EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

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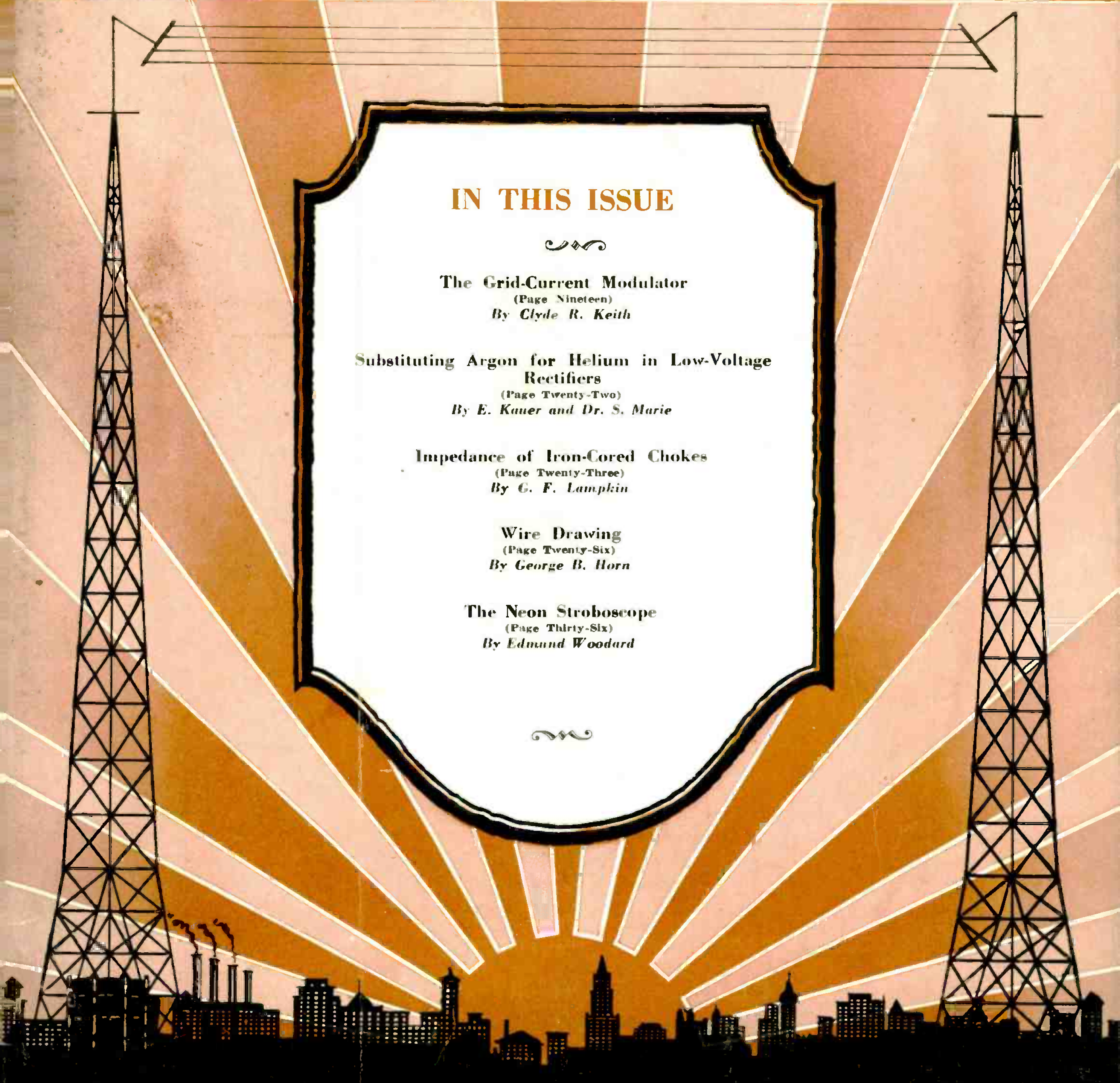

IN THIS ISSUE

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The TECHNICAL MAGAZINE of the RADIO INDUSTRY

FOR fifteen years Formica has been furnished in changing forms to suit the convenience of the radio engineer and producer. In the early days it was sold in whole sheets and whole lengths of tubing and fabricated largely by hand by the radio builders. Then there were decorated front panels printed in gold and silver. Now there are sanded or threaded tubes punched and cut to length, washers, sub-panels, shelves and terminal strips - - most of them shipped all ready to assemble.

At large expense, Formica equipment has been changed from year to year to provide production in quantity at all times of insulating parts that would meet the requirements of the moment. And the quality and uniformity of the material has also steadily advanced.

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RADIO ENGINEERING

Reg. U. S. Patent Office

Editor
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RADIO BY-PRODUCTS

By S. M. KINTNER
Manager, Research Dept., Westinghouse Electric & Mfg. Co.

WHEN applied in suitable circuits, the vacuum tube not only performs electrical functions better than any other means but also reaches to certain fields not otherwise attainable.

The perfection of special radio "by products" tubes and circuits has placed in the hands of the designers means so sensitive, so selective, and yet so reliable, that it is now possible to telephone instructions to a machine and have it perform any number of prearranged operations.

The actions of this machine are so life-like that—in the popular press—it has been called the mechanical man. Such machines are now rendering effective service in power companies' sub-stations, taking the place of human station attendants.

Many other applications of radio appliances have been made to other arts.

One of the great debts owed to radio is the new knowledge that has resulted from studies of radio phenomena. Each new art brings with it new relations which either confirm our existing theories or cause us to revise them to take into account the new phenomena. As we know nothing absolutely, it is not surprising that our theories are undergoing frequent revisions.

As our knowledge is increased by continued studies, our applications will be correspondingly improved and doubtless new applications made that are now beyond the flights of our wildest fancy.

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EDITORIAL

November 1928

THE RADIO PARTS BUSINESS

THE radio parts business has changed color and direction within the past few years. This is due principally to the fact that the radio fan has changed color and direction. The early enthusiasm, centered around the novelty of radio, has been transplanted. Today, interest is focused almost entirely on the program element.

The younger generation, as might be expected, shows a keen interest in the technical phases of radio but enthusiasm is somewhat tempered by the presence of the manufactured radio set. A large amount of the "urge to build" is thwarted by this presiding influence.

The radio parts business could never obtain sufficient nourishment from the depleted ranks of radio bugs, tinkerers and self-styled engineers. Consequently, the majority of parts and accessories manufacturers have directed more of their efforts towards supplying the set manufacturers. A large percentage of their present outputs flow in this direction. The rest is absorbed by kit manufacturers, replacement demand and custom-set builders.

A larger and more diverse field of distribution is desirable in order that the future of the business may be made impregnable. Action has already been taken in the development of business in custom-sets. We have witnessed the extension of activities into the electric phonograph and power amplifier fields which bear a close relation to custom-set building.

Obviously, there will always be a large amount of custom-set building. The important consideration is to school the men who are getting this business; form a special organization if necessary. Parts manufacturers appear to operate under the assumption that these professional men are first-rate engineers. As a matter of fact, they lose valuable time and valuable business because they are unable to obtain first-hand technical information.

The set builder doesn't profess to be an engineer, at least when business is involved, nor does he profess to be a super-salesman. He suggests that the parts manufacturers look on him as one who is sufficiently interested in radio to make it his business and sufficiently sincere with himself to learn as much of the technique as he can. Why, then, leave him solely to his own devices, particularly in view of the fact that it is equally as important, if not more important, to the parts manufacturer to have him increase his yearly business?

The present-day professional set-builder is the future radio contractor. The rapid strides being made in the commercial applications of radio devices makes it a certainty that there will be a demand for men capable of handling contracting jobs. The professional builder is the logical man to take over this business.

It is becoming common practice to wire new apartments and apartment-hotels for radio. Small theatres not capable of supporting a large orchestra or standing the expense of talking motion picture equipment are finding it to their advantage to have installed an electric phonograph and power amplifier. There is a tremendous field here alone and the same equipment is adaptable to auditoriums, road houses, churches, etc. The wiring jobs are sufficiently profitable to make it worth the while of the professional man to enter this phase of the business.

There are many other commercial fields, and many to be developed, where both the parts and accessories manufacturers and the present professional builders have rich opportunities.

Cooperative effort is the prime essential in developing the commercial field. RADIO ENGINEERING is desirous of assisting both the manufacturers and the future contractors in any way it can.

M. L. MUHLEMAN, *Editor.*


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which makes it
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it is today
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Sweet tones—true to the broadcasting—just like those on the other side of the microphone—this fact alone makes radio fans want Gold Seal Radio Tubes.
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The Guiding Hand

Hour after hour a graceful monoplane throbs across a vast ocean, searching a path from continent to continent through fog and storm. Like a mighty helping hand rising from the depths, radio points the way and keeps a wondering world informed.

The tiny wires which constitute the radio apparatus are the unseen nerves which are sustaining the navigator of the air on his trackless route. They must respond instantly to every command. Without the radio apparatus, which is an essential part of every long distance plane, the conquest of the air would be impossible.

Dependable magnet wire and coils are indispensable—for one failure—one short circuit—might mean disaster.

Dudlo takes pride in its belief that in making copper wire products which stand the severest tests, it is contributing to man's triumph over the elements.

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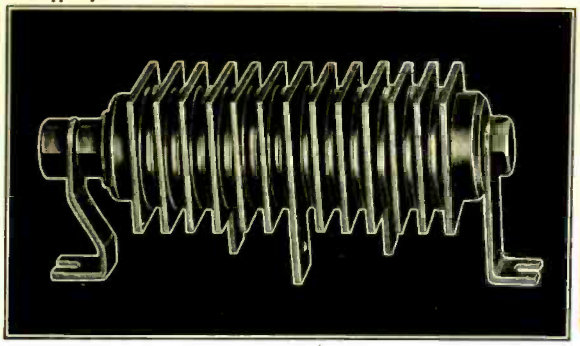
Pat. Applied for



The B-L Rectifier B-24, illustrated at left, is a full-wave unit with an output capacity of from 1 to 3 amperes at 8 to 12 volts. It is equipped with special horizontal mounting brackets for dynamic speakers, etc. List Price, $6.00.

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Because of their compact design, wide range of application and their ability to furnish smooth unfailing power, B-L Rectifiers have been adopted as standard by many of the largest dynamic speaker and power equipment manufacturers.

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St. Louis, Mo., U. S. A.

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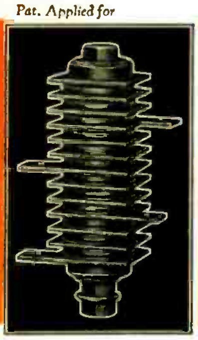

D-24, B-L Rectifying Unit is full-wave rectifier for supplying direct current to excite magnetic field coils of dynamic speakers, List price $6

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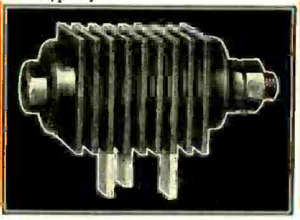

B-12 and B-16, B-L Units, are full-wave rectifiers with an output of 1 to 3 amperes at 6 to 8 volts. For trickle chargers, dynamic speakers and "A" power devices. List price, B-12 . . . . $4.50 B-16 . . . . $5.00.

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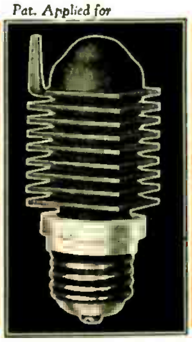


C-110, B-L Rectifying Unit is a single-wave rectifier for replacing charger bulbs. Furnished with either Edison or double-contract screw base. List Price, C-110 $4. C-210 $4. C-310 $4.

Send for Booklet explaining the characteristics and application of B-L Rectifying Units. A post card will bring it.

B-L RECTIFIERS

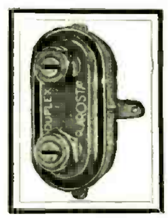
Radio "First Aids"

IT'S one thing to design a radio set or power unit, with proper components and circuits for ideal results. It's quite another to go out and service no end of sets in the homes of listeners-in. And so it is to help the service men—the greatest factors in permanent radio merchandising success—that we dedicate the following radio "first aids:"

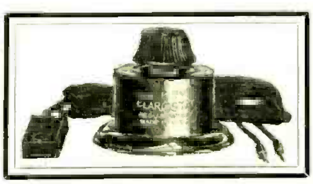
¶The most common source of poor radio is a faulty antenna. Sometimes it's the location. A Clarostat *Antenna Plug* invariably improves reception, whether used alone or in combination with an antenna, and whether used in a "dead spot" or in a "DX location". The best ground is the screw holding the wall plate of the electric outlet.

¶With the reallocation of wave lengths and the providing of many cleared channels, DX will again come into its own this winter. The simplest step in the direction of DX reception is a higher grid-leak value. Yet a low grid-leak value is still essential for powerful signals. The *Grid Leak Clarostat*, used in place of the fixed grid leak, will provide ideal operating conditions. Also, plate voltages must be carefully adjusted, particularly for the detector and the r.f. tubes. The *Duplex Clarostat* will provide two fixed resistances of any desired value. A twist of your screw-driver, and each resistance is set permanently. And if the plate voltage is to be made variable, the *Volume Control Clarostat* can be included in the set.

¶The loud-speaker volume and tone should be adjustable to meet desired conditions—from loud, crashing dance music for shuffling feet, to soft, soothing, non-interfering music for the background of the conversation. The *Table Type Clarostat*, at the finger tips of the listener-in, provides any degree of volume and mellowness.



¶Fluctuating line voltage is a factor in satisfactory socket-power operation. The *Power Clarostat*, together with the lowest voltage tap on the power transformer of the set or power unit, will provide a simple compensating means for line voltage fluctuations.



¶And there are other Clarostats and other uses for the Clarostat line, but the story is too long to be told here in detail. So—

Write for technical literature on the Clarostat line of radio "First Aid" and how to use them. Remember, these first aids apply just as well to the set being built or manufactured, as to servicing existing sets in everyday use. If you are an engineer for a radio manufacturing company, write us on your firm letterhead, and we shall place your name on our technical bulletin mailing list.

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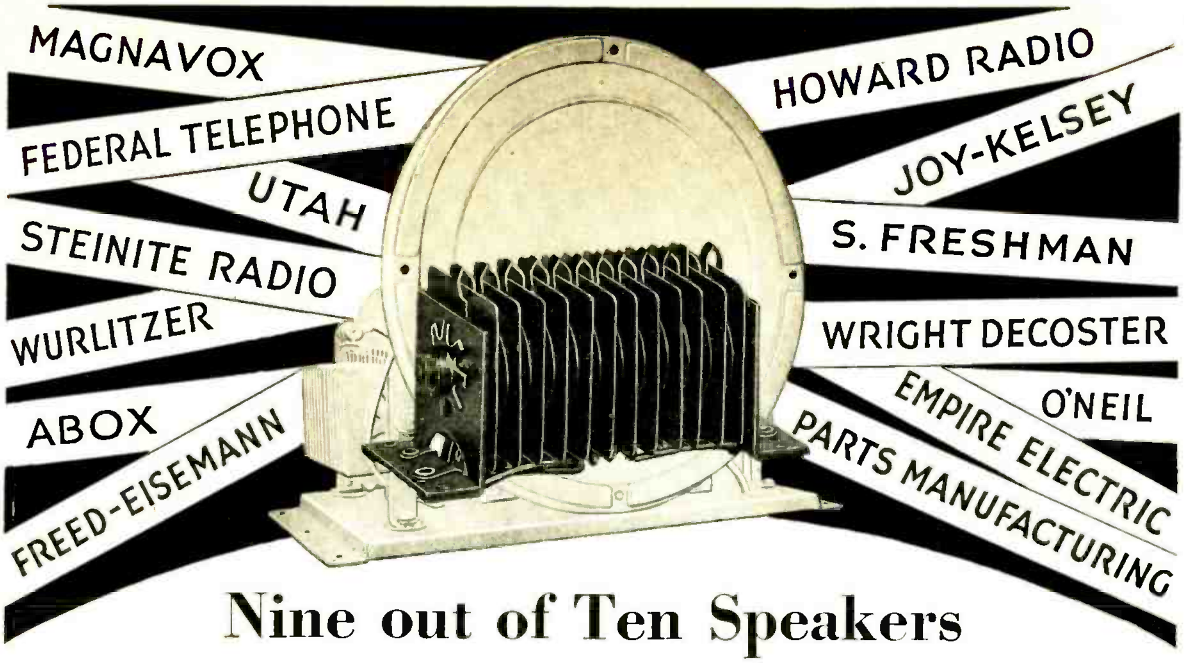

Nine out of Ten Speakers now use this perfected rectifier

THE complete list of dynamic speakers using the new perfected Kuprox Rectifier reads like a roll call of the industry. Practically every big manufacturer is included. Almost every speaker enjoying popular sale is equipped with this perfected, more efficient rectifying unit.

These Dynamics are all Kuprox-equipped

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Magnavox	Vitalitone
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Kuprox Dry Copper Oxide Rectifiers, vastly improved since their introduction almost two years ago, have proved conclusively in every engineering test their greater efficiency and absolute dependability. Solely upon these tests, conducted by speaker manufacturers themselves in their own laboratories, was the Kuprox Unit so unanimously adopted by the industry.

The performance and length of life of any speaker depends largely upon the efficiency of the rectifying unit. Can you afford to stake your success and reputation as a manufacturer of quality instruments on anything less than the best your money will buy?

75% of all orders placed this year for railway rectifiers specified Kuprox. 90% of the dynamic speakers manufactured now use Kuprox. In every large time clock and recording system installation Kuprox is used. Kuprox is specified wherever absolute reliability, high efficiency and permanent operation are necessary.

