing the Technical Service Department, Raytheon Manufacturing Company, Cambridge, Mass.

WELL KNOWN RADIO MEN JOIN AMRAD SALES FORCE

The following men have recently joined the Amrad Corp. sales force, according to announcement made recently by W. H. Lyon, general sales manager.

Mr. L. D. Trefry will work in the New England territory for Amrad. Mr. Trefry, for the past three years, has been a radio dealer and for that reason knows the problems of the men with whom he will contract. Prior to becoming a dealer, he spent several years at sea as a radio operator and has been in the radio business since its inception.

Mr. E. H. Troan, formerly announcer at WHEC, the broadcasting station at Rochester, New York, and prior to that associated with the Zinke Company of Chicago. Mr. Troan will cover New York City for the Amrad Corporation.

Mr. Edgar K. James has recently joined the Amrad sales force in the capacity of Mershon sales engineer. Mr. James is well known in the radio manufacturing business and is well fitted for his new position by reason of his past experience and knowledge 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.

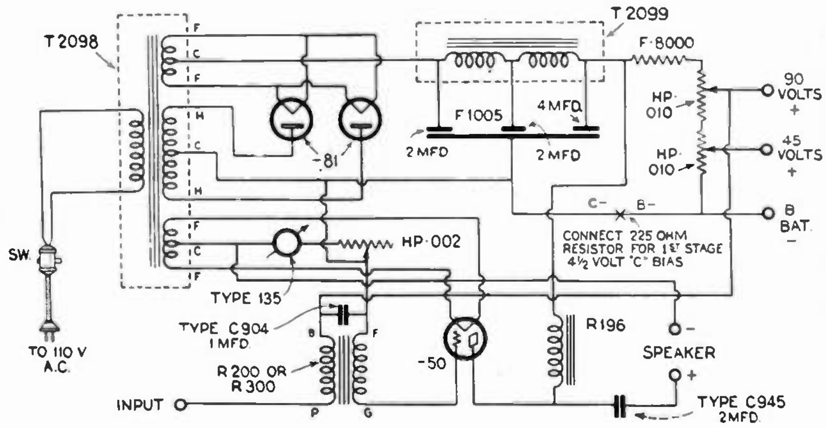
Equipment designed for the 350 tube must be capable of supplying the high plate current and the necessary grid bias, which is from —45 to —84 volts as shown in the tabulation:

Plate Volts	Neg. Grid Bias (Volts)	Bias Resistor Value (Ohms)	Plate Current (Milli-amperes)	Undis-torted Power Output (Milli-watts)
250	—45	1600	28	900
300	—54	1550	35	1500
350	—63	1400	45	2350
400	—70½	1250	55	3250
450	—84	1100	55	4050

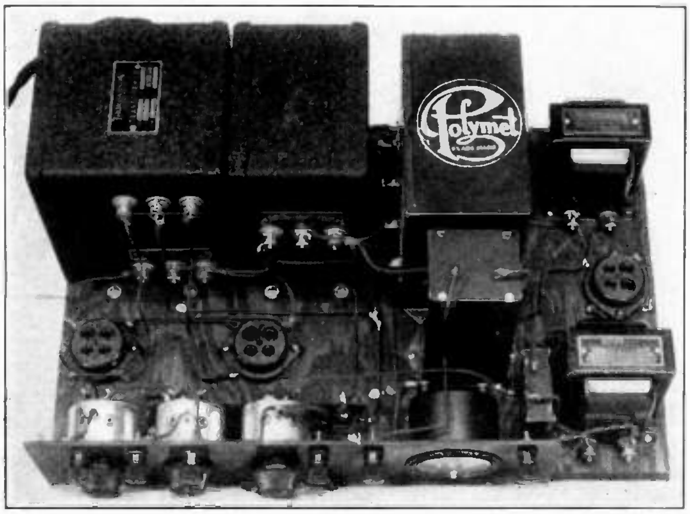
The filament rating is 7.5 volts. 1.25 amperes. The material used is of the rugged coated ribbon type, similar to that used in the 381 rectifier. This filament operates at a dull red heat. The current required is supplied from the 7.5 volt winding of the power transformer. The low operating temperature 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 5%). 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.

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.



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



The apparatus of the power amplifier and "B" supply mounted on baseboard. At the rear left, the power transformer; next the choke, condenser bank, and output choke. The A.F. transformer is at the front. See diagram on page 47 for mounting and wiring instructions.

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 laying 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-2099 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 right 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 small 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 prings are ben 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.

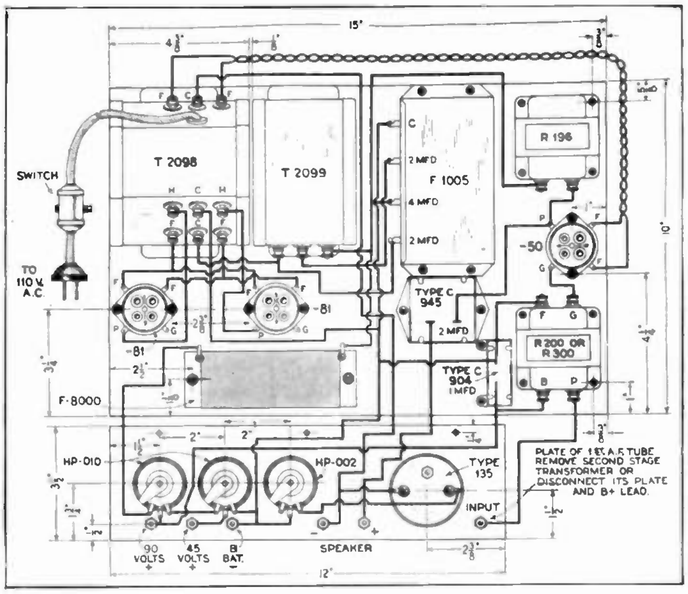
In connecting the unit to the receiver, the wire connecting the plate of the first audio stage socket to P on the audio transformer should be removed and a flexible lead connecting to the socket is to be brought down to the input post on the eliminator. The rest of the B leads are connected to their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

With the tubes inserted vary the 2,000-ohm resistance until the milliammeter reads approximately 55 to 60 mills. The filament of the rectifier tubes should burn at a dull red heat. The plates should not be red, as such will indicate a defective condenser or a short circuit elsewhere.

LIST OF PARTS REQUIRED

1—Thordarson Power Transformer (type T-2098).
1—Thordarson Choke Coil (type T-2099).
1—Thordarson Audio Transformer (type R-200 or R-300).
1—Thordarson Choke Coil (type R-196).
1—Polymet Condenser Block (type F-1005).
1—Polymet 2-mfd. By-Pass Condenser (type C-945).
1—Polymet 1-mfd. By-Pass Condenser (type C-904).
6—Eby Binding Posts marked as follows: 67 volts+B Bat—Speaker—45 volts+ ANT. Speaker+.
3—Eby Sockets.
2—Centralab 10,000 ohm Heavy Duty Potentiometers (type HP-010).
1—Centralab 2,000 ohm Heavy Duty Potentiometer (type HP-002).
1—Centralab 8,000 ohm Resister Strip (type F-8,000).
1—Roll Solid "Braidite" Wire.
1—Cunningham CX-350 or Speed UX-250 Tube.
2—Cunningham CX-381 or Speed UX-281 Tube.
1—Jewell Milliammeter (0-100 mills) (pattern No. 135).
1—Westinghouse Micarta Fabricators Panel 12 inches x 3½ inches.
1—Baseboard 12 inches x 10 inches x ½ inch.