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Complete Kit, including cabinet $58.00
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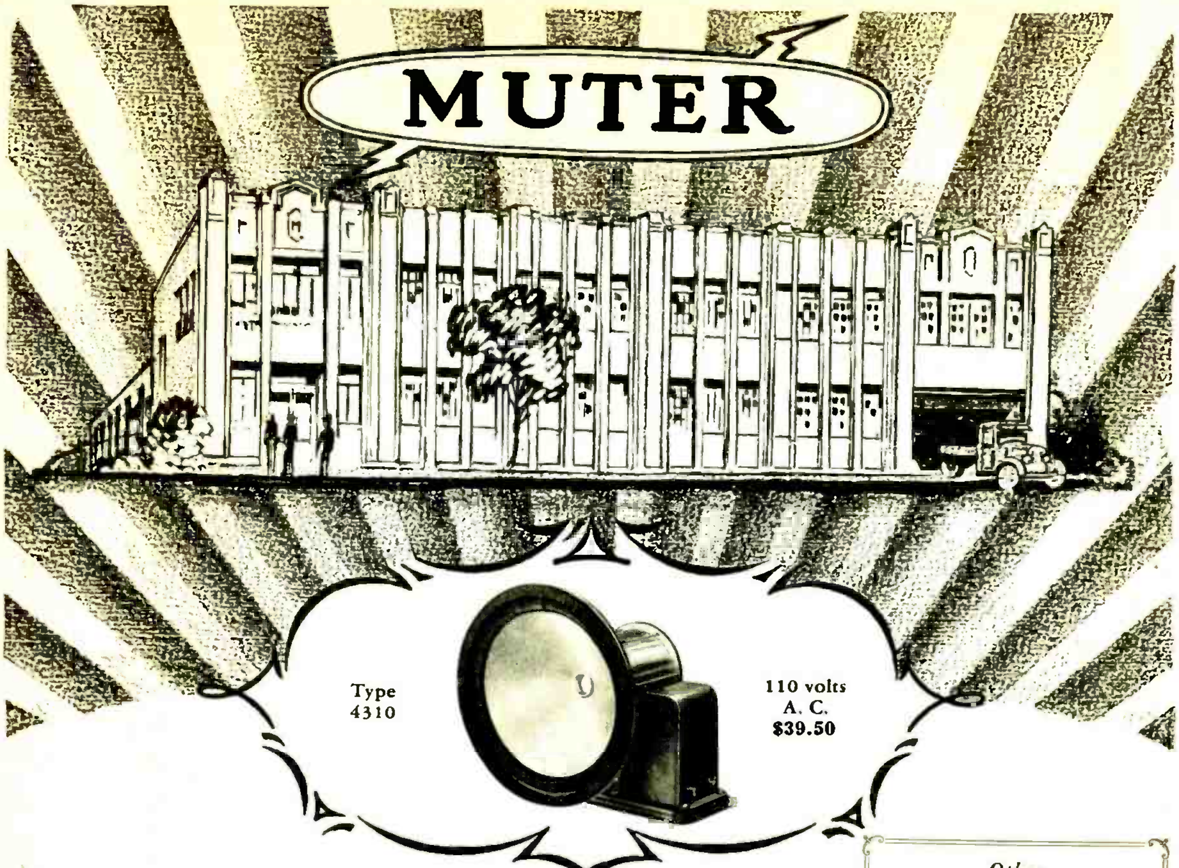
Aero Kits are complete to the last detail. No expense has been spared to make them the finest that money can buy. A beautiful two-tone metal cabinet, high-lighted in silver, is a part of each kit. Every part needed for the construction of the receiver is included—even wire, soldering lugs and wood screws—so that nothing else need be purchased. Panels are drilled, which insures proper placement of parts and full size pictorial wiring diagrams eliminate mistakes in wiring.

The New Aero Green Book for 1929 is needed by every set-builder. Has 64 pages, containing 22 new circuits for broadcast and short wave receivers and transmitters. Has a wealth of valuable data and information. Send 25 cents for your copy.



Muter Dependable Dynamic Type Speaker

THE Dynamic Speaker with its superlative performance is this season's outstanding radio sensation. It has changed the radio set from a mechanical reproducer of sounds to a musical instrument supreme. The distinctive tone of the various new manufactured receivers can be attributed almost entirely to the Dynamic Speaker, and this same improvement can be embodied in any set by the attachment of a Muter Dependable Dynamic.

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Power	Type	Price
6 volts D. C.	4306	$29.50
90 volts D. C.	4390	33.00
110 volts A. C.	4310	39.50

Table Model in Solid Walnut Cabinet

Power	Type	Price
6 volts D. C.	4406	$49.50
90 volts D. C.	4490	53.00
110 volts A. C.	4410	59.50

Spinet Console Model of Solid Walnut

Power	Type	Price
6 volts D. C.	4506	$64.50
90 volts D. C.	4590	68.00
110 volts A. C.	4510	74.50

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Soldering Lugs
A. C. Power Units
Neutralizing Condensers
Trimming Condensers
Audio Transformers
"B" Power Unit Transformers
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(tapped and variable)
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Lightning Arresters
and many others.

The Complete Quality Popular Priced Line

The Grid-Current Modulator

Detailing the Characteristics and Operation of the Grid-Current Modulator and Its Advantages Over the Plate-Circuit Type

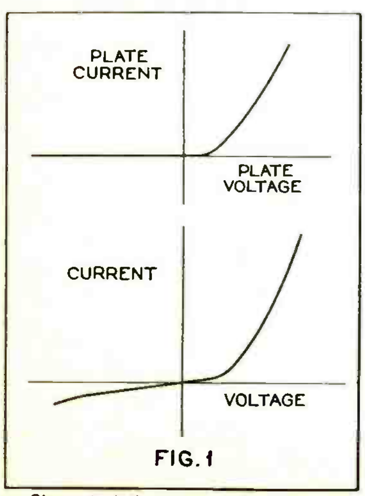
By Clyde R. Keith*

CARRIER current[1] and radio communication require that the voice frequency currents from an ordinary telephone or microphone be changed to higher frequencies for transmission and then back to voice frequencies at the receiving terminal. Frequency bands above the voice range are used in order that the carrier frequencies may not overlap either the normal voice transmission range or other carrier frequency bands. It is then possible to transmit simultaneously several channels without interfering with each other, and to separate the different groups at the receiving terminal.

To take a numerical example, if two currents of 1,000 and 10,000 cycles respectively are passed through a modulating device, many new frequencies will be produced, prominent among which are the first "sum" and "difference" frequencies, 11,000 and 9,000, respectively. Modulators as a class come in the category of circuit elements that do not obey Ohm's law. In ordinary metallic conductors, the current is proportional to the voltage, but in vacuum tubes, iron-core coils, certain crystals, and various forms of rectifiers, the relation does not hold. Fig. 1 gives some examples of current-voltage curves which can be used for modulation.

* *Research Department, Bell Telephone Laboratories.*

[1] *Multiplex Transmission by Carrier Currents*, J. W. Horton, BELL LABORATORIES RECORD, *Vol. 1, p. 147, December*, 1925.



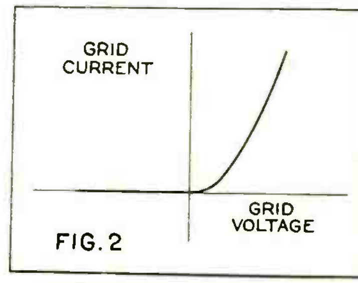
Characteristic curves: above that of the plate circuit of a vacuum tube; below, that of a rectifying crystal.

One of the most usual modulators uses the non-linear relation between plate voltage and plate current in a three-electrode vacuum tube and is consequently called a plate-circuit modulator. Although the signal or carrier or both may be applied to the grid, modulation is made to take place primarily in the plate circuit by operating the tube so that the voltage induced in the plate circuit is substantially proportional to the applied voltage. This condition holds rather closely until the grid becomes positive with respect to the filament.

However, if the grid is allowed to become positive with respect to the filament, it is also possible to produce modulation by means of the non-linear relation between grid current and grid voltage. This method is therefore called grid-current modulation since it takes place only when conductive[2] grid current flows during at least a part of each cycle of input voltage. Since grid current can flow only when the grid is positive, as shown in Fig. 2, the relation between current and voltage is evidently non-linear for positive and negative voltages. Consequently, when carrier and signal voltages are applied, modulation between the two produces currents of sideband frequencies in the grid circuit. Voltages due to these currents are then amplified by the plate circuit and all other frequencies are suppressed by high impedances in the plate circuit. This allows all the power available in the plate circuit to go into sideband output, since none is used by the flow of carrier and signal currents as is the case with the plate-circuit modulator.

[2] *This explanation neglects the current through the capacity between grid and filament since its effect is comparatively small at voice and carrier frequencies.*

Recent laboratory investigations have demonstrated that for certain applications, grid-current modulators have some important advantages.[3] They are particularly suited for use in circuits where high modulating efficiency and high output level are desired. When laboratory models of representative modulators are compared, it is found that (using the same tubes and plate voltages) the grid-current modulator gives a maximum power output eight times as high and a maximum plate power efficiency five times as high as the plate modulator. While this increased output requires sixty per cent higher plate current, a proportionately high output level may be obtained with a grid-current modulator when it uses the same plate current as the plate-circuit type. The carrier input current, although about twice that required for the plate modulator, can still be obtained from a single oscillator tube of the same type.



Relation between grid current and grid-filament voltage.

Operation

The operation of a grid-current modulator may be most easily understood by referring to the circuit of Fig. 3 which represents the general form. It consists of sources of signal and carrier voltage in series with an external impedance and the grid-filament circuit of the tube. In series with the plate-filament circuit are

[3] *Grid-Current Modulation, E. Peterson and C. R. Keith*, BELL SYSTEM TECHNICAL JOURNAL, *January*, 1928.

simply a current-measuring instrument and an output impedance. Since the new frequencies which result from modulation are obviously not produced in the input generator or in the external impedance, they must be considered as having their origin in the variable impedance of the grid-filament portion of the circuit. Therefore the grid-filament path may be considered as a generator of "side-band" frequencies and of other modulation products.

This generator has like all generators an internal resistance, symbolized in Fig. 3 by R_{GF}, and, as is the case with ordinary generators, the terminal voltage—between grid and filament—is equal to the generated voltage minus the drop caused by the current through the internal resistance. The voltage drop in the generator is small when the external impedance is high so that little current flows. Consequently the grid-filament voltage at sideband frequencies is a maximum when the external impedance at these frequencies is large compared to the internal impedance. This is accomplished in practice by means of tuned circuits, retard coils, or filters, depending on the frequency of the sideband.

Since the sideband components generated within the grid-filament impedance of the tube result from the carrier and signal voltages impressed on this impedance, the sideband voltage will also be a maximum when the power inputs at these frequencies are a maximum. This may be calculated by the usual formulae for obtaining the maximum power from a source of current having a fixed impedance and voltage, and is found to occur when the external and internal impedances are properly "matched." Therefore the external impedance of the signal and carrier sources should be equal to the grid-filament impedance at these frequencies. These impedance relations for maximum sideband voltage on the grid are summarized in the adjoining table.

In this connection the question may be raised as to how one can assign a definite value to the grid-filament impedance when it varies throughout the cycle. By definition the impedance of a circuit element at a certain frequency is the quotient of voltage by current, both being at the stated frequency. Consequently in the steady state, with a fixed voltage of a particular frequency impressed, there must be a definite current component of this frequency which determines the impedance. The grid-filament impedance has been measured in actual circuits by means of a special bridge which does not affect the flow of current components other than the one at the frequency of the measurement. When using 101-D tubes under the usual operating conditions, the grid impedance at carrier frequencies amounts to a resistance of about 75,000 ohms.

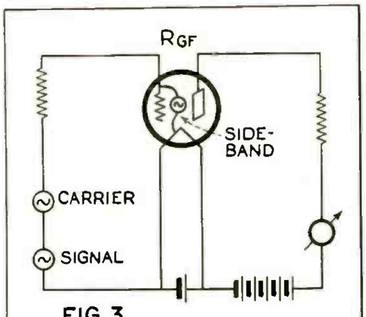


FIG. 3

General form of a modulator circuit.

Impedance Relations

Having obtained the maximum sideband voltage on the grid, it remains only to determine the impedance relations in the plate circuit for maximum power output at sideband frequencies. There are at the same time various other voltages on the grid which will produce currents of corresponding frequencies in the plate circuit depending on the external output impedances to these frequencies. If carrier and signal currents are allowed to flow in the plate circuit, they will modulate each other and so produce voltages of sideband frequencies which will combine with the voltages of the same frequencies produced by grid-current modulation. But it can be shown that the sideband voltages from these two sources are in opposite directions, so that their sum is less than the larger one alone. Therefore, since the sideband voltage induced in the plate circuit by grid current modulation is the larger, the maximum sideband output power is obtained when both carrier and signal currents in the plate-circuit are reduced to a minimum. This is accomplished by making the external output impedance high compared to the plate impedance at carrier and signal frequencies. However, the plate circuit should act as an amplifier to the sideband voltage developed on the grid by grid-current modulation. Consequently the sideband power output is a maximum when the external output impedance matches the plate impedance at sideband frequencies. These optimum plate impedance conditions for a grid-current modulator are obtained by means of transformers and filters, or, if the frequency separation is great enough, by tuned circuits.

In some cases it may be desirable to utilize plate-circuit modulation rather than grid-current modulation. The optimum impedance conditions may then be determined by the same line of reasoning as used above except that in this case grid modulation is made a minimum and plate modulation a maximum. These impedance conditions for the maximum plate modulation are listed for comparison in the table.

Optimum Relation of External to Internal Impedances

Type of Modulation	Frequency	Impedances in Grid Circuit	Impedances in Plate Circuit
Grid Current	Signal	Match	External high compared with internal
	Carrier	Match	External high compared with internal
	Sideband	External high compared with internal	Match
Plate Current	Signal	Match	External low compared with internal
	Carrier	Match	External low compared with internal
	Sideband	External low compared with internal	Match

Optimum Impedance Conditions

In both plate and grid circuits the optimum impedance conditions for maximum sideband output can often be met more easily with a balanced circuit than with a single tube. The general impedance relations are still the same as listed in the table but since part of the currents are balanced from both input and output circuits, the impedances to these frequencies may be provided by separate impedance units. Since the grid-current modulator was developed primarily with a view to its possible application to carrier telephone circuits, experimental work has been confined for the most part to balanced circuits in which the carrier is suppressed. Such a circuit is capable of giving an output of half a watt of single sideband when using 101-D tubes at 120 volts plate potential. Typical curves of single-sideband output are given in

Fig. 4 showing how the output may be increased by using the proper filters in input and output circuits. The maximum plate power efficiency is then about fifteen per cent, as compared to about three per cent for a typical plate-circuit modulator. Listening tests have shown that these modulators will give about 10 TU greater sideband output than a typical plate-circuit modulator using the same tubes and plate battery with approximately the same distortion.

Effect of External Impedances

In the preceding discussion of the effect of external impedances on the output of a grid current modulator, no consideration was given to any frequencies other than signal, carrier, and sideband. However, the impedance to direct current has a considerable effect in the grid circuit. Since current can flow in only one direction through the grid-filament path, the voltage produced when it flows through an external resistance is unidirectional. This voltage creates a negative bias on the grid, which may become so high that the grid is positive with respect to the filament during only a very small portion of a cycle. It is during this portion of the cycle that modulation occurs, and so there results a considerable decrease in the output power available for large input voltages. Thus the external grid impedance should always be as low as possible to direct current.

The familiar grid-leak-and-condenser detector so universally used in radio receiving sets operates so far as the grid circuit is concerned very nearly in accordance with the above principles. In this case the external grid impedance consists of a resistance shunted by a condenser, giving a high impedance to voice frequencies but allowing the carrier and sideband input circuits to approximately match the grid in impedance. The grid leak also has a high resistance to direct current, which limits the maximum signal output just as has been explained in the previous paragraph. However, the external plate impedance is usually low compared to the plate resistance, instead of high compared to it, as shown in the table for optimum impedance conditions. This is due to other effects at the high frequencies and low amplitudes for which it is ordinarily used.

Tests made with carrier-frequency input to a detector tube have shown that a considerable increase in maximum output has been secured by replacing the grid leak with an inductance coil having a comparatively low resistance to direct current. Under these conditions the fixed grid potential should be adjusted by a potentiometer to about that of the center point of the filament. Although this adjustment may vary to some extent with different tubes, it is not critical for large input voltages. The increased load-carrying capacity may be judged from the fact that with sufficient carrier frequency input an ordinary cone-type loud speaker may be operated from a balanced grid-current detector using two 101-D tubes.

A graphic portrayal of how grid-current modulation takes place. A full explanation is given at the end of this article.

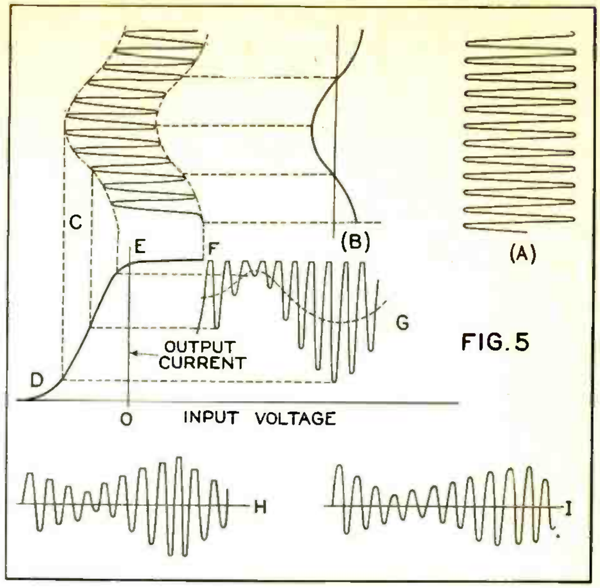


FIG. 5

Explanation of Fig. 5

A graphic portrayal of how grid-current modulation takes place is shown in Fig. 5. A and B are carrier and signal currents, respectively, and C is the current which results from their flow through the ordinary "linear" conduction of the input circuit. DEF is the characteristic "non-linear" curve of a grid-current modulator. When the wave C is applied to this conductor its form is changed to that of G by the planing off of half of each wave. Since the mid-point of the new wave is itself a sine-wave, as shown by the dotted line in G, there remains in the new wave a component of the same frequency as the signal. Removing this component by means of a filter leaves the wave H. Sharp corners in this wave indicate that it contains components of still higher frequencies than the carrier (A). When these are removed, we have I, a modulated wave.

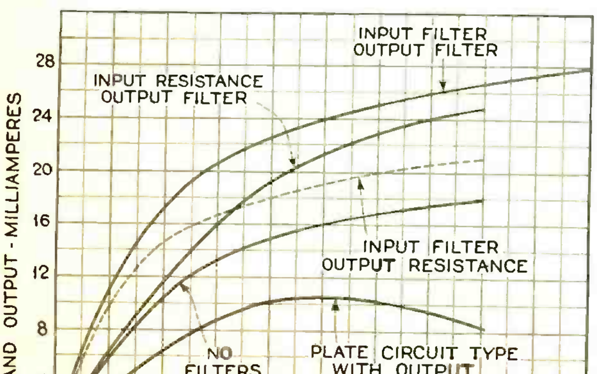


FIG. 4

Sideband output of a balanced grid-current modulator using Western Electric 101-D tubes.

AN AUTOMATIC DEVICE FOR THE TRANSMISSION OF STATISTICAL REPORTS

In the January issue of *l'Organizzazione scientifica del Lavoro*, M. Ugo Rosso describes an automatic device employed in his factory for the transmission of statistical returns from the various departments to the management. The figures transmitted are shown by means of vertical lines on boards fixed to the walls of the manager's office. The height of the vertical lines is regulated by means of a dial-shaped rotating transmitter, similar to that used for automatic telephones. This permits of automatic transmission by each department of statictical returns for production, stocks in warehouse, goods invoiced and orders received, as well as of financial data supplied by the accounting department. Time spent in making out written reports is saved.

Substituting Argon for Helium in Low-Voltage Rectifiers

A Resumé of the Results of Laboratory Research in the Manufacture of Low-Voltage Rectifiers

By E. Kauer and Dr. S. Marie*

THE attempted substitution of argon for helium in low-voltage rectifiers has been urged by several important factors, i. e., (1.) Lower starting voltage, (2.) Lower voltage drop. (3.) Smoother operation. (4.) Less gas pressure required. (5.) Cost.

The tests that have been conducted up to the present time, however, do not warrant its use because of lack of uniformity of results obtained. Three factors seem to be responsible for these results; (1.) Impure gas. (2.) Disintegration of anodes, (3.) Impure anodes.

It is difficult to separate the effect of any one factor when explaining the ultimate short life of the tube. The disintegration of the anodes is a good example and might be caused by sputtering of anodes in pure argon discharge; catalytic effect of getter; impurities in argon; or impurities in anode material.

The first of these seems most important. Through proper procedure the catalytic effect of the getter can be eliminated. Pure sheet nickel has been used constantly for cathode material during the tests of determining the relative merits of various anode materials. However, this does not point to its satisfactory employment, since in all test tubes that have operated for more than one thousand hours, the coating of active material has been wholly or partly eradicated, and the cathode often so severely eaten as to be sputtered over the anodes. Therefore, in cases where both electrodes have been attacked, it seems fair to charge both elements with the clean-up of gas and short life.

All argon used in the test was obtained from the Air Reduction Company and was supposed to be 100% purity; however, when a sample was examined spectroscopically considerable impurities were found to be present. These impurities can be eliminated.

Disintegration of Anodes

Much has been learned regarding the disintegration of the anodes in spite of the fact that the cathode finally becomes attacked.

With all material so far tried for anode purpose, their disintegration has been so rapid as to give insufficient time for the cathode to become attacked to any visible extent. The following metals have been tried for anodes, and all found to be less satisfactory than carbon: nickel, tungsten, tantalum, magnesium, molybdenum, aluminum and silver.

The data on carbon divides itself into two main portions, the first being principally of the projector carbon from the National Carbon Co., and the other entirely of Austrian carbon. To date extensive tests have been carried out only on these two makes of carbon, they being satisfactory as regards hardness and binder. From experimental tubes made in the laboratory, the following has been obtained with 1/10-inch diameter carbon anode and using DG construction.

RADIO SERVICING

Starting with the December issue, RADIO ENGINEERING *will run specially selected articles for radio technicians, covering the construction and use of testing equipment, radio trouble shooting, etc.*

We have two excellent articles scheduled for the December issue. The titles are: "Radio Inspection" and "Constructing a Modulated Oscillator." You will find them valuable.—Editor.

Pressure

A pressure of four to seven M/M cold gives the longest life. Following is a summary of experimental tubes made with various pressures.

M/M	Hours of life to 150 volts.
.5	24
2.0	72
3.0	120–240
3.5	336
4.0	525–720

Pin Length

A positive extension of pins above the plate is better than a negative length, since with the latter condition the discharge is encouraged down too near to the top of the lava insulators, resulting in rapid increase of creepage and early failure to short circuit. As far as the pins are concerned, it is unnecessary to attempt to reduce the back current to a minimum, for as will be noted in the data, tubes with pressure of 5 M/M and 3/32" extension of pins have more than 5 MA back current and are still operating satisfactorily after 2,000 hours.

It is recommended that the pin length be above 1/16" for the present short pin and lava arrangement.

Potassium, Caesium and Lithium Getters

Purity has marked influence, for when caesium and potassium are released in a tube by the bombarder, with the agency of metallic calcium the initial output may be no higher but longer life is insured. Life measurements for the period when the output stands above 150 volts are 0-220 hours without getter and 170-2400 hours with getter.

When flashed in the tube, calcium also has a beneficial influence on the extent of life. Two methods have been employed to utilize it—the first being to attach a small lump to the lower side of the cathode plate, with a spacing of 1/32" between the two, so that the calcium will not be flashed until the final stages of bombardment. The second method is to form an auxiliary calcium electrode outside the cathode. This is treated with current on the pump, to rid it of *acclouded* gases. The tube is then filled, sealed off, and the calcium flashed completely. The first method has given the most uniform results. Life measurements indicate 0-220 hours without calcium, 120-1000 hours when calcium is flashed after sealing off and 25-1000 hours when calcium is flashed before sealing off.

Heating of Anodes

The effectiveness of heat treatment of the anodes at 600 degrees in a vacuum before stemming is indicated in the following: 0-216 hours with unheated anodes and 48-1000 hours with heated anodes.

Coating

The cathode was sprayed and heated in hydrogen, with active materials, consisting of barium, strontium, sodium, potassium and lithium nitrates.

Carbon

As far as tests have indicated, there seem to be little difference between "National" and Austrian carbon. However, the variety from abroad is uniform in diameter within .001" and costs about two cents per tube.

(A series of tests are being made, using a mixture of helium and argon. Results of these tests will be presented in another paper. Editor.)

* Research Laboratory, CeCo Manufacturing Co.

Impedance of Iron-Cored Chokes

Characteristics of Iron-Cored Chokes and Methods of Measurement

*By G. F. Lampkin**

THE true figure of merit of an iron-cored choke is its impedance to alternating currents. When, as is usually the case, the choke carries both alternating and direct components of current, the former values alone must be measured as a step in obtaining the choke impedance. When the alternating component of voltage across the choke is known, the impedance is then determined as E/I. Specification of the impedance of a choke is more direct and labor-saving than specification of inductance, for the latter must be obtained by roundabout calculation from the former.

It cannot be assumed with any degree of accuracy that the choke is a pure reactance, and that the inductance therefore may be obtained by equating the inductive reactance $2\pi fL$, to the quotient E/I. The resistance of the choke winding is negligible, being of the order of three or four hundred ohms. However, the hysteresis and eddy-current losses are not negligible; their effect is to make the phase angle of the typical chokes as low as 65°. This departure of the choke from a pure reactance must be recognized and the proper relations set up if the true inductance of the choke is to be calculated. Such cannot be done unless the measurements are further complicated to include the determination of the phase angle of the choke.

Direct Current Effect

In any measurement, whether made so as to determine the inductance or merely to find the impedance, the value of D.C. in the choke must be known. In general, the higher the D.C. saturation the lower is the choke impedance.

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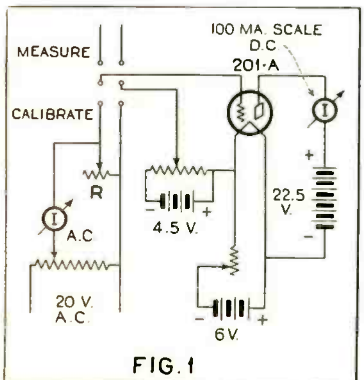
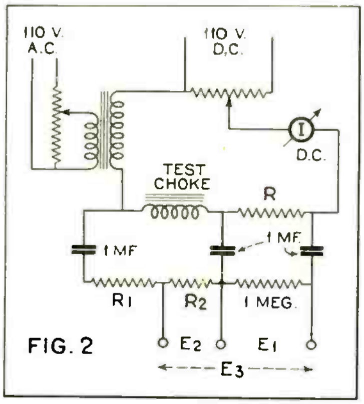


Circuit for measuring the phase angle of iron-cored chokes.

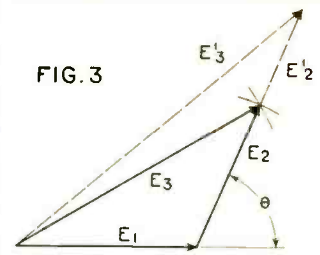
The range of impedance with D.C. variation is less in a choke with an air-gap core than in one with a continuous iron core. In either case, however, the variation is wide enough that specification of choke impedance without mention of D.C. saturation is meaningless. Not only does the impedance vary with the value of D.C. in the coil but it varies just as widely with the amount of A.C. For chokes whose dimensions are typical of those used in "B" eliminators the impedance in general increases with increase of A.C. component in the coil. Thus it is necessary to determine both D.C. and A.C. in the coil when measuring the choke. To determine the impedance an additional measurement of alternating voltage on the choke must be made; while if an accurate value of inductance is desired, both phase angle and voltage must be obtained.



Simple circuit arrangement for testing a choke.

Phase Angle Measurement

The phase angle cannot be conveniently measured by the wattmeter method. One reason is because the usual A.C. components are below the wattmeter range. Another reason is the difficulty of isolating the A.C. quantities so that they alone will register on the meter. The three-voltmeter method of measuring phase angle cannot be applied with the ordinary electrodynamometer voltmeter because its impedance is low compared with the impedances to be measured. A vacuum-tube voltmeter can be used in the method, however. In its simplest form the vacuum-tube voltmeter may be built with a 201-A type tube, a 22½-volt "B" battery, a 4½-volt "C" battery and 400-ohm potentiometer, and a 100-ma., D.C. meter. Fig. 1 gives the



$$\cos(180° - \theta) = \frac{E_1^2 + E_2^2 - E_3^2}{2 E_1 E_2}$$

$$\cos\theta = \frac{E_3^2 - E_1^2 - E_2^2}{2 E_1 E_2}$$

Vector diagram of the phase angle of an iron-cored choke.

circuit. Starting with a datum reading of 20 ma., an input-voltage range of 0.25 to 1.5 volts r.m.s. will correspond to a plate-current range of approximately 22 to 100 ma. The circuit also shows the method of calibration wherein the 60-cycle current in a standard resistance is measured, and the calculable drop impressed on the meter.

Test Circuit

To test a choke the circuit may be laid out as in Fig. 2. The total resistance across the choke is made some hundred times the choke impedance. The resistors may be the metalized grid leak type, with R_1 around 3 megohms and R_2 so proportioned that the voltage across it comes within the range of the vacuum-tube meter. Values of R_2 will as a rule range from 0.05 to 0.5 megohms. The ratio for each combination of R_1 and R_2 should be measured rather than calculated from the stated resistance values. The 1. mfd. condensers are used to isolate the D.C. potentials so that they are not impressed on the tube grid. The insulation resistance of each condenser should be checked to see that it is of the order of several hundred megohms. If the insulation resistance were low, sufficient D.C. potential would exist across the resistors to influence the vacuum-tube voltmeter readings.

The resistance R is used in series with the choke to obtain a potential in phase with the alternating current. It is also used to measure the magnitude of the A.C. component. Knowing the value of R and from the vacuum-tube meter reading the voltage across it, the current is obtained as E_1/R. If R is made 1,000 ohms, 0.25 milliamperes A.C. can be measured using the above

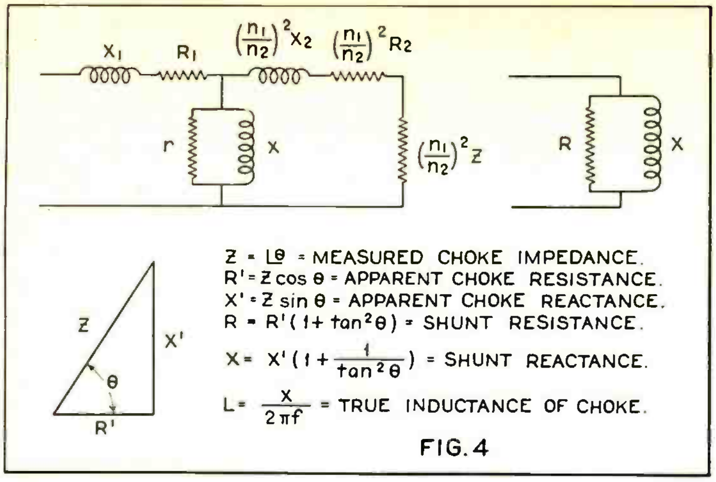


FIG. 4

Equivalent electrical circuit of a transformer. The quantities X_1 and R_1 represent the primary leakage reactance.

described tube voltmeter. Different appropriate values of R may be used to measure other alternating current ranges. The voltage E_2 measured across R_2, multiplied by the factor

$$\frac{R_1 + R_2}{R_2},$$

gives the alternating voltage across the choke. The final expression for the choke impedance in terms of the various resistances and voltmeter readings is:

$$Z = \frac{E_2 (R_1 + R_2) R}{E_1 R_2}.$$

Choke Measurement

To obtain the phase angle of the choke it is necessary to read the voltage E_3, the resultant of E_1 and E_2. Then from trigonometry the cosine of the phase angle may be computed as

$$\cos \theta = \frac{(E_3)^2 - (E_1)^2 - (E_2)^2}{2 E_1 E_2}, \text{ from}$$

whence the angle θ can be found in trigonometric tables. Or more simply, the value of voltage E_1 may be laid out to scale on paper. See Fig. 3. With E_3 as a radius an arc is drawn from one end of E_1. From the other end of E_1 an arc with radius E_2 is struck to intersect E_3. The external angle θ between E_1 and E_2, as measured with a protractor, is the phase angle of the choke. The voltage E_2 is a certain fraction of the total voltage across the choke, and is in phase with the total voltage, since a pure resistance is used for a ratio arm. Suppose a different portion of the total voltage were tapped off for measurement, say E'_2 as shown by the dotted line. The new resultant would be E'_3, but the angle between E_1 and E'_2 would be unchanged. Thus the angle θ as determined by the method is independent of the ratio of R_1 to R_2.

The equivalent circuit of a transformer is such as that in Fig. 4. The quantities X_1 and R_1 represent the primary leakage reactance, and the resistance of the primary winding, respectively. At all times, under any load conditions, an exciting current flows in the primary. A part of this current, in quadrature with the impressed voltage, is the magnetizing current which sets up the flux in the core. The other component of exciting current, due to iron losses in the core, is in phase with the impressed voltage. In the equivalent circuit these components of exciting current are represented as being drawn by the resistance r and the reactance x, which make up the primary exciting impedance. The secondary leakage reactance and resistance become $\left(\frac{n_1}{n_2}\right)^2 X_2$ and $\left(\frac{n_1}{n_2}\right)^2 R_2$, respectively, when transferred to the primary. The secondary load Z is multiplied by the same factor when transferred to the primary in the equivalent circuit.

However, a choke has neither secondary winding nor secondary load. In applying to the choke the above circuit, these elements need not be considered. The primary resistance can be neglected in comparison with the exciting impedance; as can also the leakage reactance with the same slight degree of error. Thus the equivalent circuit of the choke boils down to the exciting impedance of a transformer—a resistance and inductance in parallel. The resultant impedance of a choke can never be larger than the smaller of these two parallel elements. The greater the hysteresis and eddy-current losses in the core, the lower is the choke impedance, and the lower is the phase angle.

Inductive Reactance

The true inductance of the choke can be calculated if the impedance, Z, and the phase angle, θ, are known. These can be determined in the three-voltmeter method by utilization of the vacuum-tube voltmeter as above. The apparent inductive reactance of the choke, which may be designated X^1, is given by Z·sin θ. The true value of the inductance reactance is

$$X = X^1 \left(1 + \frac{1}{\tan^2 \theta}\right).$$

This is the value of the shunt inductance element in the equivalent circuit, whence the true inductance is

$$L = \frac{X}{2\pi f}.$$

In like manner the value of the shunt resistance due to iron loss is derived as $R = R^1 (1 + \tan^2\theta)$, where R^1 is Z·cos θ These transformation relations may be obtained by setting up the expressions for the equivalent circuit and solving for R and X. In the extreme cases, if the choke is a pure reactance, θ = 90°, $\tan^2 \theta$ = infinity, and R is infinity — that is, an open circuit, and $X = X^1$; or if the impedance is a pure resistance, θ = 0, $1/\tan^2 \theta$ = infinity, and X is infinity, while $R = R^1$.

Such a process of accurately determining the inductance of a choke is laborious and involved. The use of a vacuum-tube voltmeter is not desirable because of instabilities in calibration, because of the labor involved in transferring plate-current readings to input volts, and because of some slight error due to wave-form. The voltage across the choke is nearly sinusoidal. The voltage across R in Fig. 2 has a goodly percentage of third harmonic, however, because its wave-form conforms to that of the exciting current. The wave-form error is not as great for the type of tube voltmeter described as it would be for a peak-reading voltmeter. Lastly, the process

Circuit for the measurement of the impedance of an iron-cored choke.

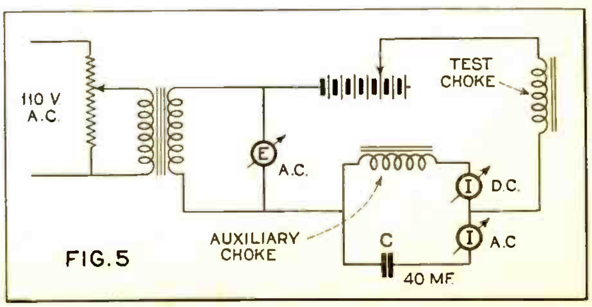


FIG. 5

necessitates an excessive amount of computation. It would be warranted chiefly in design or developmental work.

Measurement of Choke Impedance Only

The measurement of choke impedance alone is a much simpler undertaking. The results tell as much or more about the efficacy of a choke as other measurements, assuming that the D.C. resistance is kept within the usual bounds of three or four hundred ohms. Numerous ways have been developed for choke impedance measurement, such as bridge methods, special vacuum-tube voltmeter setups, D.C. bucking-out connections, and so on. The problem is to measure a few milliamperes A.C. in the presence of a greater amount of D.C. The separation of A.C. and D.C. can be most easily accomplished by a choke and condenser combination. In Fig. 5 the condenser C passes the A.C. into the thermocouple meter, but blocks the D.C. into the choke by-pass. Forty or more microfarads of "B" eliminator blocks may be used to make up C. The reactance at 60 cycles of a condenser of this size is around 66 ohms.

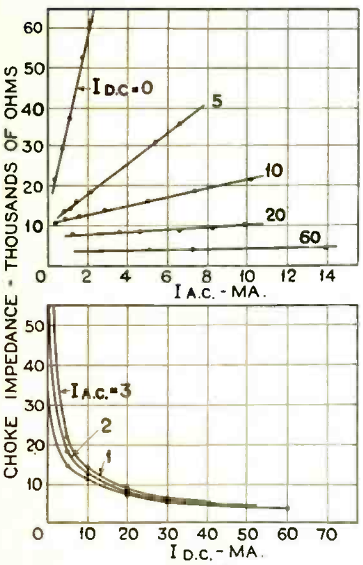


FIG.6

Impedance of iron-cored choke with leaved joints.

A typical 10-milliampere vacuum thermocouple has a heater resistance of 37 ohms, which combined with the condensive reactance presents an impedance of some 75 ohms to the A.C. component. The minimum impedance of the better "B" eliminator chokes is of the order of a hundred times this value, so that the error due to shunting by the auxiliary choke is negligible. The D.C. source had best be a tapped battery capable of supplying the maximum required D.C. A one or two-hundred ohm potentiometer could be used across the 110 D.C. mains as a source. The point is to keep the A.C. impedance of the circuit between the voltmeter and the choke as low as possible. With a choke whose impedance runs into the thousands of ohms the error introduced by the 75-ohm ammeter circuit and the low-resistance D.C. source is near, or less, than one per cent. Direct current in the circuit is measured by a D'Arsonval-movement meter. The transformer used as the source of A.C. is controlled from the primary, in order that variation of the alternating voltage will not change the D.C. flow by changing the circuit resistance. The measurement procedure is to fix the value of D.C., vary the alternating current and read the corresponding alternating voltages.