The location of the parts may be determined by the type numbers, which are given in the List of Parts on this page. The simplest wiring procedure is also indicated.



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 .00035 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.

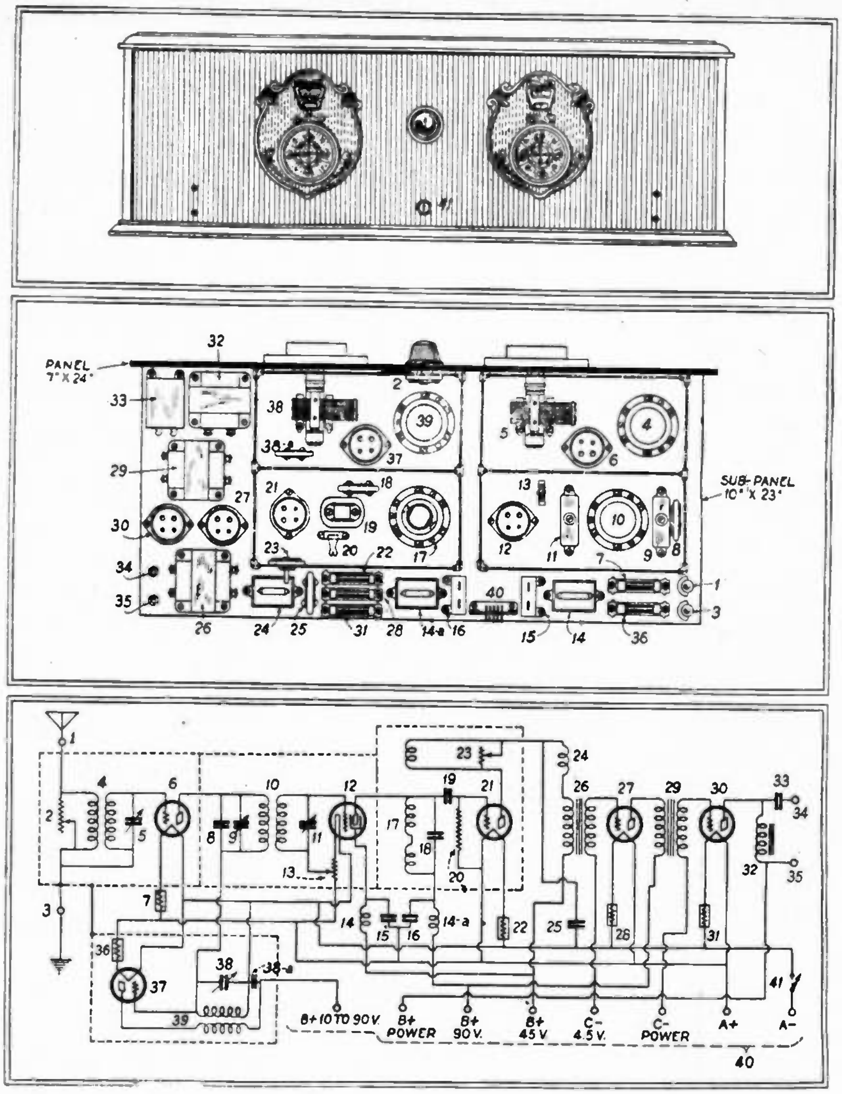
As a result, the plate potential of the mixing tube is alternately positive and negative, since it varies in unison with the potential of the oscillator grid. Therefore, the plate current flows only at intermittent intervals in the mixing tube and it is possible to regulate the frequency of the positive potential application to the plate by tuning the grid circuit of the oscillator tube. This is done by means of a .0005 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 60 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 eliminator.

The dotted lines shown on the schematic diagram indicate the apparatus enclosed within shields. Two new style Hammarlund "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

1—Silver-Marshall Plug-in Antenna Coupler, type 115-A (4).
1—Silver-Marshall Plug-in Long Wave Coupler, type 115-E (10).
1—Silver-Marshall Plug-in Long Wave Impedance Coil with Rotor, type 110-E (17).
1—Silver-Marshall Plug-in Oscillator Coupler, type 110-A (39).
4—Silver-Marshall Coil Sockets, type 515, (4, 10, 17, 39).
1—.00035 mfd. Hammarlund "Mid-Line" Variable Condenser (5).
1—.0005 mfd. Hammarlund "Mid-Line" Variable Condenser (38).
2—Mar-Co Vernier Dials, new 1928 Model.
1—Carter "Imp" Lock Switch (41).
3—Samson R.F. Chokes, No. 125 (14, 14-a, 24).
6—Eby Sockets, new style UX type, (6, 12, 21, 27, 30, 37).
1—X-L Variodenser, type G-10 (9).
1—X-L Variodenser, type G-5 (11).
2—Thordarson R-200 Transformers (26, 29).
1—Thordarson R-196 Output Choke (32).
1—Royalty Variable Resistance, Electrad, type "F" (23).
1—200 Ohm Yaxley Potentiometer, No. 5200 P (2).
1—0.5 meg. Durham Metallized Resistor Grid Leak, with Single Durham Vertical Mounting (20).
2—0.5 mfd. Acme "Parvolt" series "A" Cubical Condensers (15, 16).
2—Carter Tip Jacks (34, 35).
4—Amperites, No. 1-A, with Mountings, (7, 22, 28, 36).
1—Amperite No. 112, with M't'g (31).
1—.00025 mfd. Sangamo Grid Condenser (19).
1—.00035 mfd. Sangamo Fixed Condenser (18).
1—.0005 mfd. Sangamo Fixed Condenser (8).
2—.001 mfd. Sangamo By-Pass Condensers (25, 38-a).
1—2 mfd. Acme "Parvolt" series "A" Cubical Condenser (33).
1—Carter Filament Resistor, type CC-5-15 for Screen Grid Tube (13).
2—Rolls Acme "Celatsite" Wire.
1—Yaxley 12-Conductor Cable, complete with Connector Plug & M't'g (40).
1—Can Kester Radio Solder (Rosin Core). By the Chicago Solder Co.
1—Composition Panel, 7" x 26" x 3/16".
1—Sub-Panel, 10" x 25" x 3/16".
2—Brackets, low type.
2—X-L "Push-Posts" (1, 3).
2—Hammarlund new "HI-Q" type Shields.
4—"Speed" Super Emission Tubes, type 201-A (6, 21, 27, 37).
1—"Speed" Super Emission Tube, type X-171 (30).
1—Shield Grid Tube, 222-type (12).

Airplane Radiobeacon 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 radiobeacons which are used to guide aircraft. Experience has shown that the beacons 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.

SM

S-M LEADERSHIP
means Better Radio

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 kinks that will help you to get the most out of radio.

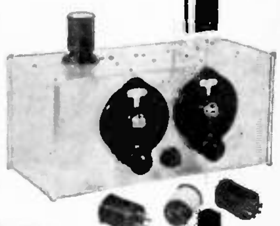
You can't afford to be without "The Radiobuilder," for besides general news of interest to every setbuilder it gives advance notice and previews of new products and detailed constructional and operating data on new apparatus before the information appears in the S-M DATA SHEETS.

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.

IN 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, but 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 made-to-order or home-built radio sets 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 receivers that will consistently outperform all ready-made sets at anywhere near their amazingly low prices.