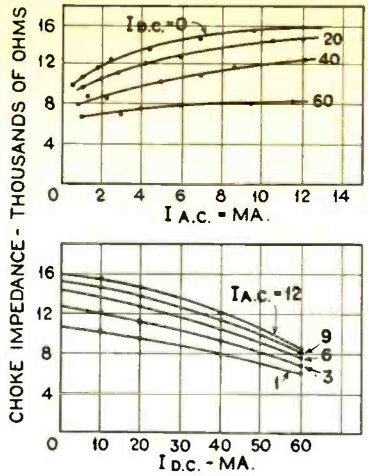


FIG.7

Impedance of iron-cored choke with butt joints.

Typical Impedance Curves

Typical impedance curves for two different chokes, in Fig. 6 and Fig. 7, are given. The difference between chokes with and without an air-gap core is evident. The aid gap reduces the range of impedance with D.C. variation; it makes for higher impedance at high saturations, but lowers it when little D.C. is flowing. The variation in impedance with A. C. component is also apparent. The ranges due to this cause are as great as those due to change in D.C. saturation.

RADIO SIGNAL TRANSMISSIONS OF STANDARD FREQUENCY

THE Bureau of Standards announces a new schedule of radio signals of standard frequencies, for use by the public in calibrating frequency standards and transmitting and receiving apparatus. This schedule includes many of the border frequencies between services as set forth in the allocation of the International Radio Convention of Washington which goes into effect January 1, 1929. The signals are transmitted from the Bureau's station WWV, Washington, D. C. They can be heard and utilized by stations equipped for continuous-wave reception at distances up to about 500 to 1,000 miles from the transmitting station.

The transmissions are by continuous-wave radio telegraphy. The signals have a slight modulation of high pitch which aids in their identification. A complete frequency transmission includes a "general call" and "standard frequency" signal, and "announcements." The "general call" is given at the beginning of the 8-minute period and continuous for about 2 minutes. This includes a statement of the frequency. The "standard frequency signal" is a series of very long dashes with the call letter (WWV) intervening. This signal continuous for about 4 minutes. The "announcements" are on the same frequency as the "standard frequency signal" just transmitted and contain a statement of the frequency. An announcement of the next frequency to be transmitted is then given. There is then a 4-minute interval while the transmitting set is adjusted for the next frequency.

Information on how to receive and utilize the signals is given in Bureau of Standards Letter Circular No. 171, which may be obtained by applying to the Bureau of Standards, Washington, D. C. Even though only a few frequency points are received, persons can obtain as complete a frequency meter calibration as desired by the method of generator harmonics, information on which is given in the letter circular. The schedule of standard frequency signals is as follows:

Radio Signal Transmissions of Standard Frequency Schedule of Frequencies in Kilocycles

Eastern Standard Time	Nov. 20	Dec. 20	Jan. 21	Feb. 20	Mar. 20
10:00 — 10:08 P. M.	1500	4000	125	550	1500
10:12 — 10:20	1700	4200	150	600	1700
10:24 — 10:32	2250	4400	200	650	2250
10:36 — 10:44	2750	4700	250	800	2750
10:48 — 10:56	2850	5000	300	1000	2850
11:00 — 11:08	3200	5500	375	1200	3200
11:12 — 11:20	3500	5700	450	1400	3500
11:24 — 11:32	4000	6000	550	1500	4009

Wire Drawing

A Story of the Step-by-Step Manufacture of Wire with an Introduction to the History of the Art

*By George B. Horn**

THE art of wire-drawing came into existence in the middle of the 14th Century. All the wire that was made before that time was made by the tedious and laborious process of cutting a thin continuous strip from a sheet of flat metal and then rounding this flat strip under the hammer. Strange that the ancients made round wire by rounding flat wire and we moderns make flat wire by flattening round wire.

The genius who discovered that wire could be made from metal rods by pulling them through funnel shaped holes is supposed to have been one Rudolph of Nurenberg and we have documentary evidence of this process being carried out in Augsberg in 1351. Some twenty years later mention is made of a wire-drawing mill in Nurenberg making wire from several different metals but nearly three hundred years more elapsed before the art was introduced into England.

* *Chief Engineer, Dudlo Manufacturing Company.*

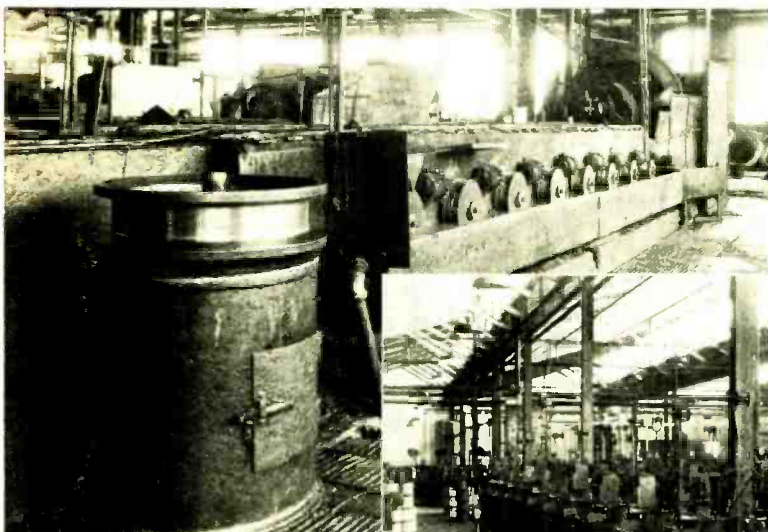
In America the first wire-drawing mill was built in 1775 at Norwich, Connecticut, by Nathaniel Niles. With the dawn of the Electrical Age, the demand for wire was enormously increased and the modern wire-drawing mill with its truly stupendous output is the result of that demand.

Nature of Metal Required

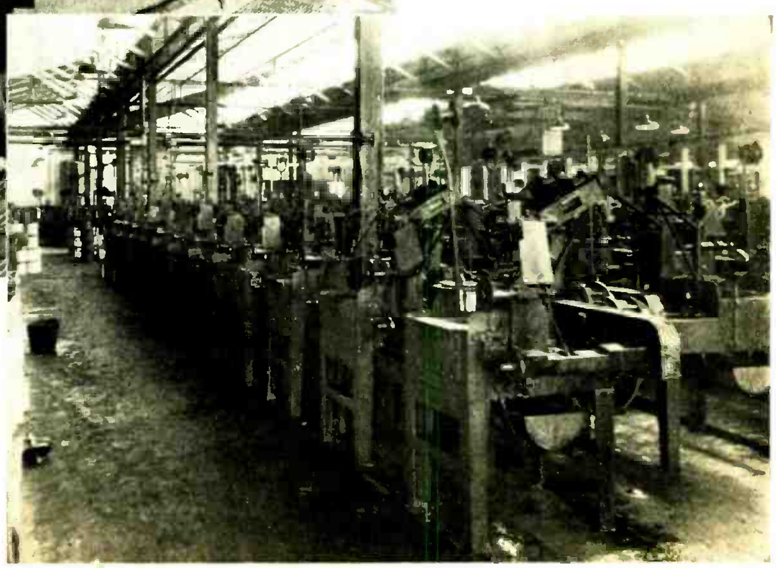
A metal must have both ductility and tenacity to make it suitable for wire-drawing. It must be ductile enough so that it can readily be squeezed and stretched to a smaller diameter, and correspondingly longer lengths, as it passes through the dies, and it must be tenacious enough so that it does not pull apart under the strain. The greater the ductility and the greater the tensile strength of a metal the greater the allowable speed of drawing will be.

Not every metal possesses these requirements. In fact, the number of metals suitable for practical wire-drawing are rather small and of these, three are precious metals,—gold, platinum and silver. The other commonly used metals are copper, iron (or steel) and aluminum. Alloys of these metals such as brass, etc., are also used.

The number of substances used as dies for wire-drawing are also very limited. The dies must be much harder than the metals being drawn and they must have strength enough to stand the strain. In practical use only three materials have been found of value and these are chilled cast iron, steel and the diamond. Of these, the last is far superior to the others and is exclusively used for the smaller sizes of wire with their more exact requirements. The diamond, of course, is the hardest of all substances but, unfortunately, it also happens to be one of the most expensive and, in the larger sizes, this cost becomes almost prohibitive. While the diamonds that are used for this purpose are ones that are unsuitable for use as gems, due to being off color or badly flawed, and are therefore not as high-priced as



A bank of wire drawing machines for sizes No. 30 to No. 46. Diamond dies are necessary for drawing such fine wire. The wire is fed to the machines from the spools on the ends of the rods, over the machines, and after reduction in size it is fed on to other spools.



(Photos. courtesy of Dudlo Manufacturing Co.)

A section of the rod mill for drawing heavy sizes, from No. 4 to No. 14 gauge, from the copper rod. The rod is reduced in stages and after attaining a small diameter is drawn through special dies.

the gems, nevertheless they are sufficiently rare to make their cost by no means a negligible factor.

Wire Dies

The hole through the die must be at right angles to the face of the die; it must be true; it must be within the limits of tolerance for size; it must be properly tapered to the throat and the entire passage through the die must be smooth and highly polished so as to oppose as little frictional resistance as possible. As these smaller dies are drilled with a tolerance of only 0.0001 of an inch and, as the speed of the drawing depends largely on the proper design of the dies, it can readily be seen that the making of wire-drawing dies is an art in itself. The diamond dies are drilled, tapered and polished by needles covered with oil and diamond dust and the size of the hole is gauged by drawing some wire through it and then measuring the wire with fine micrometers.

It is necessary to use a lubricant in the drawing process. This may be tallow, oil, soap, or soap solution and, in drawing iron and steel wire, deposited lime and iron rust actually act as lubricants. As a considerable amount of heat is given off during the drawing process it is necessary that this be absorbed. An aqueous solution of soap serves the double purpose of lubricating and also cooling the dies and the wire.

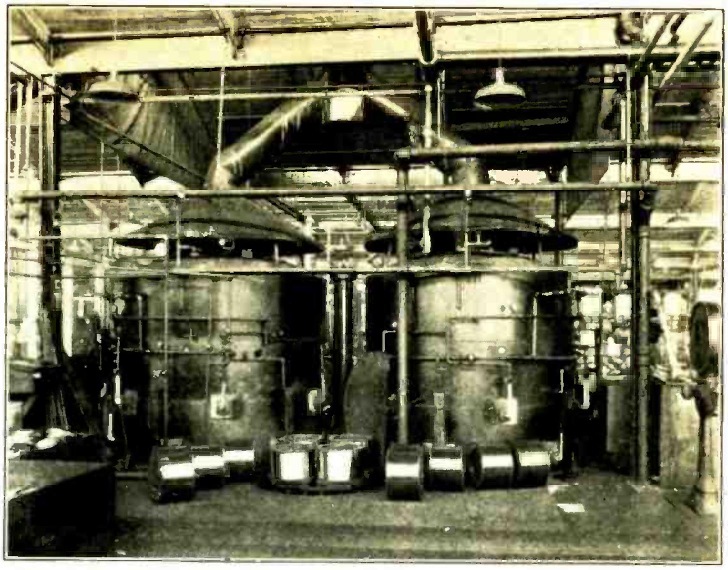
(Photo. courtesy of Detroit Wire Die Co.)

A diamond die for drawing No. 14 to No. 50 gauge wires.

Speed of Drawing

The speed of drawing depends on the nature of the metal being drawn, the size of the wire and the design and construction of the dies and mill. In general, it may be said that the speeds vary from somewhat less than 60 feet per minute to over 900 feet per minute.

The life of the dies depends on the nature of the metal being drawn and the speed of the drawing. Hard steel wire may wear a die out in a few days while with a soft copper wire, the life of the same die might vary from several months to several years. Instances have been recorded of diamond dies lasting up to eight years on soft copper wire.



(Photo. courtesy of Dudlo Manufacturing Co.)

Two of the numerous annealing ovens which remove the crystal strain from copper wire between the drawing operations.

While the foregoing statements have necessarily been of a general nature, the following will be more specific, describing the manufacture, step by step of copper wire from the raw material—copper rod. Certain variations, of course, would be necessary in handling other metals but the inclusion of such variations would make this article unnecessarily long, and, as copper wire is of primary importance in the electrical industries, its manufacture will be the one described.

Manufacturing Processes

The end of the rod of one of these "bundles" is pointed in a pointing machine which consists of grooved rollers so arranged that the rod can be tapered between these rolls. The tapered end is then thrust through the various sized dies which are strung on in a stringing machine: the largest die first, followed by the next smaller and so on down to the smallest. From four up to nine dies are strung on for drawing on this first or rod mill.

Since the wire that is handled on this mill is large in diameter, the mill must be of heavy construction to stand the strains and the lubricating and cooling must be ample as a large amount of power is dissipated as heat.

Each die is followed by a drum which furnishes the necessary tension for drawing the wire through the die. As many as nine dies may be used on this heavy mill so nine drums are required, the last one of which is used for winding the finished wire. On the other drums one or two turns is sufficient to furnish the tension. As the wire elongates at each "pass" it is necessary to rotate each succeeding drum enough faster to compensate for the extra length of the wire.

The dies used on this mill are made of chilled cast iron and they are rotated during the drawing so that they will not wear unevenly. While their life varies somewhat, it is usually necessary to ream and polish them to the next larger size after one bundle of rod has been drawn. In order to draw good non-kinking wire the throat of the die must form a straight line with the tangent of the tension drum. Lubrication and cooling are accomplished by means of an aqueous soap solution which is pumped and splashed over the wire and dies and is circulated so as to dissipate the heat given off during the drawing.

While the number of "passes" through both the rod mill and the succeeding mills varies according to the requirements of the wire being drawn, it is possible to reduce ¼" rod to 14 Gauge wire by nine passes thus doing somewhat better than reducing it one gauge smaller on each pass.

Wire-drawing strains the metal crystals and hardens the metal so that after a certain number of passes the

Chilled cast iron die for drawing No. 3 to No. 14 gauge wires.

wire must be annealed to take the strain out of the crystals and soften the metal before drawing it further. This annealing is carried out by placing the coils of wire in an annealing oven and heating it to the proper temperature and for a sufficient length of time to secure the desired degree of softness in the metal. For a rough example, the annealing may be carried out at about 800 to 900 F for a period of from one and one-half to four hours. At this temperature copper wire will oxidize in air so the annealing is carried out in an atmosphere of either steam or gas and the wire is introduced and taken out through seals which keep the air from entering the ovens.

After annealing the wire may be sent to the intermediate mill where a reduction of from 14 Gauge to 22 Gauge or even 26 Gauge may be effected. While the procedure varies somewhat on the wire requirements, drilled, cast iron dies are generally used only down to about 14 Gauge and for smaller sizes and even for 14 Gauge, diamond dies are usually used.

The Diamond Dies

These dies, while made from off-colored and flawed diamonds which cannot be used in jewelry, are nevertheless very expensive, especially in the larger sizes. This expense is due not only to their rarity but also to the cost of making them, as the drilling, tapering and polishing are extremely laborious. They are practically all made in Europe and a high degree of skill is necessary in their production. Briefly described, the drilling and polishing are done by means of steel needles covered with oil and diamond dust and these diamonds are then mounted in steel plates by pouring molten brass around them. In spite of their high original cost, the cost per unit of copper wire drawn is very reasonable as the extreme hardness of the diamond dies makes them very long lived. This hardness also makes it unnecessary to rotate the dies during the drawing process.

The power consumption on the intermediate and fine wire mills is only a fraction of that consumed in the rod mill and it is not necessary to compensate for the increased lengths of wire by driving the tension drums at varying speeds or constructing them of varying diameters. Instead, slippage takes care of this factor very nicely.

After passing through the intermediate mill, the wire must again be annealed before going to one of the fine wire mills where it can be reduced from 22 Gauge to 36 Gauge or 38 Gauge.

If still finer wire is desired, the wire is again annealed and may be reduced from 36 Gauge to 44 Gauge.

It might be mentioned that in the smaller mills the dies are supported in brackets and the entire drawing operation is conducted while immersed in a soap solution.

Special Processes

While this gives a general idea of the drawing of copper wire, the exact procedure for producing any specific gauge and quality of wire may vary considerably from the above as the hardness and tensile strength of the wire can be greatly varied by the proper regulation of the drawing and annealing processes.

Flat wire is made from the round wire by flattening between rollers of special alloy steel. If very thin, flat ribbons are required, it is necessary to true the edges by slitting.

Square wire is made by passing round wire through a "Turks Head" consisting of four adjustable special alloy steel rolls.

Tinned wire is made by running the copper wire through a pickling bath, then through a bath of molten tin followed by a colding bath, after which the wire is passed through a single polishing and finishing die.

The Mathematics of Radio

Covering the Fundamental Structure and the Characteristics of the Vacuum Tube

By John F. Rider, Associate Editor

PART XII

THE success of the radio industry is founded upon the vacuum tube. Broadcasting as we know it today would be virtually impossible were it not for the perfection of the vacuum tube. It is very likely that further developments upon the singing arc invented many years ago would have been a basis for some sort of broadcasting at this stage, but the invention of the vacuum tube obviated the necessity of improvements upon the arc with the purpose of utilizing the system for speech and music transmission. Consequently, a series of articles or papers describing the phases of radio would not be complete without a discussion of the vacuum tube, hence a chapter on tubes in the "Mathematics of Radio."

Recent developments in the radio receiver field have brought to public light a new use of the vacuum tube, namely the conversion of alternating currents into direct currents, i. e., rectification, constituting the power supply systems of millions of receivers in use throughout the world. This field of utility necessitates a more extended discussion or rather a more basic discussion of the vacuum tube since the vacuum tube when utilized in a B-eliminator is of the type practically identical to the original two element tube in its first form of invention; later to be followed by the three and four element tubes.

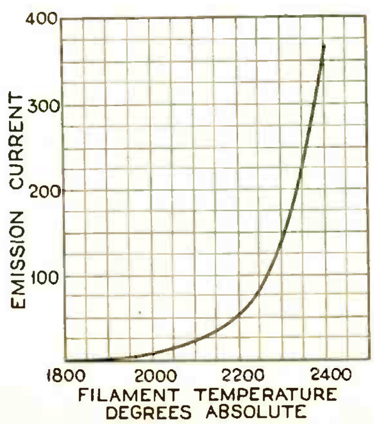


FIG. 68

Curve of the emission from a tungsten filament.

We do not propose to enter into the physics of the vacuum tube but rather to discuss and to explain important points which will be of general utility to the radio man and aid him in his work.

Another contributory cause for more than a rudimentary discussion is the A.C. tube, utilized in the A.C. receiver. While this tube differs from its D.C. brothers in but one respect, namely, the filament circuit, this difference is of sufficient importance to warrant an explanation. This explanation is necessary because it governs the successful utilization of the tube.

Electron Emission

The basis of all vacuum tubes irrespective of their utility, whether of two, three or four elements, is electronic emission from one of the elements within the tube. The vacuum tube as we know it today consists of a number of elements contained within a chamber, from which has been withdrawn, by certain processes, all air and gases. This statement must be qualified somewhat insofar as the gases

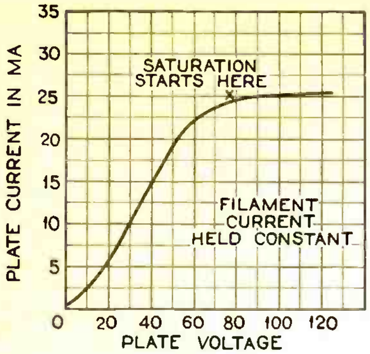


FIG 69

Plate-voltage, plate-current curve of a vacuum tube, indicating saturation point.

are concerned, since under certain conditions certain gases are permitted to remain in certain tubes, particularly rectifier tubes, of which the Tungar tube is an example. However, at this time we are not specifically concerned with the evacuation of a tube but rather with its operation and utility, and consequently will omit lengthy discussions of the effects of residual gases or gases which have been deliberately placed into the tube, other than to mention specific instances where the presence of gases is detrimental to the satisfactory operation of the tube.

Referring again to electrons, we find them present in all metals and our reference to metals is based upon the fact that the electron emitting element in our vacuum tube is a metal. We made mention that the basic principle of operation of a vacuum tube is the electronic emission from a heated element, usually referred to as the cathode. The electronic emission from an element is governed by two factors. The structure or constituency of the element and the degree of incandescence or temperature. The first is a variable very closely allied with the second since a vital item is sufficient electronic emission at minimum temperature. It is for this reason that certain substances are utilized as the source of electrons. Three kinds of filament material are employed in the everyday vacuum tube, namely tungsten, thoriated tungsten and platinum coated with a certain oxide. Undoubtedly the reader at this time is thinking about the cathode type of A.C. tube. Let us forget this for the moment and consider it later in this text. Tungsten possesses certain properties which make it quite popular as a filament in vacuum tubes and as the source of electrons. First, it emits electrons quite freely and second, it can be heated to a high temperature but the one disadvantage of the filament made of tungsten is that it must be heated to a fairly high temperature, when compared with the required temperatures of the other materials.

Thorium and Oxide Filaments

The electronic emission from a tungsten filament at a certain temperature can be increased by the addition of a small amount of thorium to the tungsten before it is drawn, and when the filament is heated to the proper temperature, the thorium rises to the surface and constitutes what is practically a coating on the tungsten filament. It is this phenomenon which permits what is known as the "reactivation" of the thoriated tungsten filament, wherein after the first layer of thorium has been exhausted, the tungsten is heated to an abnormally high temperature to cause the thorium within the filament to rise to the surface, after which the filament is again operated at normal temperature. An idea of the necessity of heating tungsten to a very high temperature in order to obtain satisfactory electronic emission is shown in Fig. 68 depicting emission from a tungsten filament at various temperatures. Another classification of filaments is the oxide coated

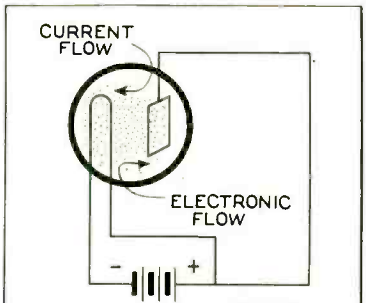


FIG.70

Illustrating the electron flow in a vacuum tube.

filament, previously mentioned, where a platinum wire is coated with certain oxides such as strontium oxide, calcium oxide and barium oxide. The salient property of these chemicals is the free emission of a great number of electrons at low heat or temperature. As a comparison of operating temperature between tungsten and a platinum filament coated with oxides, the former is operated at white heat, at a temperature between 2200 and 2400 degrees Absolute, while the latter is operated at a cherry red heat and much lower temperature.

Another distinct difference between the above two types of filaments is a structural change during operating life. The degree of volatilization of a filament increases with temperature and it is therefore easy to comprehend that a filament operated at white heat will volatilize much faster than a filament operated at low temperature. The action of this volatilization is to decrease the diameter of the filament and this is exactly what takes place with the ordinary tungsten type of filament. The thinner the filament due to evaporation, the greater its resistance and the problem of voltage or current control becomes of importance. If the voltage is maintained constant during life, the current gradually decreases because the resistance of the filament increases. A decrease in current results in a decrease in temperature and electronic emission. On the other hand, if the current is maintained constant, there is danger of "burn-out" since a reduction in diameter of the filament means a reduction in current capacity. On the other hand, the coated filament does not possess these properties. First, the temperature is much lower and the volatilization is less. Second, the operating life is governed by the life of the coating. Third, the heating current is carried by the core while what evaporates is the coating. Once the coating has been exhausted, the tube is useless. Since the resistance of the filament remains constant during the life of the coating, voltage or current regulation is suitable with equal facility.

Voltage Limitations

Now we come to details of greater interest. Since the electronic emission from a filament is governed by the temperature, it is logical that at any one value of temperature or incandescence, the electronic emission is definitely limited, that is, as far as the maximum value is concerned. This statement is undoubtedly confusing to many who recall that an increase in plate voltage results in an increase in plate current, and since plate current is indicative of electronic emission, emissivity is apparently unlimited. This idea is erroneous and the increase in plate current with increased plate potential is a function of the difference in potential between the filament and the plate, resulting in variation in the number of electrons which actually reach the plate. The maximum number of electrons governed by the filament temperature is emitted from the filament when the filament is at the correct temperature but the number of electrons from this total which actually reach the plate is governed by the plate voltage or the potential difference between the fila-

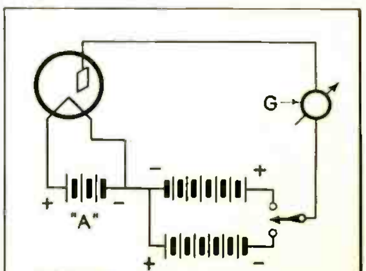


FIG.71

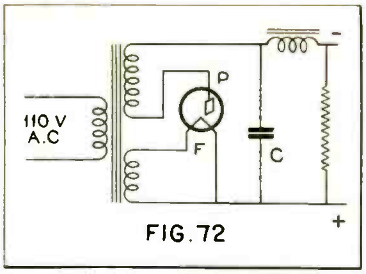
Circuit explaining the rectifying principles of a two-element tube.

ment and the plate. From this we learn two facts directly applicable to everyday radio use. First, electronic emission is definitely limited, since an increase in filament temperature above the manufacturer's rating, which in everyday use is interpreted in the form of filament potential, would result in irreparable damage to the filament. Second, the plate voltage applicable to a certain tube is likewise definitely limited since, when at a certain value of plate voltage all of the electrons emitted by the filament reach the plate, increase in plate voltage will not result in any further increase in plate current. When the maximum amount of plate current is reached, plate current saturation is said to have been obtained. Hence, the usual interpretation of increasing the amplifying power of a vacuum tube by increasing its plate voltage is definitely limited and likewise the power output of a detector tube, amplifying tube or rectifying tube is likewise limited. An idea of such plate current saturation is shown in Fig. 69. This curve shows the relation between plate current and plate voltage and constant filament temperature for a two-electrode vacuum tube. The two-electrode tube is selected as an illustration because this data is general for all types of vacuum tubes.

With respect to electronic flow in a vacuum tube and the resultant current flow, we find that the direction of the current is opposite to the motion of the electron. That is to say, if the electronic flow is from filament to plate, the current flow is from plate to filament, as shown in Fig. 70.

Rectifying Tubes

Prior to the advent of the rectifying tube and its general use, the public interested in radio was generally acquainted with but one type of tube, namely, the regular three element tube consisting of a filament, grid and plate. This includes the A.C. tubes as well as the D.C. tubes. The rectifying tube utilized in many "B" power units is, however, a two element tube consisting of a filament and a plate contained in an evacuated chamber, the filament being the cathode and the plate the anode. The physical structures of these elements are of no real importance to us and we will, therefore, omit details pertaining to such structures. Fig. 71 shows the two element tube arranged in a manner which will permit the application of a positive or negative potential to the plate for the purpose of explaining the rectifying principles of the tube and the general function of the tube. Since the two element tube as shown finds prevalent use as a rectifier of alternating currents into direct currents and not as a detector, we will consider its function as a rectifier and at the same time accept its operating principles as applicable to rectifying tubes in general.



Conventional half-wave rectifier circuit, including resistance representing load.

We find from Fig. 69 that the plate current flow is governed by the positive plate voltage applied; that as the plate voltage is reduced, the plate current flow is reduced since fewer electrons find their way to the plate. It is, therefore, logical that the plate attracts the electrons by virtue of the positive charge, and if the charge were negative of any value, great or small, the number of electrons which reach the plate would be zero and no current would flow. Hence, we see that the tube conducts in but one direction, when the plate is positive. It is this phenomenon which permits rectification of A.C. into D.C. in the conventional "B" power circuit shown in Fig. 72. If we assume a sine wave input into such a rectifier tube we would obtain the current variations shown in Fig. 73-A. We note that the tube passes current during the positive half of the cycle but not during the negative half of the complete cycle. Since it functions on but one-half of the wave the tube is a half-wave rectifier. Just as it appeared logical to assume that an increase in plate voltage with the regular tube will increase output, just so does it appear logical to increase the current output of the rectifier tube by increasing plate voltage, as for example by applying 1000 volts to a 281 tube when the tube is rated at a maximum potential of 750 volts. Again the assumption is incorrect, because of the plate current saturation characteristic, and instead of obtaining greater current output, the current curve is flattened, as shown in Fig. 73-B, the start of the flat portion of the curve being equivalent to the point at which saturation of the plate current is reached. Hence, we find that for a constant value of filament potential, we have an optimum value of plate voltage which can be satisfactorily applied to the rectifying tube.

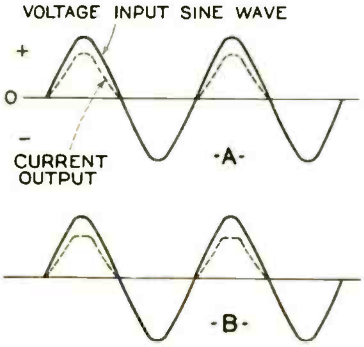


FIG. 73

Current and voltage characteristics at output of half-wave rectifier under representative conditions.

Plate Voltage

The plate current output of such a rectifying tube may be increased by various means. First, by increasing the filament potential or temperature, but this is hazardous when the increase is above the manufacturer's rating, due to danger of filament "burn out." Second, by increasing the length of the filament, but this is impossible in a finished tube. At this stage, readers undoubtedly recall some of their experiments wherein they increased the current output by increasing the plate voltage beyond the rated value. This is possible within certain limits when the tube operating characteristic is similar to that shown in Fig. 74, and when the manufacturer's maximum voltage rating is equivalent to the axis shown, at which point it is not the absolute maximum. Another reason is the load placed upon the tube, which assumes the form of a resistance and alters to a certain extent the current-voltage characteristic of the tube, by straightening out this characteristic and permitting greater current output and voltage in excess of the maximum. This phenomenon, however, is not unlimited in its scope. A limiting factor, insofar as the application of excessive voltage is concerned, is the physical structure of the tube. The spacing between the filament and plate governs the maximum permissible voltage. The design of the plate is also of importance. If the voltage is excessive the plate will heat, and volatilize and cause a metallic deposit upon the mash of the tube, which in turn will cause

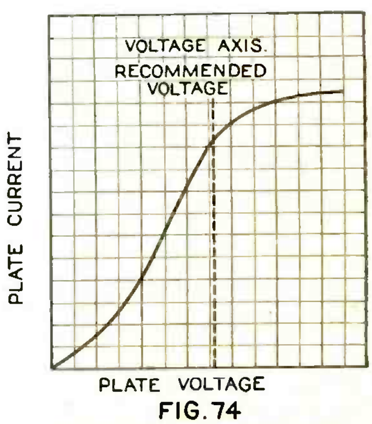


FIG. 74

Plate-voltage, plate-current curve of typical half-wave rectifier tube.

a breakdown in the tube, rendering it unfit for further use.

Assuming such a half-wave rectifier in an average "B" eliminator circuit, we obtain approximately the current and voltage output shown in Fig. 75. The voltage output is the charging voltage across the condenser. The sign wave is the input voltage, and it is obvious that the rate of charge is the same as the frequency of the supply, hence in a half-wave rectifier system, the fundamental frequency present in the output or impressed upon the filter is 60 cycles or the frequency of the supply voltage.

Three-Element Tubes

The two-electrode vacuum tube was the forerunner of the present three-element tube of today. In the three-element vacuum tube, we find but one difference, the addition of another electrode or element, the grid, which is interposed between the plate and the filament. Its name being indicative of its structure, the grid is usually in the form of a network of wires or a fine mesh, the exact structure being dependent upon the type of tube. This third element, the brain child of Dr. Lee deForest, made possible the present

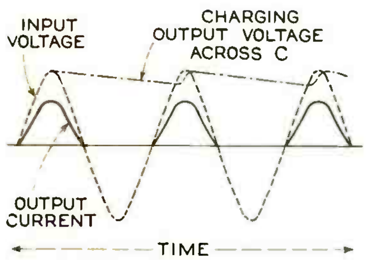


FIG. 75

Current and voltage output of half-wave rectifier in conventional B-eliminator circuit.

status of the radio industry, by giving to the vacuum tube the property of amplifying and oscillating or generating oscillations and energy. The two-electrode tube is essentially a rectifier and does not possess the property of amplification or generating oscillations. The three-electrode tube on the other hand, while generally accepted as rectifying when used as a detector, cannot be classed as a rectifying tube, or rather it should not be classed as a rectifying tube. The action of the grid located between the filament and plate as a control element is well known to the readers of this page and consequently does not justify detailed discussion.

Detector systems as we know them today are of two types, the grid bias type and the grid leak type. We are now concerned with the three element tube as a detector. The grid bias system, when a negative bias is applied to the grid and the tube characteristic is similar to curve B in Fig. 76. Here we find a variation in plate current at a fixed plate potential and a fixed filament potential when the bias applied to the grid is positive or negative. This curve displays the influence of the grid. Note that for zero grid voltage the plate current with constant plate voltage and filament potential is 3 milliamperes and that a bias of 2 volts negative reduces the plate current to 1.5 milliamperes and conversely that a grid bias of 2 volts positive increases the plate current to approximately 4.8 milliamperes. The function of the 3-element vacuum tube is governed by its connection into the circuit and by the operating point of its characteristic curve. By this we mean that a system of wiring does not necessarily influence the operation of the tube. As an example, the conventional detector system utilizing a grid bias is very similar to the wiring diagram of a stage of audio amplification, yet the function of the tube as an amplifier is different from the function of the tube as a detector. The difference lies in the position of the tube and its operating characteristic in that position.

Relation of Grid Voltage to Plate Current

The salient property of the vacuum tube is that an alternating voltage impressed upon the grid-filament circuit of the tube will produce amplified current variation of identical wave form in the plate-filament circuit. Hence, we find the property of amplification within the tube but the faithful reproduction of the input voltage wave form and is obtained only when operating upon a certain portion of the grid-voltage, plate-current curve of the tube. Three such curves are shown in Fig. 76, all of which show the effect of grid voltage upon plate current.

In the process of detection or when the tube is utilized as a detector, we duplicate to a certain extent the phenomenon found with the two-element tube, but we are not dependent upon the positive half of the input cycle of voltage for sound or current in the output circuit of the tube. The operating point on curve B in Fig. 76 governs which half of the cycle will cause current variations in the plate circuit. The selection of the operating point on this curve is governed by the system of detection employed, that is, grid bias system or grid leak and condenser system. If we use the grid bias system, of negatively biasing the grid a predetermined value, we are operating at the lower bend of this curve. It is evident from Fig. 76, curve B, that the negative half of the input cycle of voltage will have very little influence upon the plate current but the positive half will cause a distinct variation, in this case an increase and for a certain number of cycles we will

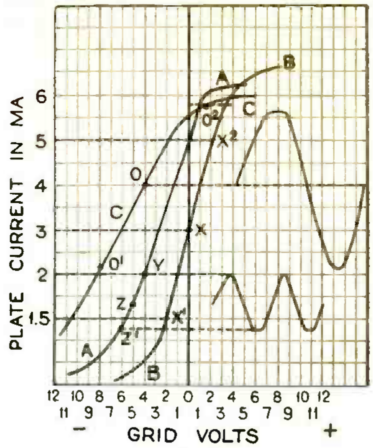


FIG. 76

Three curves indicating the effect of grid voltage on plate current in a three-element tube.

have current variations in the plate circuit of a wave form governed by the envelope of the modulated radio frequency carrier voltage impressed upon the grid. The plate circuit of the tube will therefore contain an amplified reproduction of the positive half of the input modulated carrier wave. The radio frequency carrier is eliminated by means of the by-pass condenser usually employed in the plate circuit and the modulating frequencies are made audible in the headset or passed on to the audio system. It is therefore evident that when the grid bias system of detection is being utilized, the input signal voltage results in an increase in plate current.

The reverse, however, is true when the grid leak and condenser system of detection is employed. Here we are operating on the upper bend of the characteristic and the positive side of the input cycle of voltage has very little influence but the negative half has greater effect and reduces the plate current. The reduction of the plate current is in the form of the wave envelope of the input signal. The statements pertaining to the presence of radio frequency currents in the plate circuit and the amplification present in the tube made in the preceding paragraph, is likewise applicable to the grid leak and condenser system of detection. It is obvious from the upper bend of curve B, Fig. 76 that when the grid leak and condenser system of detection is employed, the effect of the input carrier signal is to reduce the plate current.

Mr. Rider's series on "The Mathematics of Radio" will be concluded in the December issue. He will then put his time to the preparation of material on testing and servicing equipment, special measuring devices, etc. The equipment will be constructed in Mr. Rider's laboratory—Editor.)

The Engineering Rise in Radio

By Donald McNicol

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

PART VI

SEVERAL of the largest of the stations erected in various parts of the world by German engineers were equipped with extensive counterpoise systems. At the station at Sayville, on Long Island, New York, the counterpoise system consisted of a radial screen of wires suspended on poles about twenty feet in height and extending out to some distance from the antenna base.

The English and American engineers were inclined rather to have faith in positive grounding systems f r long distance operation. J. A. Fleming, in England, stated "All practical experience shows that to produce telegraphic effects at a great distance, the lower ends of the radiating and receiving antennas must be conductively connected to the earth, or what is equivalent, must be connected to earth through a condenser of large capacity: currents must flow into and out of the earth in the neighborhood of the antenna." Fleming distinguished between two forms of indirect earthing, one in which is employed a single wire, plate, sphere or other capacity horizontal to the surface of the earth and the other a condenser of large capacity, one side of which is connected to the antenna coupling and the other to the earth by means of a regulation grounding plate or other surface.

Obviously, inasmuch as a condenser passes high-frequency current it is necessary only to have in series with the earth a wire condenser large enough to pass a current volume equal to that passed by a given size of metal conductor, in order to have a condition closely simulating direct grounding.

And so theory proceeded to march along with results observed in actual practice; theory at times in step with practice and again lagging or leading, but ever guiding and aiding to the end that ultimately practice should embody applications and procedure founded on reasoning adjusted from time to time to accord with further discoveries.