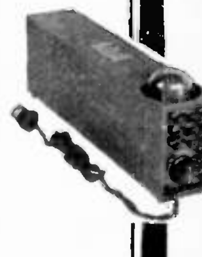
New S-M Offerings Now Ready

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 unequalled 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 revelation in four-tube results. Type 700 metal shielding cabinet as illustrated is but $9.25 additional, for either set, finished in duo tone brown; it marks a new standard of style and distinction.

The Sargent-Rayment Screen Grid Seven, type 710, is the wonder set of the season, and S-M offers, exclusively, the approved kit at $120.00. It is complete with aluminum shielding cabinet and will bring in 100 stations on any average evening.

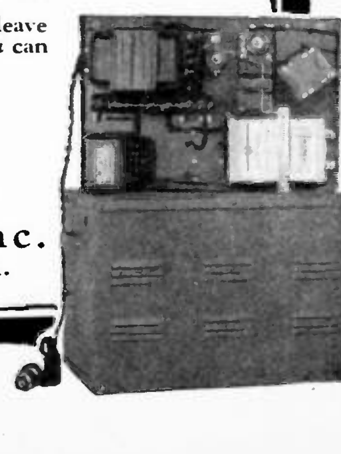


The S-M "Round the World" Short Wave sets are the trimmest, most efficient short wave sets yet, priced from $36.00 to $51.00 complete with shielding cabinet. New S-M condensers are marvels of rigidity and flexibility in Universal single, and triple types. The 685 Public Address Unipac—the first really 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 Unipacs 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 255 and 256 ($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 wish to build, yet want your radio to be custom-made, 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.

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

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

For enclosed............in stamps, send me the following:

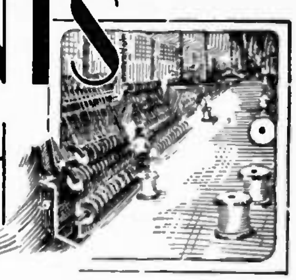
....(50c) Next 12 issues of THE RADIOBUILDER
....($1.00) Next 25 issues of THE RADIOBUILDER

S-M DATA SHEETS as follows, at 2c each:

....No. 1. 670B. 670ABC Reservoir Power Units
....No. 2. 685 Public Address Unipac
....No. 3. 730, 731, 732 "Round-the-World" Short Wave Sets
....No. 4. 223, 225, 226, 255, 256, 251 Audio Transformers
....No. 5. 720 Screen Grid Six Receiver
....No. 6. 740 "Coast-to-Coast" Screen Grid Four
....No. 7. 675ABC Power Supply and 676 Dynamic Speaker Amplifier
....(50c) Sargent-Rayment Instruction Booklet

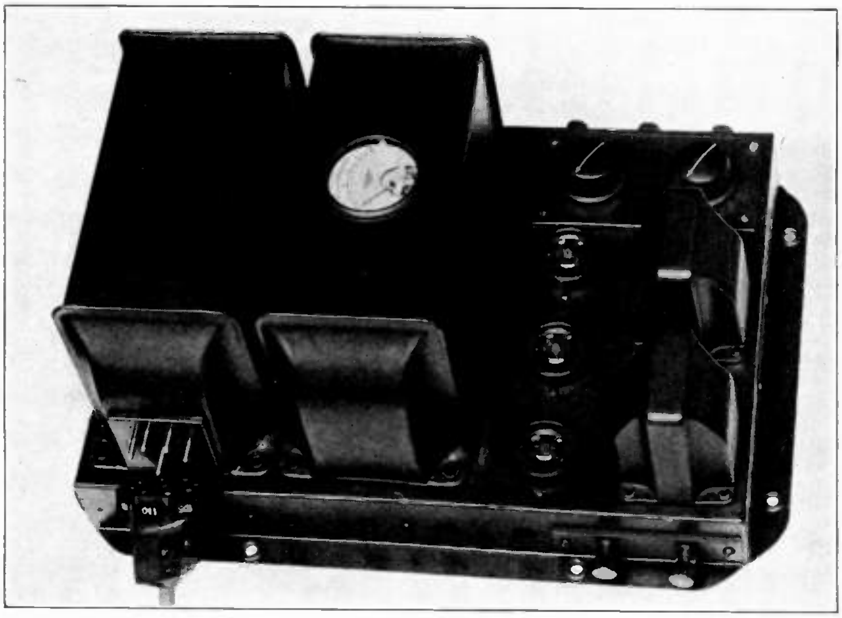
....Name
....Address

NEW DEVELOPMENTS OF THE MONTH



SAMSON MICROPHONE INPUT AMPLIFIER

The Samson Electric Company, of Canton, Mass., have announced the MIK 1 microphone input amplifier. This unit is designed for use with the PAM 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, interstage transformer, type 227 output tube with gain control and microphone current control, together with the A-B-C power supply, all mounted on a sturdy metal assembly. A meter is provided to read the button current with two-way switch for either side. The T.U. gain is approximately fifty.



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

HOLYOKE COMPANY ANNOUNCES NEW PRODUCTS

The Holyoke Company, of 621 Broadway, New York City, with Mills at Holyoke, Mass., manufacturers of high insulated weatherproof wire, also of high insulation radio wires, have incorporated their products into the manufacture of special forms and wiring harnesses for radio and electrical apparatus manufacturers who have complicated wiring devices.

The progress and development of radio calls for a higher degree of insulation and more rigid specifications than heretofore, and the precision of manufacture today must be accurate to meet with the high standard specifications. For example, tinsel cords, in which they are leaders require a much higher carrying 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 Holyoke Company have specialized for many years, and as radio has progressed specifications have become more rigid. The Engineering Department of the Holyoke Company after experimentation have been successful in producing a material with a higher insulating value than the ordinary beeswax and the dielectric contained in the new Holyoke Hook-up Wire is equivalent to that of Bakelite, it is claimed.

An interesting item which The Holyoke 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 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 Holyoke 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.

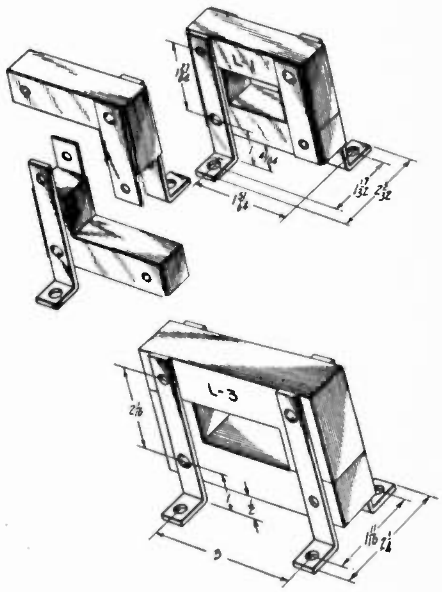
DUBILIER DRY "A" CONDENSERS

The Dubilier Condenser Corporation of New York City now announces the Dubilier 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 Dubilier PL 917-A Dry "A" Condenser units are rated at 2000 Mfds. (ballistic galvanometer method of measurement) and are especially designed for use in A-battery elimination work. These new condensers possess many desirable characteristics which are novel 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 6 to 10 milliamperes 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 bone-dry electro-chemical dielectric.

The Dubilier Dry "A" condensers are available in three sizes of 2000, 4000 and 6000 Mfds. capacity.