CHAPTER 6

Spark Gaps, Oscillators

THE oscillator employed by Hertz in his demonstrations of 1887, 1888, consisted of a pair of metal spheres connected across the terminals of the secondary winding of an induction coil. A variation of the arrangement included an additional, and larger, sphere or plate, directly connected to each of the knobs of the spark-gap.

In 1889, 1890 Lodge experimented with oscillator devices similar to those employed by Hertz. In his 1894 lecture on the work of Hertz, Lodge displayed a form of "radiator" which consisted of a spark-gap arrangement consisting of a comparatively large central sphere situated midway between smaller terminal spheres. Augusto Righi, in Italy, later improved this assembly by mounting the spheres in a container made of insulating material and filled with oil. Thus it may be realized that the Hertz Oscillator and Righi Oscillator, were quite simple contrivances, and it was with these that Marconi experimented and carried out the early trials of wireless signaling.

As previously stated in this work, those who experimented with induction coils and oscillators throughout the years 1888–1895, appear to have had no suspicion that the energy radiated would be effective at distances beyond a few yards. In 1894, Lodge mentioned a possible range of one-half mile, employing as a detector the early form of filings tube, but up to that time his experience had been with distances of forty to sixty yards. Popoff and Marconi had the vision to coax electric waves to disclose their presence at distances from the oscillator far in excess of the ranges previously thought of.

In small radio installations the spark gaps employed usually consisted of but two knobs, generally of zinc, brass or copper. The adjustment of the knobs, as to distance apart while in operation, was somewhat critical. With the knobs far apart the resistance of the gap was too great, causing excessive damping. With the sparking distance too short, arcing took place, which was simply a direct discharge that did not produce effective electric oscillations. And, with the knobs adjusted too closely together there was likelihood of the associated condenser discharging across the gap before the condenser charge had reached maximum, resulting in weak oscillations.

Very early in the work it was learned that the best results were obtained when the spark was of a "bright," "crackling" nature. With such sparks passing across the gap oscillations were produced which set up electric radiation, the oscillations expended their energy in creating a state of alternate electric strain and magnetic flux, constituting an electric wave. In wave-form the energy is conveyed away from the oscillator system into the surrounding medium, progressing outward with the velocity of light.

It may well be realized that with the spark-gap the seat of the oscillations, innumerable investigations were inaugurated with a view to devising a type of gap which would be efficient as a radiator of wave energy, regular in operation and free from mechanical difficulties which frequently caused service interruptions.

A noteworthy step was taken by Fessenden, in 1901,[1] when he proposed a form of gap between sparking terminals occupied by insulating material and under pressure above a certain critical high pressure.

With simple, open gaps, Fessenden believed there was an oscillation energy gain proportional to the length of the spark up to one inch in length, beyond which gap-separation there was no increase in radiation. Fessenden devised a gap one terminal of which was a metal rod of small diameter, the other a metal plate or disk. The terminals were sealed into a chamber in which the air pressure could be raised to, say, eighty pounds per square inch. With this arrangement Fessenden stated that the radiation and spark length were proportional, thus permitting of increased radiation by extending the gap separation considerably beyond one inch. Obviously, as the gap separation was increased it was necessary to enlarge the condenser capacity associated with the gap, and to maintain a correspondingly high secondary potential.

A.C. Generator Used

Lee deForest, in America, in 1902, 1903, employed an alternating current generator, step-up transformer and condenser, used a spark gap with a

[1] U. S. Patent 706,741, filed November 5, 1901.

Detection With A.C. Heater-Type Tube

Everyone is acquainted with the fact that the '27-type A.C. tube functions exceedingly well as a detector and is capable of satisfactorily handling a much greater grid voltage swing than ordinary detector tubes. This property has permitted, in many cases, the elimination of the intermediate audio frequency stage; the output of the detector being ample to "swing" the power tube.

Mr. J. R. Nelson, well known to our readers, has completed a very fine article on grid circuit detection distortion, dealing principally with the '27-type tube. It will clear up many points of question.

Mr. Nelson's article is to appear in the December issue of *Radio Engineering*.—Editor.

third metal element situated between the two terminal knobs, similar to the Lodge oscillator of an early date. DeForest, however, employed disks of metal about one-fourth inch in thickness, the diameter of the disks also being one-fourth inch. The efficacy of a "short, fat spark" for dependable telegraph signaling over the distances at that time attempted, had been noted, especially by experimenters in America. In the deForest gap the separation between the terminal disks and the central disk was in each case one sixty-fourth inch.

Quenched Gaps

In the year 1906, Professor Max Wien, in Germany, brought out a type of discharger subsequently referred to as a "quenched spark gap." Pretty much the same thing was invented by T. B. Kinraide, in America,[2] six years previously, but it did not at the time attract attention or have wide use.

As observed by deForest, and others, it was early apparent that there was a certain length of spark gap which would have the smallest damping and consequently the greatest integral effect. This gap, in air, was found to be quite small; of the order of one millimeter.

Professor Wien discovered that employing a very short gap consisting of two smooth plates of good conducting metal, with their surfaces parallel, the spark is rapidly extinguished (quenched) due to the cooling effect of the metal surfaces, the condenser discharge then consisting of but one or two oscillations. With the primary discharge circuit coupled to a secondary the transfer of energy to the latter results in many oscillations of one period only.

The Wien gap was made up of seven or more copper plates in series, separated by mica rings. Modifications of this type of spark gap were introduced by von Lepel, and Peukert, in Germany, and by Fleming, in England. Lepel employed a paper ring to separate two water-cooled flat or conical surfaces. Peukert arranged a thin film of oil between two rotating metal surfaces.

In the quenched spark arrangement the sparks follow each other so regularly that they give out a clear musical tone. In time the system became known as the "singing spark" system. Singing sparks permitted of from fifty to seventy-five per cent. of the generator output being transferred as antenna energy.

The quenched spark oscillator came into use at a time when something of the kind was greatly needed. Although it had been a comparatively simple matter to calculate inductance and capacity values which, incorporated as elements of transmitting and receiving circuits, should make possible selective operation, in practice it was the general experience that the tuning accomplished was far from being within narrow limits of frequency (wavelength).

With the quenched gap distinctive tones could be given to individual transmitters. At once this was recognized as an advantage in operating several stations in a common territory. If undesired signals could not be kept out of a particular receiving system by electrical tuning, the situation was not quite so bad when the interfering signals were of a different tone from those of the desired signals.

The arrangement was in fact a "shock excitation" system in which the oscillations in the primary were quickly damped out, making it practicable to employ an alternator having a frequency of 1,000 to 2,000 cycles to create a corresponding number of primary discharge sparks per second,

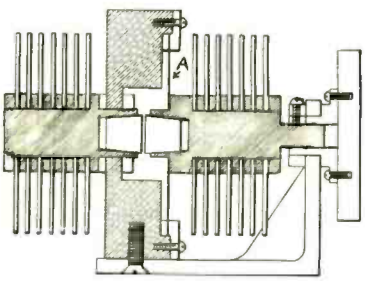


Fig. 8. Cross section of the spark gap invented by Prof. E. L. Chaffee.

without introducing the difficulties of arcing. The rapid succession of highly damped sparks in the primary created an equally rapid succession of very feeble damped trains of oscillations in the secondary, with a large mean-square value; approaching the conditions obtainable with the more complicated arc apparatus which produces continuous or sustained oscillations.

The Fleming-Marconi gap used in English space telegraph installations in 1905, consisted of two balls or disks of iron or steel, mounted on separate shafts driven by motors. The shafts carrying the spheres were revolved at a slow rate by means of gearing. Motors, gears and spheres were mounted in a closed chamber in which air or other gas could be compressed. The discharge thus was practically noiseless, which was a distinct improvement over previously used open gaps.

Marconi Disk-Discharger

In 1907, the Marconi disk-discharger appeared, by means of which the persistency of oscillation was made to approach in regularity that of a generator of continuous waves. The apparatus consisted of a metal disk having copper studs firmly fixed at regular intervals in its periphery and placed transversely to its plane. The disk was caused to rotate very rapidly between two other disks, by means of a motor or turbine. The side disks also were rotated in a plane at right angles to that of the middle disk. The studs were of such length as to just touch the side disks in passing, thereby bridging the gap. For large installations this discharger proved to be quite efficacious. At the Clifden Marconi station, where a frequency of 45,000, with a potential of 15,000 volts across the condenser was used, the spark-gap, of the type here described, was practically closed during the time of one oscillation, when the disk peripheral speed was 600 feet per second.

The result was that the primary circuit continued to oscillate without material loss due to resistance of the gap. The number of oscillations taking place was governed by the thickness of the side disks, the primary being abruptly opened as the studs on the middle disk departed from the side disks. The sudden rupture of the primary circuit served to quench any oscillations which continued in the condenser circuit.

Other Forms of Spark-Gaps

Up to the time of the discovery of the oscillating properties of the audion, in 1912–1913, and later, the subject of spark-gaps continued to be examined in all countries with a view to possible improvements. There seemed no end to the variety of methods which might be employed to energize the transmitting antenna system.

Walter W. Massie, in America, in 1905, developed a form of gap consisting of a hollow wheel slotted on its face and revolved between two terminal electrodes by means of a motor. To control the temperature of the gap elements air was drawn inside the wheel by a fan arrangement connected to the shaft, similar to blower devices; the air being forced out through the slots onto the face of the wheel.

One of the most highly developed forms of gap employed was that due to Prof. E. R. Chaffee, illustrated in Fig. 8. Its use continued up to the day of the tube transmitter.

Balsillie, in England, in 1909, employing an alternator and step-up transformer, had in service a form of rotary spark-gap so constructed that when rotated a considerable air pressure was produced at the opposite electrodes when they were in closest proximity to each other. By regulating the speed of the rotating member the discharge from the condenser could be interrupted from 300 to 1,500 times per second. The gap comprised two outside electrodes, each four and one-half inches wide on the sparking edge, placed in close proximity to a longitudinally toothed wheel. The wheel, five inches long, had truncated teeth cut on its periphery, the design providing for from twenty to thirty sparks in parallel for each condenser discharge. Quite small gaps were used; with a 1 K.W. transmitter, one sixty-fourth inch, and with a 2 K.W. transmitter one thirty-second inch. This

[2] *U. S. Patent* 623,316, 1899.

device provided a fairly definite frequency and a musical tone, the note, of course, being independent of the frequency of the alternating-current used to charge the condenser.

CHAPTER 7

Electric Wave Detectors

IN the annals of science the hunt organized and directed by Mr. Edison with the objective of discovering a suitable bamboo fibre for filaments for incandescent lamps, prosecuted throughout the years 1879–1880, while various expeditions scoured the forests of tropical countries, stands as a record of research, industry and perseverance. But the search instituted a decade later for the *ideal* material or substance to place between the metal electrodes of electric wave detectors may well be set up as a monument to the inquiring pioneers who contributed to the advancement of signaling through space.

In the early "coherers" almost everything was tried, from iron to gold and from gelatine to steel. The search for the ideal coherer material early branched off into a search for the ideal "detector" of the crystal type; search for the best electrode and electrolyte combination for electrolytic detectors; experimental development of "magnetic" detectors, and so on up to the time of the advent of the audion, in 1905. Even after the arrival of the audion, the crystal type of detector was continued in service for a decade as a competitor of the bulb, for as a simple detector the bulb was little more sensitive than the best crystals.

In the search for a perfect detector was engaged the thought of a greater number of scientists, professors, experimenters and boys, in every country of the world, than had ever before centered attention upon a single objective. The extensiveness of the crusades for the recovery of the tomb; the migrations of the oppressed from east to west; even Mr. Edison's expeditions and caravans in search of elusive fibres, were limited concentrations compared with the hosts attacking the coherer problem.

In the laboratory, Hertz detected electric waves in space a short distance away from his induction-coil transmitter, the presence of the received energy being indicated by minute sparks at the slightly separated ends of a split metal ring. Plainly, a detector of this sort required a considerable amount of energy to function. At a distance of a few hundred feet away from a transmitter of the usual size the Hertz resonator (detector) could hardly be expected to give a visual indication of intercepted waves. In the original laboratory apparatus there was little of telegraphic suggestion. As a telegraph possibility distances of a mile or more would have to be bridged.

Coincidentally, and fortunately, a converging line of knowledge was at an opportune time destined to attract the attention of physicists experimenting with Hertz waves. This knowledge concerned devices which had been observed to be sensitive to small currents in conductors, and to space effects produced by electric sparks in their neighborhood.

It is to be remembered that Marconi and Popoff, in 1895, had available the filings tube coherer of Branly, brought out five years previously. But long before Branly's time wave responsive characteristics of imperfect-contact assemblies had been noted by other observers. Munk af Rosenschoeld, as early as the year 1835, described the permanent increase in the electrical conductivity of filings of tin, carbon pieces, and other substances, when situated in the neighborhood of a Leyden jar in operation. This savant reported also that restoration to a state of high resistance was accomplished by shaking or disarranging the loose particles after being subjected to the discharge from a condenser.

In the year 1852, a young telegraph engineer, S. Alfred Varley, in England, observed that metallic powders presented high resistances to potentials as high as one hundred volts. The outcome of Varley's investigations was the invention by him of a form of lightning arrester (1866) consisting of two metal terminals between which was deposited a small portion of metallic filings. The phenomenon involved was that flashes of lightning created electric waves which caused the filings of the arrester to cohere, greatly reducing the electrical resistance of the device. With one terminal of the arrester connected to a telegraph wire while the other terminal was connected to ground, the path to earth presented by the filings served to protect the station instruments employed to operate the line from damage due to lightning. Obviously, the arresters had to be shaken, or tapped, after each lightning storm. Mr. Varley's paper read before the British Association, in 1870, described the experiments which led up to the development of his filings arrester.

In 1885, Professor Calzecchi Onesti, an Italian scientist, observed the variation in electric resistance of metal filings when subjected to electric discharges. Onesti's experiments seem to have been extended toward investigating the action of imperfect contact devices when connected in series with the secondary winding of an induction coil, effects being studied as the primary was opened and closed. But this was three years before Hertz, and although from the records it is clear that Onesti was being flirted with by the unrevealed, ripening truth, later grasped by the German professor, it may be concluded that his observations, Munk's, Varley's and Hughes' (the latter referred to in a previous chapter) should be regarded as fruit plucked too early, so far as the needs of space signaling were concerned.

Lodge, in 1889,[1] observed that two knobs sufficiently close together, cohered when a spark passed between them. Branly, in France,[2] carried out a rather complete investigation into the phenomena of imperfect contact arrangements, in the year 1891. Branly experimented with metallic films on glass, with rods, with pastes and with filings. The metallic filings device proved to be the most regular in action, and as in design it could be made rugged and of simple construction it at once became a laboratory instrument of most interesting behavior.

In his 1894 lecture on Hertz's work, Lodge exhibited coherers of the Branly filings type: in fact it was Lodge who gave the device the name "coherer."

The Branly coherer was a very wonderful device. A small glass tube, fitted at its ends with metal terminals, the space between the metal electrodes being filled or partly filled with particles of metal, responded with regularity to transmitted impulses from a Leyden jar or induction-coil transmitter of electric waves. As a laboratory instrument the coherer was bandied about the laboratories from 1891 until 1895, being used to demonstrate electric wave phenomena over such distances as were possible in college rooms. As previously pointed out it was Marconi, in Italy, who first (1895) undertook to investigate the maximum distance over which a coherer would respond to transmitted electric waves of the Hertz type, notwithstanding that, in February, 1892, Sir William Crookes, in England, in a paper published in the *Fortnightly Review*, in plain words called attention to the immediate possibility of wireless telegraph signaling by means of the radiation from a Hertz oscillator and the detectors then available.

Coherer Theory

Marconi's astonishing demonstrations of 1896, 1897, at once directed attention to the coherer. The phenomena involved in the responsive characteristics of the tube were forthwith made the subject of innumerable inquiries. Out of the great bulk of research which followed, two theories, two schools of thought were evolved.

Lodge had demonstrated an actual welding together of closely adjusted points and of metal filings, after these had been drawn into contact by electrostatic attraction of the opposite charges induced upon the faces of the separate metal particles. Branly ascribed the action to a breaking down or puncturing by minute sparks of the dielectric film (gaseous or metallic oxide) which he believed existed between opposing surfaces of the filings.

In the course of time when every possible theory had been analyzed,

[1] *Journal, Institution of Electrical Engineers*, 1890, *Vol. XIX, pp.* 352–4.
[2] *Comptes Rendus, Vol. CXI, p.* 785; *and Vol. CXII, p.* 90.

the general conclusion was that in a measure both Lodge and Branly were right. It was pointed out that the Branly effect afforded an explanation of the self-decohering phenomenon observed in the operation of the microphone type of detector, particularly the carbon, steel, carbon-mercury and aluminum, variations, in which the formation of a resisting film was easily accomplished.

When the coherer consisted of filings of soft metal, of relatively low fusing point, silver, lead, et cetera, the Lodge cohering effect through actual welding might follow on the Branly action, reducing further the resistance through the particles.

Coherer Operation

If the coherer was to be used as a wave detector which would cause to be operated a telegraph relay it was essential that the filings be immediately restored to the high resistance state at the cessation of each series of oscillations representing the "dot" and "dash" elements of the Morse code. The promptness with which the coherer was made ready for succeeding signals largely determined the speed in letters per minute at which signaling by code could be carried on.

The "tapping back" process, therefore, was made automatic. Reduction of resistance of the coherer as a result of arriving waves, permitted a local e.m.f. to energize the coils of a telegraph relay connected in series with the coherer. The armature of the relay, in turn, through an additional local circuit, was made to actuate a tapper resembling a vibrating electric bell, the hammer of which vibrated against the coherer tube, or its base support, so long as the resistance of the coherer remained at minimum.

A difficulty at once experienced was that the spark continuing at the make-and-break contact points of the tapper (de-coherer) produced electric effects which disturbed the intended operation of the coherer. To remedy this Dr. Lodge, in 1894, devised a clock-mechanism arrangement which, operating mechanically, introduced no sparking.

Many other ingenious arrangements were brought out with a view to making regular and positive the de-cohering operation. The form introduced by H. Shoemaker, in America, in 1901, was typical of the best ideas submitted. Shoemaker mounted the coherer in a vertical position, the filings resting in a V-shaped pocket at the lower end. In the filings mixture were some nickel or iron particles. The coherer tube was surrounded by a soft iron sleeve on which was wound a coil of wire, the winding of this magnet being in series with a local battery and the armature circuit of the relay. With each closure of the armature contact the filings were attracted upward by the electromagnet, and upon cessation of the incoming waves the armature opened, de-energizing the magnet, allowing the filings to drop downward and thus become de-cohered.