SILICON STEEL CORE LAMINATIONS

The Lamination Stamping Company, of 764 Windsor St., Hartford, Conn., have brought out a number of standard assembled transformer and choke core laminations to meet radio requirements.



Standard core laminations made by the Lamination Stamping Co.

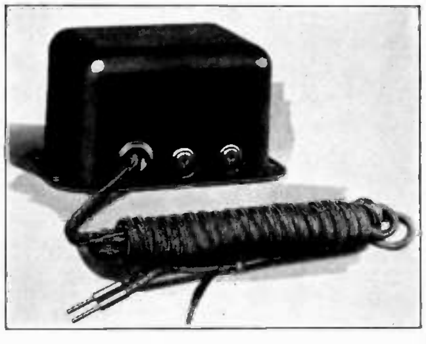
Lamination L-1, shown in the accompanying illustration, has a leg supplied with each stack, which is strap riveted in assembly with the laminations. To complete the assembly it is only necessary to slip the coil in place, bring the stacks into alignment as shown, then bolt or rivet the two corner holes.

For larger chokes, such as would be made up from L-3 or L-5 laminations four legs are required, as shown.

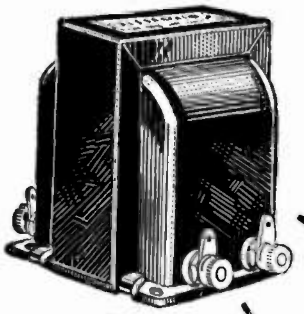
The Lamination Stamping Co. is in a position to supply special design cores or core material.

RCA OUTPUT TRANSFORMER

To insure the proper application of loudspeakers to any type receiver or power amplifier, a special output transformer is now being introduced by the Radio Corporation of America.



New RCA Output Transformer.



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.

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.

THORDARSON

RADIO TRANSFORMERS

Supreme in musical performance

THORDARSON ELECTRIC MANUFACTURING CO.

Transformer Specialists Since 1895

WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS

Huron and Kingsbury Streets — Chicago, Ill. U.S.A.

3581

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 mechanism 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 100-A with any of the present models of RCA Radiolas, the output transformer accessory is not required since loudspeaker coupling systems are incorporated in the receiver itself.

FLECHTHEIM 250 CONDENSER BLOCK

Supplementing their line of high grade by-pass, 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 DX-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.

Flechtheim 210-250 Condenser Block.

It is tapped as follows: 0-2-2-2-4-1-1 Mfds. The first 2 Mfd. unit which connects across the output of the rectifier tube, either a type 280 or 281, delivering about 500 volts of pulsating D.C., has been made to withstand a continuous operating potential of 1000 volts D.C. Thus an excellent safety margin, which will protect valuable tubes and apparatus, is employed.

The Flechtheim Co. has recently issued a supplement to their catalog 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, X-ray and transformer coils of various types.

The "Universal" Four Coil Winding Machine which will produce paper insulated coils for transformers, etc.

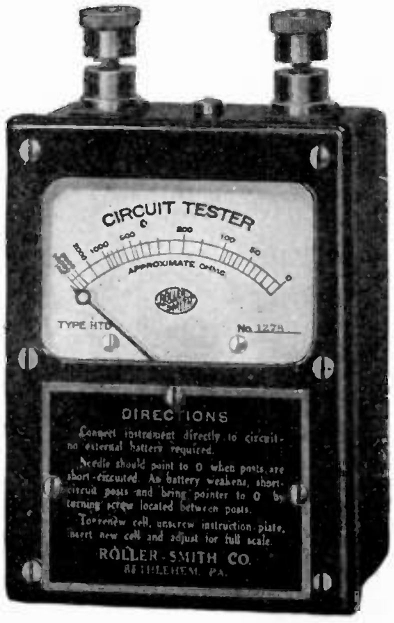
This machine winds self-supporting circular or rectangular coils in which adjacent wire turns are laid parallel to one another with insulating paper automatically inserted between the layers of wire. It handles enameled wires ranging from No. 29 to No. 44 BVS gauge. The mechanism for inserting the paper will accommodate paper wide enough for two coils, so that by the use of two supplies and two wire guides on each side of the machine, a double coil is wound on each side of the single spindle. To overcome 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 to each layer of wire, without slowing down.

Attachments for small or large diameter coils can be supplied. Fitted with one equipment the machine will wind coils from ½ inch to 2 inches in diameter; other attachments are available to produce windings from 1½ inches to 4½ inches and from 3 inches to 9 inches in diameter.

ROLLER - SMITH PORTABLE, DIRECT READING CIRCUIT TESTER

The Roller-Smith Company, of Bethlehem, Pa., have introduced a portable, direct reading circuit tester, known as Type HTD.

The uses of the HTD Circuit Tester are two-fold. 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 read the resistance of the circuit under test. The HTD Circuit Tester is recommended for use in preference to magnetos and A.C. bell-ringing devices because of its accuracy of indications under all conditions and its lightness and compactness as well. The instrument measures 4½" x 3" x 1½", which dimensions are obviously much less than those of the conventional magneto outfit. Likewise, its light weight of 19 ounces commends it when compared with the bulkier and heavier magnetos. Indications on the HTD Circuit Tester are never misleading, whereas, the alternating current generated by the hand driven magnetos will often cause the bell to ring when circuits include condensers, even though the circuit itself is not complete. Likewise with magneto testing the accumulative leakages in wiring encased in metal conduit will indicate that the circuit is complete because of the condenser action, while actually the circuit is open. With the HTD Circuit Tester inductance or capacity in the circuit under test have no effect on the readings.



Roller-Smith Portable, Direct Reading Circuit Tester.

This instrument consists of a small high grade d'Arsonval type D.C. voltmeter connected in series with a small dry cell. The circuit is such that when the two terminals of the instrument are connected the circuit is completed. The instrument pointer will indicate full scale when the terminals are short-circuited.

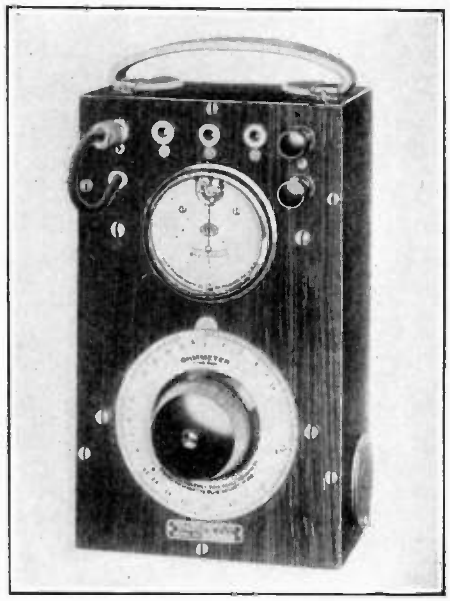
The scale reads directly in ohms from zero to 10,000 which enables resistance readings of the circuit under test.

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 replacal of the battery and the checking of the calibration. By the removal of three screws the instruction plate can be taken off and the dry cell rendered accessible for replacal. The removal of this plate also gives access to the internal zero adjuster.

ROLLER - SMITH PORTABLE, DIRECT READING OHMMETER

The Roller-Smith Company, of Bethlehem, Pa., have introduced a portable, direct reading ohmmeter, known as Type COM.

This instrument is a form of slide wire ohmmeter designed with particular reference to speed and simplicity in operation



Roller-Smith Portable, Direct Reading Ohmmeter.

and low initial cost. Its design is such as to make it an ideal instrument for the rapid measurement of coils 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 5¾" wide, 9¾" long and 4¼" high. The net weight is 3½ 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:

Range in Ohms	Value per Div.	Range in Ohms	Value per Div.
.5- 1	.02 Ohm	50- 100	2.0 Ohms
1- 2	.05	100- 200	5.0
2- 5	.1	200- 500	10.0
5- 10	.2	500- 1000	20.0
10- 20	1.0	1000- 2000	100.0
20- 50	5.0 Ohms	2000- 5000	500.0
5- 10	.2 Ohm	500- 1000	20.0
10- 20	.5	1000- 2000	50.0
20- 50	1.0	2000- 5000	100.0
50-100	2.0 Ohms	5000-10000	200.0
100-200	10.0	10000-20000	1000.0
200-500	50.0	20000-50000	5000.0

The battery for this ohmmeter is self-contained, and consists of two standard cylindrical flash light cells each 1¼" diameter and 2⅜" long which can be bought anywhere.

In connection with the measurement of coils of fine wire, the operation of connecting the coil to the ohmmeter will be greatly speeded up by the use of an adapter. This adapter has spring jaws, which can be operated by two fingers of the person using the instrument. Much time may be saved by this method in preference to the placing of fine wires underneath the conventional binding post nuts.

Two fine wires can be connected or disconnected in a fraction of a second by the use of an adapter. The use of this adapter 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.

BIDDLE "MEGGER" DIRECT-READING OHMMETERS

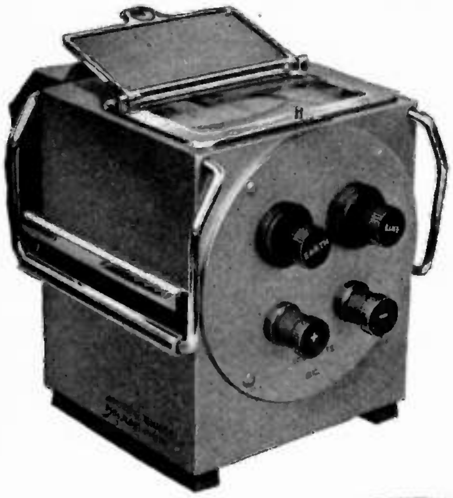
"Megger" Ohmmeters comprise a complete line of direct-reading instruments for the rapid measurement of resistance, from as low as .01 ohm up to 5000 megohms (5,000,000,000 ohms). They are designed especially for factory production and laboratory use, being arranged for operation from an external source of direct-current, and are used extensively by radio manufacturers for insulation tests of condensers, transformers, speakers, completed sets, etc., and 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 *true* 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 voltage (which may be a D.C. lighting circuit, storage battery, "B" battery, "B" eliminator or rectifier)—thus making the instruments more simple to use, much more rapid for production testing, and considerably less expensive.

"Megger" Ohmmeters are supplied in various types, including "Megger" and "Meg" designs, as here illustrated, and also small wood case instruments of lower cost for work of moderate accuracy. The following are some of the outstanding characteristics of "Megger" Ohmmeters:

1. Direct-reading—by means of the deflection of a pointer on a scale—like a voltmeter or ammeter.
2. Do not require an exact operating voltage. The instruments read accurately even though the voltage supplying the testing current varies as much as 20% either way from normal. Except in testing condensers, the operating voltage can fluctuate without affecting the reading.
3. Test terminals can be short-circuited without injury to the instrument or to the source of current supply.
4. Low operating current.
5. Built in a wide assortment of ranges, with one, two and three ranges in the same instrument. Selection can be made for practically any requirement.
6. Scales approximately proportionally divided in low range instruments,—i. e. ranges up to 10,000 ohms.
7. Of well-known "Megger" construction.

Manufactured by James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

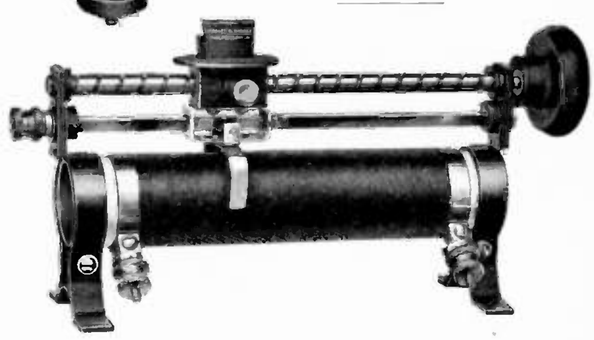


Above: The "Meg" Ohmmeter, widely used for measuring grid-leaks and resistors.

Right: High-range "Megger" Ohmmeter, for insulation resistance tests up to 5000 megohms. Supply voltage does not have to be exact.

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 assortment of current capacities and resistance values—from as low as .34 ohm, 25 amperes, up to 30,000 ohms, .1 ampere.



Right: The Jagabi Sliding Contact Tube Rheostat, 8-inch size, with screw-driven fine adjustment. Also supplied without screw-drive.

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

Manufactured by James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

RAWSON EXTENDS RANGE OF MODEL 503 INSTRUMENT

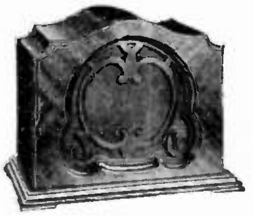
Rawson Electrical Instrument Co., Inc., Cambridge, Mass., has extended the range of their model No. 503 semi-suspended indicating instrument to new low values.

The movement being similar in construction to their ordinary single pivot movement but the spiral spring is replaced by a suspension strip which in turn lifts the weight of movement off the pivot giving all the high sensitivity characteristics of a suspension meter but with the disadvantage of the necessity for leveling, etc., removed, as the pivot around which the movement is balanced, acts as a guide while not carrying the weight. Full scale ranges as low as .5 microampere D.C. and .5 milliamper A.C. can be obtained when used in conjunction with their Thermo Couples. Can be supplied together with low range voltmeters with resistance of two million ohms per volt.

Rawson Model 503 Indicating Instrument.

NEW PORTABLE NEWCOMBE-HAWLEY DYNAMIC CONE REPRODUCER

Newcombe-Hawley, Inc., of St. Charles, Ill., have added to their line of radio reproducers a new portable reproducer using their Dynamic Cone Chassis. It is designed for apartments and homes where a small radio reproducer is desired that can easily be moved from place to place.



Newcombe-Hawley Dynamic Cone Reproducer

The cabinet of this portable reproducer is constructed of walnut with a satinwood front. The reproducer is made in three models for use with 6 volt battery sets, 100-200 volt D.C. sets, and 110-115 volt, 60 cycle, A.C. sets.

EISLER ELECTRIC WELDING MACHINE

The constant demand by manufacturers of radio tubes and its allied industries for an efficient, fine welder has been met by the introduction of a new type electric welding machine, made by the Eisler Engineering

Company, Inc., 750-762 South 13th Street, Newark, New Jersey.

The machine, as shown in Fig. 1, is designed especially for rapid, fine welding. The welder is used extensively in sheet metal work, jewelry, metal novelties and wire welding. Wire as fine as .0005 to ⅛" may be welded.