It was quite natural that Dr. Branly, the inventor of the coherer employed in the first wireless telegraph demonstrations, should be one of the most interested of investigators seeking improved methods of detecting the presence of electric waves in receiving systems. Out of his study of the subject came a detector used by him in 1902, which was based on the simple contact of a polished and an oxidized metal surface. This is shown in Fig. 9. To obtain the contacts of oxidized and polished metal he arranged the coherer in the form of an upper disk of metal fixed with three rods of tempered steel, tapering and pointed at their ends. The points of the rods were rounded and given a high polish, after which they were given a very thin layer of oxide by heating in air to a suitable temperature. The reason for the three rods was to provide separate contacts, so to insure dependable working. The tripod thus formed was placed on a disk of steel, highly polished.

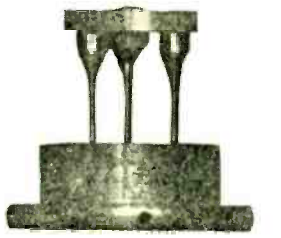


Fig. 9. The Branly Tripod Detector.

The coherer effect, upon the arrival of incoming electric waves, was between the points and the polished surface. When properly designed and assembled this device was as sensitive as the filings type of instrument and it had the merit of being more easily and regularly de-cohered. A single slight tap was effective, which made it practicable to mount the coherer direcently on the telegraph relay—the slight mechanical shocks given by the armature of the relay being sufficient to accomplish the desired purpose.

The Lodge-Muirhead Detector

Dr. Lodge also, in conjunction with Dr. Alexander Muirhead, the London scientific instrument maker, put forth a system of wireless telegraphy, in 1902, 1903, in which the coherer employed consisted of a small steel disk, rotated continuously in contact with a column of mercury. Between the two was interposed a thin film of oil, the disk being revolved by clockwork. The film of insulating oil was the sensitive separating medium, serving the same end as the film of oxide in the Branly device. In the Lodge detector, contact established due to arriving waves was automatically disrupted by virtue of the continuously rotating electrode, the disk. With this detector a potential difference of one volt was sufficient to break down the resistance of the insulating film; thus, in practice a siphon recorder of received signals was operated by a single cell of battery shunted by a potentiometer.

The filings coherer itself was subjected to variations in design which made the instrument more dependable in operation, more sensitive, and less troublesome in decohering. Tissot, in France considerably reduced the element dimensions of the original Branly coherer. In one form widely used by Rochefort in French installations, the Tissot coherer had electrodes from three to five millimeters in diameter with beveled ends to form a V-shaped pocket. While the glass container was being blown a nipple was drawn in the side of the tube, filled with carburet of calcium to take up any moisture remaining in the tube after being sealed.

Slaby and Arco, in Germany, in the years immediately following 1900, employed a coherer of ingenious construction, being so arranged that small, hardened steel balls were placed between aluminum plates. Under a microscope the aluminum surfaces would have shown uneven, minute projections, closely resembling filed particles in contact. This detector was fairly sensitive and was self-decohering. In principle it was pretty much the same as a detector patented in the United States, in 1903, by Popoff, of Russia. As arranged by Popoff, the end electrodes of the coherer each contained a metallic pin, one being placed above and one below the axis of the tube, but slightly separated. There were three insulating partitions, one at each end of each pin, and the third midway between. The chambers thus formed were filled with steel filings, having surfaces of various degrees of oxidation. The detector was self-decohering, and with this device in a receiving system, as well as with the Slaby-Arco detector, a telephone receiver was employed to read the incoming signals.

The "coherer" in any form was destined to give way to other types of detectors better suited to the needs of actual signaling. At its best the coherer was slow in operation; given to producing false signals in translating devices employed in connection with it; was not adaptable to refinements of tuning and, in general, was a rather temperamental contrivance, notwithstanding that it was employed from 1890 until 1900, and later, as the only practicable means of registering the presence of intercepted electric waves. Indeed, as late as 1905, the Slaby-Arco form of coherer described in the foregoing paragraph, was still extensively used in German wireless telegraph installations.

(*To be continued*)

The Neon Stroboscope

The Neon Lamp as a Means of Observing Vibrating Surfaces, Mechanisms and Objects in Motion

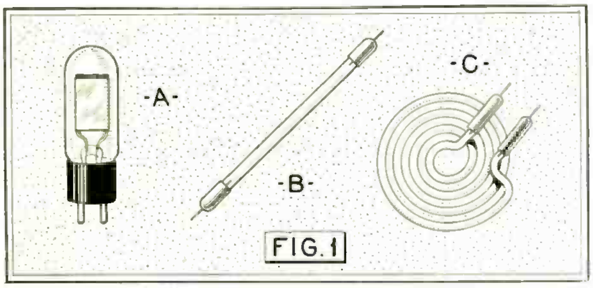
By Edmund Woodard

THE advent of television and the exploitation of the neon lamp offers the solution, or at least the means of arriving at the solution, of many problems associated with vibrating surfaces, mechanisms or objects in motion. As such the neon lamp, a commercial development for radio work finds application in many other industries.

The neon lamp we will consider is suitable for research work, and while we will apply it directly to some radio problems, we will show it applied to other fields as well. Our interest in the neon lamp is based upon two of its properties. First, that the gas within the tube will glow when under the influence of an electric potential of practically any frequency, from a fraction of a cycle to many million cycles. Second, that the above action of the gas within the tube is practically without lag. Possessing these properties, the neon lamp constitutes an excellent source of frequency controlled light. In other words, it is a source of light of known frequency, since the frequency of the potential applied is known and controllable.

Applications of Neon Stroboscope

Our major interest is the application of the neon tube as a stroboscope for the observation of the movements and actions of loud speaker diaphragms and loud speaker "motors." Other applications will be discussed later. A knowledge of exactly what is taking place in a loud speaker "motor" or the exact movements of a loud speaker cone diaphragm, is of vital importance to the engineer, since it governs the operating efficiency of the complete unit, and consequently its salability. Unfortunately, however, the movements of the various elements in a speaker when placed into operation are too rapid for the eye to follow. Consequently, actual visual observations, so necessary for accurate and scientific work are unavailable and the work must progress in a "cut and try" manner unless some form of stroboscope is used.



Three general types of neon tubes. A, is the square-plate type, mainly associated with television work. B and C are the commercial tubular and spiral types.

The neon lamp of the square plate type is satisfactory for the observation of loud speaker operation. When utilized with certain other equipment, available in any laboratory, it constitutes a testing unit unparalleled in its work and utility, since it permits observation with the naked eye of the movements of an armature vibrating at any band of audio frequency utilized in everyday radio work.

The utility of the neon lamp when employed as a stroboscope is not limited to the observation of speakers. It may be used for studying any device in motion, parts of which change their position a number of times per second. The stroboscope to be described for the testing of loud speaker diaphragms and "motors" is adaptable, with very few changes, to all the other work to be mentioned.

Principle of Operation

The operating principle of the stroboscope, or at least of stroboscopic observations, is very similar to the operating principle of the everyday superheterodyne receiver. Whereas in the superheterodyne receiver we "beat" a locally generated signal against the incoming signal to produce a third, in the stroboscope, we "beat" the light beam against the movements of the vibrating element, or the object in motion and we produce a beat which is clearly visible to the eye. This beat is in the form of "slow motion" of the element in action. The acceleration or movement of the "beat" motion is governed by the "beat" or frequency difference between the vibrating light and the object in motion. The result of the combined action of the vibrating light and the vibrating element in motion is an *apparent* reduction of speed of the unit in motion, although it is actually moving at the rate governed by the potential applied to the speaker unit or diaphragm of the speaker. In other words, if any object is moving or changing its position 50 times per second or at the rate of 50 cycles, the effect of the beat is to cause an optical illusion insofar as the human observer is concerned, and the object in motion at the rate of 50 cycles, *appears* to be moving or completing its cycle of vibration once a second, once in two seconds, or at any other desired rate, which is governed by the value of the beat. The deceptive appearance is due to the apparent position of the vibrating element with respect to the cyclic variations of the source of light.

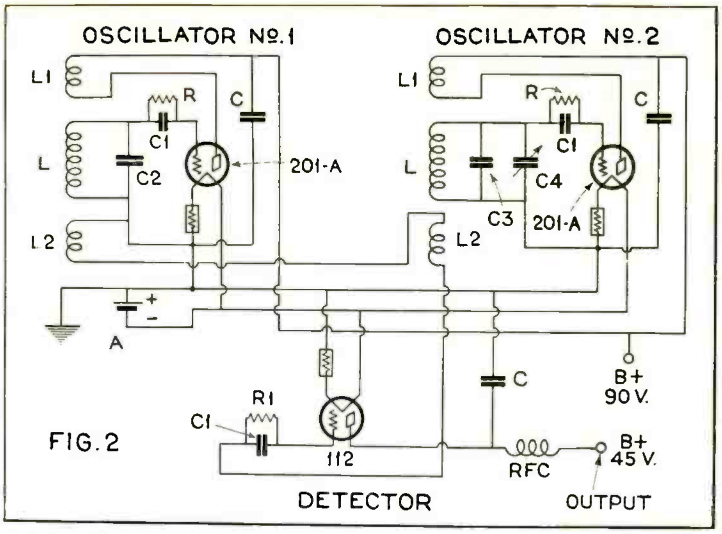
Since the rate at which the vibrating mechanism *appears* to be vibrating, is governed by the beat between the frequency of the source of light or the light beam and the frequency of motion of the mechanism in action, it is easy to comprehend that observation over a large band of frequencies is possible. Whatever the speed of the unit to be observed, it is only necessary to raise the frequency of the light beam until the desired beat is produced. Suppose we have a vibrating element, the contact arm of a battery charger, moving at the rate of 120 per second, or a speaker unit armature moving at the same rate. Visual observation with ordinary methods is impossible, since the eye cannot follow the rapid movements, but if we adjust the frequency of the potential actuating the neon lamp to 119 cycles or 121 cycles, so as to produce a beat of 1 cycle, the unit in motion will appear to pass through a cycle of movement once a second, and observation of many details will be possible.

Physical Requirements

The actual size and power of the complete stroboscope is governed by the requirements. The larger the area to be observed, the greater must be the luminosity in order to permit observation of the moving elements in that area, consequently the greater must be the size of the neon lamp and the output power of the audio oscillator feeding the lamp. The larger the lamp, the greater must be the power applied to cause luminosity or ionization of the gas.

The small square plate neon lamp used in the television receiver is satisfactory for the observation of small units or objects in motion. Neon lamps are available in various shapes, as shown in Fig. 1, A, B and C. A is the regular square plate television lamp. B is a tubular lamp about two feet long; although greater lengths are available, and is suitable wherever the light must be spread over a long area, for the observation of a long rod in motion. C is a neon lamp in the form of a spiral, where the light must be powerful and concentrated into a small area. The potential requirements of such lamps vary from 200 volts for the square plate television neon lamp to perhaps 100,000 volts for lamps utilized to observe the movements of locomotive rods or automobile motor parts. It should be remembered that this voltage is not D.C. It is A.C. and of varying frequency, obtained from a source whose frequency can be varied over the band required for the observations.

The writer's work along this line has been carried out with an improvised stroboscope to be described herein. The source of potential of variable frequency was a beat note audio oscillator consisting of two radio frequency oscillators tuned to 220 KC at zero beat. One of the oscillators remained fixed at this frequency, and the other was variable to produce a beat note from zero to approximately 24,000 cycles. The two radio frequency oscillators are inductively coupled to a detector tube and then passed into a three stage audio amplifier, utilizing impedances for the audio coupling units, 227s as the first and second stage amplifiers and a pair of 250s in parallel as the output tubes. The two radio frequency oscillators and the detector were D.C. operated and the complete audio amplifier was A. C. operated. The output of this system was sufficient to operate the square plate neon tube at frequencies between 15 and approximately 18,000 cycles.



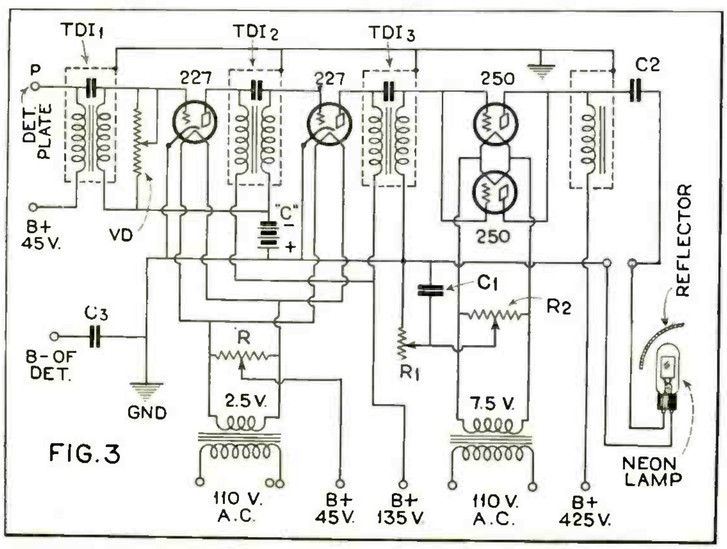
Schematic diagram of the beat note oscillator employed in connection with the neon tube to produce low light frequencies. Oscillator No. 1 is fixed.

A detailed discussion of the oscillator system is unnecessary, since it is of conventional type. The voltage output of the complete unit shows a substantially flat characteristic between 20 and 5000 cycles and a slight falling off characteristic on frequencies above this value.

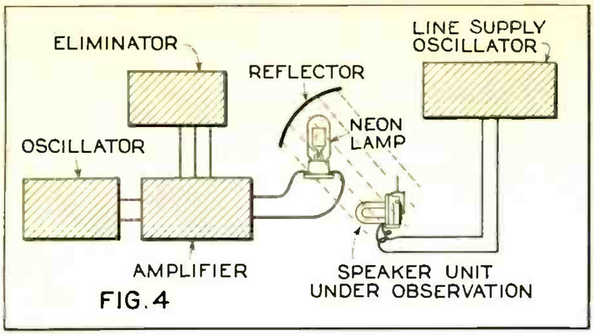
Beat Note Oscillator

The beat note oscillator system is shown in Fig. 2. The inductances L_2 couple the two oscillators to the detector tube. The tuning of oscillator No. 1 is fixed by means of the fixed condenser C2. It is best if this condenser is of known value. This aids in the selection of a capacity for C3 which will be slightly less than that of C2 and affords excellent tuning for C4. The oscillator tubes are 201-As and the detector is a 112. The complete list of parts employed in this oscillator is as follows:

L—60 turns No. 24 DCC wire on 3" form.
L1—48 turns of No. 24 DCC wire on small form with ¼" separation between L and L1.
L2—12 turns of No. 26 DCC wire on same form near filament end with ¼" separation between L1 and L2.
C1—.00025 mfd. grid condenser.
R—2 meg. grid leak.
R1—5 meg. grid leak.
C—.001 mfd. fixed condenser.
C2—.0025 mfd. fixed condenser.
C3—.00225 mfd. fixed condenser.
C4—.0005 mfd. variable condenser.
3—4-prong sockets.



Schematic diagram of the double impedance audio amplifier which amplifies the low frequencies from the beat note oscillator before they are impressed on the neon tube.



General layout of the apparatus constituting the neon stroboscope, and the line supply oscillator connection.

A—.25 ampere automatic filament control.
A1—.5 ampere automatic filament control.
RFC—85 millihenry choke.

The Audio Amplifier

The complete audio amplifier system is shown in Fig. 3, and while it is conventional, a few remarks are necessary about the filament circuit. Separate transformers are employed to feed the filaments of the 227s and the 250s. The reason for this arrangement is that it permits minimization of the "hum" due to the effect of the external field of the transformers upon the amplifier wiring. By correctly placing these transformers with respect to each other and by reversing the connections to one transformer, the fields are neutralized and minimum hum is the result. That this system is successful is proved by the fact that the total hum is less than 150 millivolts, whereas the hum with a single filament transformer is several times that value.

While A.C. operation of the oscillator is possible, it is not recommended due to modulation of the carriers, unless special and tedious precautions are exercised.

The list of parts required for the amplifier unit is as follows:

2—5-prong sockets.
2—4-prong sockets.
3—1st stage double impedances.
C3—1 mfd. by-pass condenser.
C1—4 mfd., 200 volt condenser.
C2—4 mfd., 600 volt condenser.
R—20 ohm potentiometer.
R1—1000 ohm variable resistance, 25 watts.
R2—50 ohm center-tapped resistance.
14—binding posts.
VD—0 to 500,000 ohm potentiometer.

Operation of Stroboscope

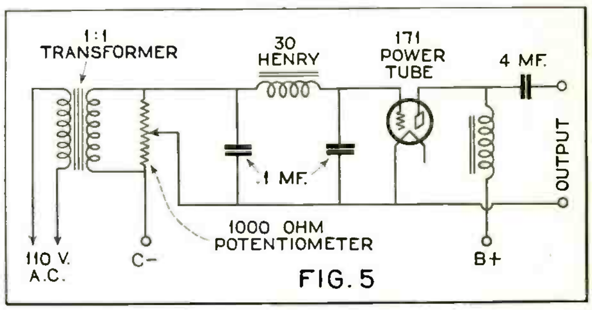
Assuming that all of the equipment necessary for the stroboscope is available, let us proceed to apply the complete unit. Let us consider four fields, although many more will suggest themselves. The stroboscope is of utility wherever vibrating objects in motion are to be observed. The first field is radio, and we wish to observe the movement of the various parts of a cone speaker motor. The complete system is arranged as shown in Fig. 4, the neon lamp being placed within a reflector so that the light is concentrated upon the element to be observed. A unit is actuated from some source at the frequency desired. This source may be another audio oscillator or if a single frequency of 60 cycles is sufficient a unit similar to that shown in Fig. 5 may be used. This is a line supply oscillator, wherein the harmonics of 60 cycles are removed by means of the filter. It should be understood that such measurements cannot be made when the speaker is actuated from the regular broadcast signals, since the operating frequency varies instantaneously. A constant frequency must be applied. The filter in Fig. 5 is arranged to pass all frequencies up to 80 cycles, in order to decrease the attenuation at 60 cycles. The potentiometer across the supply governs the voltage fed into the amplifier tube.

The radio frequency oscillators are started a few minutes before observation in order to permit the attainment of stable temperature.

Examples of Use

We will assume that a discussion has arisen relative to the movement of the speaker unit armature when the unit is under the influence of a low frequency potential. We wish to observe these movements at 60 cycles. The power has been applied to the speaker unit and it is moving with fair intensity. We now tune the beat note oscillator to approximately 60 cycles. The neon lamp reflector is focused upon the object, so that a fair amount of light is impressed upon the speaker unit. The remainder of the room should be dark, the illumination for the test being obtained from the neon lamp. If the frequency of the light differs by two or three cycles from the frequency applied to the unit, observation of the moving mechanism will show slow motion. The neon lamp oscillator is now varied slowly towards resonance with the speaker unit frequency. The closer the resonance, the slower will be the apparent motion of the armature. At exact resonance the unit will appear stationary. When the correct speed of movement has been obtained, the desired details may be observed. The amplitude of motion may now be observed. It is understood, of course, that sufficient power must be applied to the speaker "motor" to cause an appreciable movement of the parts. All parts of the unit may be observed. The movement of the drive pin, the stabilizer bar and other parts are clearly visible. The thrust of the drive pin may be determined by fastening to it, at a 90 degree angle, a light pin or needle which is caused to make an impression upon carbon or smoked paper. The same is true of the armature. As an example, data was required on the movement of a speaker unit armature when a certain amount of power was fed into the unit at 30 cycles. A very light pin was attached to the armature and arranged to rub across a strip of smoked paper. With known input power, permanent record and visual observation of the armature movement with varying power and frequency was thus obtained.