Production depends entirely on the skill and the work in question. The machine as in Fig. 1, is directly connected to the

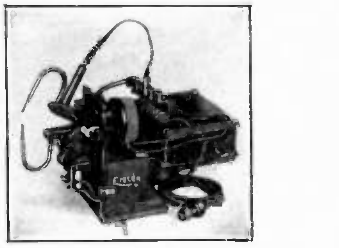
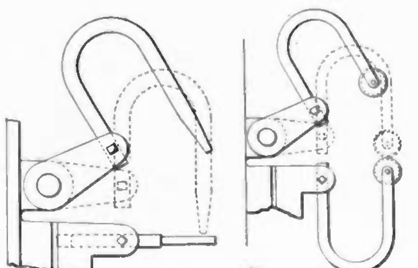


Fig. 1. Eisler Electric Welding Machine

source of current, either 110 or 220 volts. Two styles of transformers may be used, ½ and 1 K.V.A., sizes of which depends on the work to be done. A rheostat is connected to the primary of the transformer. Adjustments on same may be made for various welding degrees of heat according to the size of the substance welded. When the foot treadle is pressed the upper electrode moves down and makes contact holding the necessary pieces to be welded. On



2 3

further pressing of the foot treadle the breaker wire makes contact causing the electrical current to flow, making a good weld. Finally, on pressing foot treadle completely down the contact is broken but the metal is still held by the jaws. On releasing foot treadle, jaws return to original position. This operation takes but a few seconds.

Different types of electrodes are employed. In Fig. 1 the welder shown is equipped with hook type electrode. Fig. 2 shows the hook and anvil electrode used for spot welding. Fig. 3 shows the roller electrodes which are used in welding grids. A heavy braided copper lead connects the electrodes to the variable side of the transformer. Various heating degrees may be secured by changing to any of the five steps. The machine weighs but 37 pounds and occupies but 150 sq. inches of table space.

NEW WILLIAMS-HUSKY COMBINATION ELECTRICAL SET

Here is another new Williams-Husky Combination Wrench Set made possible by the recent reciprocal sales arrangement between J. H. Williams & Co., Buffalo, N. Y., and the Husky Wrench Company, Milwaukee, Wis. This arrangement enables each Company to merchandise in Combination Sets the other's quality Open-End, or Socket Wrenches. It is made for sales purposes only and is limited to the items which constitute these sets.

Williams-Husky Electrical Set, No. 287 is claimed to be the only complete assortment on the market combining open-end and socket wrenches to service the Electrical Equipment of all makes of cars, for general Electrical and Radio work and for all delicate adjustments. All units are of high quality:—Every "Superrench" and "Husky" Socket is guaranteed against breakage.

Set contains seven Williams' Midget "Superrenches" (Chrome-Molybdenum steel) sizes 7/32, ¼, 5/16, 11/32, ⅜, 7/16 and ½ inch, each wrench having two openings of the same size—but at different angles (15° and 75°). Where one head can't operate, the other will. Extremely light and thin, with narrow, pointed jaws; Chrome-plated finish, heads buffed bright.

The Huskys included in Set are eight

Williams - Husky Combination Electrical Set.

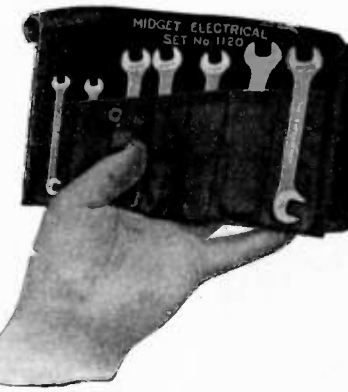
"Baby" Sockets, tapered for work in close quarters, sizes 5/32, 3/16, ¼, 5/16, 11/32, ⅜, 7/16, and ½ inch Hex, together with a 5 inch Combination Tee and a 4½ inch Handy Grip. The latter can also be used as an extension. Full bright nickel finish.

Set is packed in a convenient and durable metal box, sixe 5¼ x 2¾ x 1 inch high. Total weight 1½ lbs.

WILLIAMS MIDGET ELECTRICAL SET

In order to care for a need, long felt by servicemen, 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 "Superrenches" with openings running from 7/32" to ½". Each wrench has two openings of the same size, but set at different angles, 15 degrees and 75 degrees. It is claimed that where one head cannot be used, the other can. These wrenches, an addition to Williams' "Superrench" line, are drop-forged 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, magnetos, timers, radios and other electrical devices, this new set is also handy for fine adjustments. Wherever small



Williams Midget Electrical Set

wrenches are required it is sure to find innumerable uses. The seven Midget "Superrenches" are packed in a black leatherette carrying case which, when closed, measures only 5 x 4 x ⅜"—a convenient size for carrying in either some small compartment of the tool box or the side pocket of a coat.

AMPERITE LIN-A-TROL

The experience in operating radio receivers from the line circuits during the past year has clearly demonstrated the need for line voltage regulation. Alternating current tubes are so designed that a variation of 10% will have practically no effect upon its operation or life. In other words, it is really of no advantage to regulate the voltage to less than 10% since such variation has no effect, but greater variations materially effect both the operation of the set and life of the tubes. The "B" and "C" voltage, should also be kept to a variation not greater than 10%.

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

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

YANKEE TUBE TESTER AND REJUVENATOR

The Lundquist Tool and Manufacturing Co., of Worcester, Mass., announce their Tube Tester and Rejuvenator, No. S-550. The Tester has been designed to meet the requirements of testing practically all the different types of tubes in general use. This includes all D.C. and A.C. types as well as a number of the two-element rectifier tubes.

Yankee Tube Tester and Rejuvenator.

No batteries of any kind are necessary, the current used for testing being taken from any 110-volt 60-cycle line. The different voltages are supplied by a special variable transformer, the use of resistors being eliminated.

The entire unit is mounted in a wooden carrying case having a Bakelite panel. All necessary wires, attachment plug, etc., are supplied together with a tube data chart and directions for the convenience of the operator.

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. CELATSITE—This consists of one strand of black and one strand of red 16/30 flexible Celatsite, twisted together. The wires are machine twisted and present a very neat appearance. The wire is ideal for A.C. filament hook-up work.

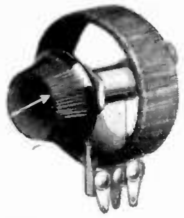
R-112 BATTERY CABLE—This is a universal type cable which can be used for either A.C. or D.C. work. It contains 4 twisted pairs and 4 single conductors, making a total of 12 conductors. One of the twisted pairs is made of 41 strands of No. 30 flexible Celatsite, which is equivalent to No. 14. This is to take care of the heavy current filament requirements. All other conductors consist of 16 strands of No. 30 wire, which are ample for their purpose.

PUSH-BAK WIRE—This is a fine hook-up wire for general purposes. The wire proper is solid but very soft and flexible and therefore easily worked. Being soft, it will not break easily.

The most interesting part is the insulation which is a treated braid that cannot unravel. It is just loose-fitting enough so that it can be pushed back from the wire to make the soldered connection. After the connection has been made the insulation can be drawn back again, thus leaving no exposed wire.

HEAT--*proof*
WARP-*proof*

For POWER Circuits



POWER

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 Rheostat.

SEND —for Folder 328. It shows the correct application of resistances in receiver and power supply circuits.

Central Radio Laboratories
25 Keefe Ave. Milwaukee, Wis.

Centralab

ZINC-FOIL

(MIKROFOIL)

FOR CONDENSERS

A STRONGER, BETTER FOIL AT A LOWER PRICE

Zincfoil is not only much stronger and tougher than 83-15-2 composition foil but its cost is substantially less.

It solders readily, has high conductivity, and from every angle is an ideal foil for condensers.

In coils of all thicknesses up to .0004 inch.

Samples gladly submitted for test. Write for them and for prices.

U. S. FOIL CO.
Louisville, Ky.

ALL GRADES OF FOIL

Aquadag

A concentrated colloidal solution of Acheson Electric Furnace Graphite in distilled water.
Manufacturers of grid leaks, other resistances, "getters," and those interested in the establishment of positive contacts are consistent users of Aquadag.

Acheson Oildag Company
Radio Division
P. O. Box D, (Hillside Station) Elizabeth, N. J.

Independent Laboratories

Newark, N. J.

Oxide Coated Filament

for

All Tubes

Special Getter

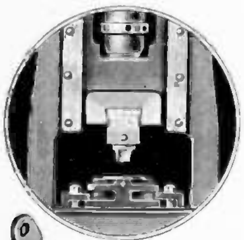
for

Detectors — A.C. Tubes — Amplifiers
Power Tubes — Gas Rectifiers

Cerium Alloys

Exclusive Sales Representative

A. U. HOWARD
50 East 42nd St. New York City
Phone: Murray Hill 0342 & 0343

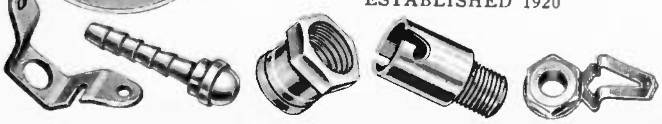


Arrow Automatic Products Corp.

27-29 Vestry Street New York

Screw Machine Products
Metal Stampings

ESTABLISHED 1920



Buyers Directory of Equipment and Apparatus

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

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

ADAPTERS:
Carter Radio Co.

ALUMINUM:
Aluminum Co. of America

ALUMINUM FOIL:
Lehmaier and Schwartz Co.
U. S. Foil Co.

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

ANTENNAE, LAMP SOCKET:
Electrad, Inc.

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

BASES, VACUUM TUBE:
Formica Insulation Co.

BINDING POSTS:
Arrow Automatic Products Corp.
Eby, H. H., Co.
X-L Radio Labs.

BOXES, PACKING:
Tifft Bros.

BRACKETS, ANGLE:
Arrow Automatic Products Co.
Electrad Inc.
Scovill Mfg. Co.

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

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

BUTTS:
Scovill Mfg. Co.

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

CELLS, PHOTOELECTRIC:
Burt, Robert C.
Photion Instrument Corp.
Radio Electrical Works.

CERIUM:
Independent Labs.

CHARGERS:
Acme Elec. & Mfg. Co.
Elkon Co.

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

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

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.

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

CLAMPS, GROUND:
Electrad, Inc.
Fahnstock Elec. Co.
Scovill Mfg. Co.

CLIPS, SPRING:
Arrow Automatic Products Co.
Electrad, Inc.
Fahnstock Elec. Co.
Scovill Mfg. Co.

COIL FORMS:
Cross Paper Products Corp.

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

COILS, IMPEDANCE:
Dudlo Mfg. Co.

COILS, INDUCTANCE:
Air King Products Co.
Cardwell, Allen, D., Mfg. Co.
Dresner Radio Mfg. Co.
Hammarlund Mfg. Co.
Radio Engineering Laboratories.

COILS, MAGNET:
Dudlo Mfg. Co.

COILS, RETARD:
Hammarlund Mfg. Co.

COILS, SHORT WAVE:
Dresner Radio Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Silver-Marshall, Inc.

COILS, TRANSFORMER:
Dudlo Mfg. Co.

CONDENSER PARTS:
Arrow Automatic Products Co.
Scovill Mfg. Co.

CONDENSERS, BY-PASS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Automatic Electric, Inc.
Brown & Caine, Inc.
Burt, A. G., Jr.
Carter Radio Co.
Condenser Corp. of America.
Deutschmann, Tobe Co.
Dongan Electric Mfg. Co.
Electrad, Inc.,
Fast, John E. & Co.
Polymet Mfg. Co.
Sterling Mfg. Co.

CONDENSERS, FILTER:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Automatic Electric, Inc.
Brown & Caine, Inc.
Carter Radio Co.
Condenser Corp. of America.
Deutschmann, Tobe Co.
Dongan Electric Mfg. Co.
Fast, John E. & Co.
Polymet Mfg. Co.
Sterling Mfg. Co.

CONDENSERS, FIXED:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Automatic Electric, Inc.
Brown & Caine, Inc.
Burt, A. G., Jr.
Carter Radio Co.
Condenser Corp. of America.
Deutschmann, Tobe Co.
Dongan Electric Mfg. Co.
Electrad, Inc.
Fast, John E., & Co.
Polymet Mfg. Co.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
General Instrument Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories

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

CONDENSERS, NEUTRALIZING:
X-L Radio Labs.

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

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

CONNECTORS:
Arrow Automatic Products Co.
Carter Radio Co.
Fahnstock Elec. Co.
Jones, Howard W. Co.
Scovill Mfg. Co.

CONTROLS, ILLUMINATED:
Hammarlund Mfg. Co.

CONTROLS, VOLUME:
American Mechanical Labortories
Carter Radio Co.
Central Radio Laboratories

CONVERTERS:
Cardwell, Allen D., Co.

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

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

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

DIALS, DRUM:
Hammarlund Mfg. Co.
United Scientific Laboratories

ELIMINATORS, A BATTERY:
Acme Elec. and Mfg. Co.
Radio Receptor Co.
Sterling Mfg. Co.
Webster Co.

ELIMINATORS, B BATTERY:
Acme Elec. and Mfg. Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Radio Receptor Co.
Silver-Marshall, Inc.
Sterling Mfg. Co.
Thordarson Electric Mfg. Co.
Webster Co.

ELIMINATORS, A-B-C:
Acme Elec. and Mfg. Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.
Webster Co.

ELIMINATORS, UNITS FOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.
Webster Co.

ESCUTCHEONS:
Crowe Nameplate and Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FILAMENT, OXIDE COATED:
Independent Laboratories, Inc.

FILAMENT CONTROLS, AUTOMATIC:
Radiall Co.

FOIL:
Lehmaier and Schwartz Co.
U. S. Foil Co.

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

GETTER MATERIAL:
Acheson Oildag Co., Inc.
Independent Laboratories, Inc.

GRAPHITE:
Acheson Oildag Co., Inc.

GRID LEAKS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Amsco Products Co.
DeJur Products Co.
Deutschmann, Tobe Co.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Polymet Mfg. Co.

HARNESSES, A-C.:
Carter Radio Co.
Eby, H. H., Co.

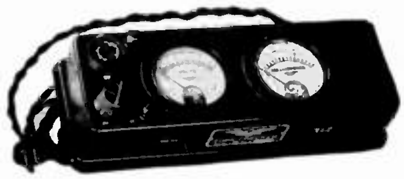
HINGES:
Scovill Mfg. Co.

HORNS:
Operadio Co.
Racon Electric Co.
Temple, Inc.

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

JEWELL

A New
Simple Tube Checker



Pattern No. 150
A.C and D.C. Tube Checker

Jewell has developed a Tube Checker that is indeed simple. It is so simple that all that is required to prepare it for testing tubes is to plug the attached cord into a 110 volt 60 cycle outlet.

This new tube checker known as Pattern No. 150 is somewhat similar in appearance to other Jewell tube checkers which have earned an enviable reputation for accuracy and reliability, but differs in that all tubes can be tested without resorting to batteries of any kind. This is accomplished by incorporating a transformer which furnishes the required voltages, making use of alternating current instead of the conventional A and B batteries.

All tubes can be tested from the WD-11 and 199 tubes up to the 210.

A five prong socket is supplied with an adapter for 4-prong tubes and a rheostat enables adjusting the filament in conjunction with the O-48 volt AC voltmeter. Plate current is read on a O-15 Milliammeter.

This new tube checker is described in our Form No. 2004. Write for a copy.

"28 Years Making Good Instruments"

Jewell Electrical Instrument Co.
1650 Walnut St., Chicago

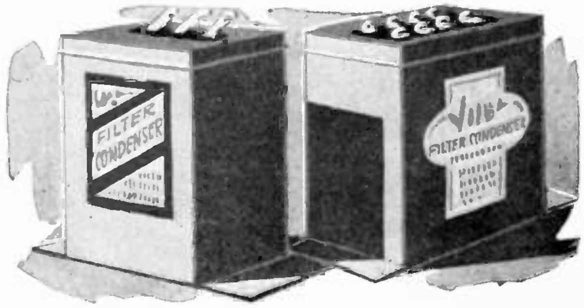
CONDENSER
TISSUES

NO Radio set is any better than its weakest link, and the weakest link is very often a filter Condenser. No Condenser is any better than the thin strips of Insulating Tissue which separate the layers of metal foil. A pinhole or a speck of metal in the Condenser Tissue means a break down of the Condenser, with the entire set put out of commission.

DEXSTAR Condenser Paper is regarded by Radio experts as being the highest grade Insulating Tissue ever made—the freest from defects, the most uniform in quality, the most lasting under exacting and unusual requirements. DEXSTAR Condenser Tissue is the specialized product of a paper mill which has excelled in Tissue Paper production for three generations.

RADIO designers and builders should have the assurance that Condensers which they use are made with DEXSTAR Condenser Tissues. It is insurance against many radio troubles. The leading Condenser manufacturers are now using DEXSTAR Condenser Tissues exclusively.

C. H. DEXTER & SONS, INC.
Makers of Highest Grade Thin Papers
WINDSOR LOCKS, CONN.



INDUCTANCES, TRANSMITTING:
General Radio Co.

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

INSULATION, MOULDED:
Bakelite Corp.
Formica Insulation Co.
General Plastics, Inc.
Westinghouse Elec. Mfg. Co.

JACKS:
Carter Radio Co.
Electrad, Inc.

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

KITS, SHORT WAVE:
Dresner Radio Mfg. Co.

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

KITS, TRANSMITTING:
Radio Engineering Laboratories.

LACQUER:
Walker, J. V., Co.
Zapon Co., The

LABORATORIES:
Electrical Testing Labs.

LAMINATIONS:
Arrow Automatic Products Co.
Lamination Stamping Co.
Sterling Mfg. Co.

LEAD-INS:
Electrad, Inc.
Fahnstock Elec. Co.

LOCK WASHERS:
Arrow Automatic Products Co.
Shakeproof Lock Washer Co

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

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MAGNETS:
Thomas and Skinner Steel Products Co.

METERS:
Jewell Elec. Inst. Co.
Sterling Mfg. Co.
Westinghouse Elec. & Mfg. Co.

MICROPHONES:
Amplion Co. of America

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

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

MOUNTINGS, RESISTANCE:
DeJur Products Co.
Electrad, Inc.
Fahnstock Elec. Co.

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

NUTS:
Arrow Automatic Products Co.
Shakeproof Lock Washer Co.

OSCILLOGRAPH:
Burt, Dr. Rob't C.

OSCILLOSCOPE:
Burt, Dr. Rob't C.

PACKING:
Tifft Bros.

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

PANELS, METAL:
Crowe Nameplate and Mfg. Co.
Scovill Mfg. Co.

PAPER, CONDENSER:
Dexter, C. H. & Sons, Inc.
Schweitzer, Peter J., Co.
Strype, Fred C., Co.

PAPER, CONE SPEAKER:
Seymour Co.

PHONOGRAPH MOTORS:
(See Motors)

PHOSPHOR BRONZE
Baltimore Brass Co.

PHOTOELECTRIC CELLS:
(See Cells)

PICK-UPS:
Gordon, L. S., Co.

PLATES, OUTLET:
Carter Radio Co.

PLUGS:
Carter Radio Co.
Jones, Howard B., Co.

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

RECEIVERS, ELECTRIC:
United Scientific Laboratories.

RECTIFIERS, DRY:
Benwood-Linze, Inc.
Elkon, Inc.

REGULATORS, VOLTAGE:
DeJur Products Co.
Radiall Co.
Sterling Mfg. Co.
Webster Co.

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

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Allen-Bradley Co.
Amsco Products Co.
Carter Radio Co.
Central Radio Laboratories.
De Jur Products
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Polymet Mfg. Co.

RESISTANCES, VARIABLE:
Allen-Bradley Co.
American Mechanical Labs.
Amsco Products Co.
Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.
Hardwick, Field, Inc
International Resistance Co.
Lautz Mfg. Co.
Polymet Mfg. Co.

RHEOSTATS:
Amsco Products Co.
Carter Radio Co.
Central Radio Laboratories.
De Jur Products.
Electrad, Inc.,
United Scientific Laboratories.
Westinghouse Elec. & Mfg. Co.

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

SCREW MACHINE PRODUCTS:
Arrow Automatic Products Co.
Scovill Mfg. Co.

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

SHIELDS, TUBE:
Carter Radio Co

SHORT WAVE APPARATUS:
Cardwell, Allen D., Co.
General Radio Co.
Radio Engineering Laboratories.

SOCKETS, TUBE:
Benjamin Electric Mfg. Co.
General Radio Co.
Silver-Marshall, Inc.

SOLDER:
Chicago Solder Co. (Kester).
Westinghouse Elec. & Mfg. Co.

SOUND CHAMBERS:
Air Chrome Corp.
Lektophone Co.
Operadio Mfg. Co.
Racon Elec. Co., Inc.
Temple, Inc.
United Radio Corp.

SPEAKERS:
Airchrome Studios, Inc.
Temple, Inc.
United Radio Corp.

STAMPINGS, METAL:
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TESTERS, TUBE:
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TESTING INSTRUMENTS:
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Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Corp.

TESTING KITS:
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TINFOIL:
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TOOLS:
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Ferranti Ltd.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
United Radio Corp.
Webster Co.

TRANSFORMERS, B-ELIMINATOR:
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American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Webster Co.

TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.

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

TRANSFORMERS, POWER:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Westinghouse Elec. & Mfg. Co.
Webster Co.

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.

TUBES, A. C.:
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Ceco Mfg. Co.
Cunningham, E. T., Co.

TUBES, RECTIFIER:
Arcturus Co.
Ceco Mfg. Co.
Cunningham, E. T., Co.

TUBES, VACUUM:
Arcturus Co.
Ceco Mfg. Co.
Cunningham, E. T., Co.

UNITS, SPEAKER:
Air Chrome Corp.
Temple, Inc.
United Radio Corp.

VOLTMETERS, A. C.:
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Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Corp.

VOLTMETERS, D. C.:
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Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co
Weston Elec. Instrument Corp.

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