As an example of the utility of the device in another phase of the radio field, we quote the following. Trouble had been encountered with the contact breaker on a full-wave vibrating charger. Data was required on the actual movement of the contact arm and to determine the required rigidity of the arm. The charger was set into operation in the normal manner. The stroboscope was tuned to the frequency of the contact arm when in motion. With a small beat, it was easy to observe that the pull of the magnets was so great as to push back the contact arm whenever contact was made, thus necessitating the placement of the stationary contact on a spring. It also showed the bend in the arm.



Circuit diagram of the line supply oscillator which is used in connection with the speaker unit under observation.

The neon stroboscope with a sufficently powerful oscillator and lamp is ideally suited for the observation of the movements of parts of an automobile motor, such as valves and rocker arms, when the motor is operating "wide open." The same is true of other parts in motion, whose rate of movement is too fast for observation by the naked eye under ordinary conditions.

Lincoln 8-80 One Spot Super

*By W. H. Hollister**

JUST a few words in respect to the original design of the Lincoln 8-80 One Spot receiver.

In the past performance of the super circuit, one outstanding feature has been noticeable, namely: selectivity. This one point has been greatly in favor in the super circuit over the tuned R. F. circuit. To the fan who has, the past few years, industriously tried to build a satisfactory working super receiver, it has been apparent from the start that many detrimental features persisted in making themselves known, and refused to be conquered.

Many methods of controlling oscillation were tried, but oscillation with amplification was always present. Repeat points or harmonics persisted in filling the dials and covering the available spaces between the local stations (especially in congested districts) which halved or quartered the good effects of the sharp tuning ability of the super circuit.

In the laboratory-matched intermediate transformers very fine work was done in peaking the different stages at a uniform frequency. We all recall the great desire to obtain the finest peaked set of transformers, and no doubt many of us just put into operation in a receiver, many sets of accurately peaked intermediates, and we all know the trouble that immediately arose as soon as the receiver was put into operation. We had an unstable circuit producing side-band cutting of musical frequencies which could not be brought up to high amplification without going into oscillation; repeat points two or three places on the dial for each station and many other detrimental features which we strove in vain to eliminate.

Then, the new screen-grid tube came into existence and straightaway we had hopes of an entirely bettered situation due to the high amplification available in this tube. However, we were again destined to disappointment as the advent of the very sensitive screen-grid tube into the super circuit did not seem to eliminate the harmonics. It required very careful shielding and much more care in construction than the old three-element tube super.

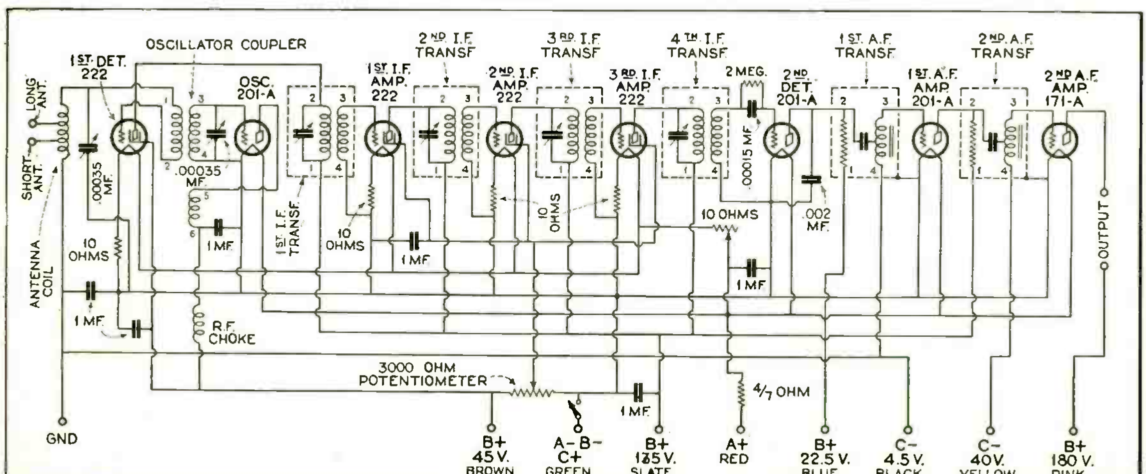
The Lincoln 8-80 Receiver in its Console Cabinet. The Receiver has two tuning controls.

With this situation in view, the primary motive in developing the new Lincoln 8-80 receiver was to try to utilize the high amplification available in the screen-grid tube, and at the same time eliminate as many as possible of the detrimental features, which we, hopelessly, tried to remedy in the past. To do this, the design was started from the ground up and the final development far exceeded the wildest expectations.

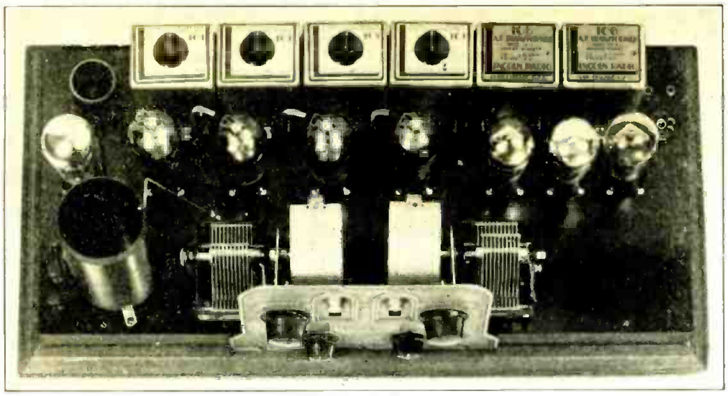
A radically new system of intermediate coupling was developed, using a frequency which can only produce one-spot registration above 220 meters.

Anyone who has ever operated a superheterodyne will appreciate that the primary drawback of the superheterodyne today is that the effectiveness of the oscillator dial is at least halved because each station is heard at two points upon the dial instead of at only one, as in T.R.F. sets. This is due to the fact that with 50 KC intermediate amplifier, for example: the sum and difference settings of the oscillator will bring in a given station. The method of eliminating this is to raise the intermediate frequency until one set (lower) of oscillator dial heterodyne points are thrown so far away from the other set (upper) that the lower repeat points fall beyond the used tuning range. Just how this works out can be illustrated by considering a 400 KC I.F. amplifier, used in a super to cover the 200 to 500 meter band (1,500 to 500 KC. approximately). The oscillator settings for both extremes must be the highest and lowest signal frequency to be received plus and minus the I.F. Thus, for a 200 meter signal (1,500 KC) the oscillator must be tuned to 1,900 or 1,100 KC. For a 545 meter signal (550 KC) obviously only the sum of the oscillator and signal frequencies can be had in a practical set which is 950 KC. Thus the oscillator tuning range must be 1,900 to 950 KC, or 157 to 315 meters, approximately. The 315 meter setting (950 KC) will heterodyne either a 550 meter station, or a 1,350 KC station, which would be at 222 meters. Thus it is seen that a 400 KC intermediate fre-

*President and Chief Engineer, Lincoln Radio Corp.



The schematic diagram of the Lincoln 8-80 One Spot Super. Note that a screen-grid tube is used as the first detector. The same type of tube is used in the I.F. amplifier. The Clough system of audio frequency amplification is employed.



Inside view of the Lincoln 8-80. The I.F. and A.F. transformers are mounted in a straight line along the rear of the sub-base.

quency will provide a superheterodyne that will be one spot for all stations above 222 meters, and that the oscillator settings for stations below 222 meters will be so far away that the input tuning circuit is only called upon to discriminate between signals at the extreme opposite ends of the broadcast wave-length band, which is not difficult with a good input circuit.

High impedance was incorporated into the plate circuit of the screen-grid tube in transformer coupling design, producing a sharp frequency filter to counteract for the different tube charateristics and capacities incorporated in wiring, which in the past have unbalanced a multi-stage intermediate amplifier. A small manually operated variable capacity was incorporated in the top of the copper shielding and across the plate wiring of the transformer, whereby the frequency of each individual stage could be tuned to any frequency between 350 and 600 KC, at the same time correcting for all tube reactions and capacities, and producing a perfect filter systerm. Each intermediate transformer was housed in heavy copper and the system worked out so exceedingly well that shielding of the screen-grid tubes was found to be absolutely unnecessary.

The oscillator coupler is of the tuned grid type with compact field in the plate wiring, which is immediately below the grid wiring. Above the grid wiring is the pick-up in series with the grid lead to the first detector.

The screen-grid tube was used in the first detector circuit with suitable bias for perfect rectification. Three screen-grid tubes were used in the I.F. amplifiers.

The antenna coupler is a highly designed coil of No. 16 enameled copper, wound on a threaded bakelite shell. The low high-frequency resistance of this coil augments to a great extent the sharp tuning of the Lincoln 8-80. One 201-A type tube is used in the second detector.

Two audio stages are of the well-known Clough system of audio amplification and each is designed for high efficiency in its respective stage. Registration from 30 cycles up, with a decided rise in amplification from 30 to 125 cycles is characterlstic in these transformers; the curve dropping decidedly above the musical frequency rance helps to a great extent to eliminate any high frequencies and atmospheric noises, which in the past has taken the pleasure out of reception.

The lay-out as noted from the accompanying photograph is straight line, which enables a great percentage of the wiring to be done in straight busbar and simplifies construction to a great extent.

The net result of the development of this receiver has eliminated oscillation; regeneration is not used in any degree; registration is one-spot; separation is well under 10 KC; and complete musical frequencies are brought through without sideband cutting, augmented by the Clough system of amplification, produces tonal quality beyond comparison.

In actual performance in the hands of the set-builders who have built the Lincoln 8-80 for the first time, each receiver built works exactly alike, due to the balancing of the intermediate explained in the forepart of this article.

In highly congested broadcasting districts, of which Chicago is possibly the worst in this country, having 19 separate frequencies, long lists of DX stations are brought in nightly, through the summer months, with heavy volume. This is made possible by the one-spot registration, utilizing every available 10 KC interval between the many powerful local stations.

LIST OF PARTS REQUIRED

1—Lincoln No. 102 Oscillator Coupler.
1—Lincoln No. 103 Antenna Coupler.
4—Lincoln No. 101 Tuned I.F. Transformers.
1—Lincoln No. 105 First A.F. Transformer.
1—Lincoln No. 106 Second A.F. Transformer.
2—Lincoln No. 104L and 104R .00035 Mfd. Condensers.
1—Lincoln Escutcheon Control Panel.
1—Bakelite Sub-Base 21¾" x 9⅞" x ⅛", complete with 8 tube socket assemblies, drilled.
2—Wood Sub-Base Supports.
1—Jones 8-Lead Battery Plug and Cable (special).
2—S-M 806L and 806R Drum Dials.
6—Potter No. 4, 1 Mfd. Condensers.
1—Aerovox .002 Mfd. Condensers.
1—Aerovox .00015 Mfd. Condenser with Clips.
1—Aerovox 2 Megohm Grid Leak.
1—Yaxley 53000, 3000 Ohm Potentiometer.
1—Yaxley 10 Ohm Midget Rheostat.
2—Yaxley 420 Tip Jacks.
3—Binding Posts.
1—Carter H-4/7 .57 Ohm Resistor.
4—Carter RU-10, 10 Ohm Resistors.
1—S-M 275 R. F. Choke.
1—Yaxley 500 Switch Attachment.
Small parts assortment consisting of screws, nuts, lugs, bus-bar, flexible wire, shielding braid and screen grid clips.

The Scott Power Pack and Amplifier

By Harold Newmann

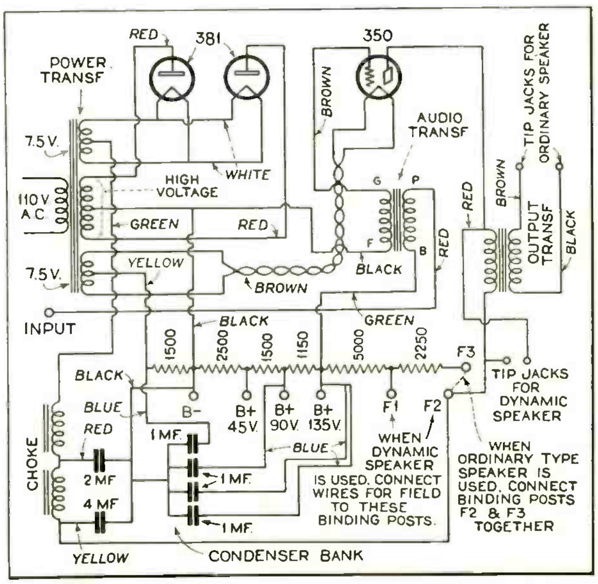
THE Scott Power Pack and Amplifier was especially designed for the "Scott World's Record Shield Grid Nine," described in the October issue of RADIO ENGINEERING. It supplies all the necessary "B" and "C" voltages for the receiver tubes as well as the "A," "B" and "C" voltages for the power amplifier tube, an integral part of the unit.

The accompanying photograph of the Power Pack and Amplifier reveals the simplicity of the mechanical design and suggests consequent simplicity of electrical design. The two tubes to the left are the 281, high-voltage, half-wave rectlfiers, which supply all the necessary "B" and "C" power for the receiver and for the 250 power tube seen to the right.

The metal cases at the rear of the unit contain the power transformer, the filter chokes and the filter condenser block. The smaller metal cases, to either side of the tubes, contain the input and output transformers. The resistors and smaller condensers are mounted underneath the metal base.

The unit is so arranged that it may be used with either an electro-magnetic or electro-dynamic speaker. Four tip jacks are provided, two for connection of a magnetic speaker and two for a dynamic speaker. Two extra binding posts are provided for the field of the dynamic speaker which obtains its energizing voltage direct from the power unit; no separate rectifier or other equipment is required. Of course the dynamic speaker must be of the type having a high voltage field winding. If the dynamic speaker has a low voltage field, in which case it has its individual rectifier, it may be used with this amplifier by con-

Schematic diagram of the Scott Power Pack and Amplifier; a unit designed for the "Scott World's Record Shield Grid Nine," described in the October issue of Radio Engineering. Note that a 350 power tube is used.



necting it to the two tip jacks provided for the magnetic speaker. However, such an arrangement is not advised.

Circuit Details

Referring to the schematic diagram, it will be seen that the power transformer has three secondary windings. The center winding supplies the high voltage to the two 281 half-wave rectifiers. The lower winding supplies the 7½ volts A. C. for the filament of the 250 tube. The upper winding supplies the 7½ volts A. C. for the filaments of the 281 tubes.

Two filter chokes are employed in connection with a high capacity condenser bank, for smoothing out the ripple in the rectified current.

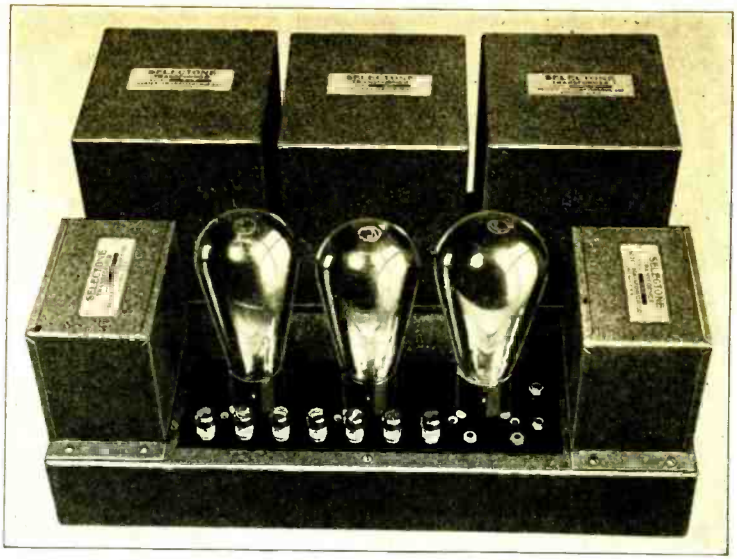
A resistor bank is included for providing the correct "B" and "C" voltages for all tubes, including the 250 power tube. The external voltages, for the receiver, are picked up from the binding posts mounted on the base of the unit.

The input transformer is designed to match the plate impedance of a 112 A tube, this type of tube being used in the first audio stage in the receiver.

The output transformer is designed to match the plate impedance of a single 250 tube and has a secondary winding with a value of impedance best suited to the impedance of a magnetic type speaker.

This amplifier is capable of producing very high outputs and due to the comparatively low impedance of the 250 tube the low frequencies are particularly favored.

It is an excellent amplifier for all purposes and though it can be employed effectively in connection with other receivers, it is working at its best with the "Scott World's Record Shield Grid Nine."



General view of the Scott Power Pack and Amplifier. The rear cases contain the power transformer, filter chokes and filter condenser block.

The Karas 'Round the World' Short-Wave Receiver

THE radio amateurs, who are chiefly responsible for most of radio's progress, and who have been confined to short waves for years, have found that the regenerative circuit devised by Roy Weagant best fitted their needs.

The Karas short-wave receiver uses this circuit. There is an interchangeable coil system which, with a seven plate variable condenser of .00014 mfd. capacity, will cover the range between 15 and 130 meters. A small base is provided, on one end of which there is an adjustable primary. Into this base by means of a plug-in arrangement, three different sets of secondaries and feedback coils are plugged.

It would be possible to design and construct a simple coil that could be used with a variable condenser of correct size, which would operate over the range mentioned above. The tuning, however, would be so critical, and the three most popular channels would be so bunched, that the result would be very disappointing. Better results follow the use of plug-in coils so designed that there would be slight overlap in the ranges each would cover.

As the set of coils is now made, there are 19 turns on the largest grid coil and, with the .00014 mfd. variable condenser, it covers 57 to 133 meters. On the intermediate coil there are 8 turns to cover 31.5 to 68 meters and, on the smallest coil, there are three turns covering 15 to 33.5 meters. The plate coils have 6, 4 and 2 turns, respectively.

In order that the tuning sensitivity would be equal from end to end of the dial, no matter which coil is used, a straight line frequency condenser must be used with the system and, naturally, it must have rugged mechanical strength, with electrical losses as low as possible.

Dead Areas

While the following point will not present any problem, we are quite sure that most experimenters will be interested in some of the factors that led to the placing of the parts as they have been finally arranged. When the set designer goes below the 200 meter point on the wave length range he runs into what might be called absorption. Parts must be so placed that there is the minimum possible metal of any nature in the fields of the coils and near the variable condensers. This practice is also true in designing broadcast receivers, but in this latter work it is to prevent broadening of the tuning while in short wave sets it is to avoid dead spots. If an error is made it will be noticed in tuning and there will be several places in the possible range where regeneration and oscillation cannot be secured.

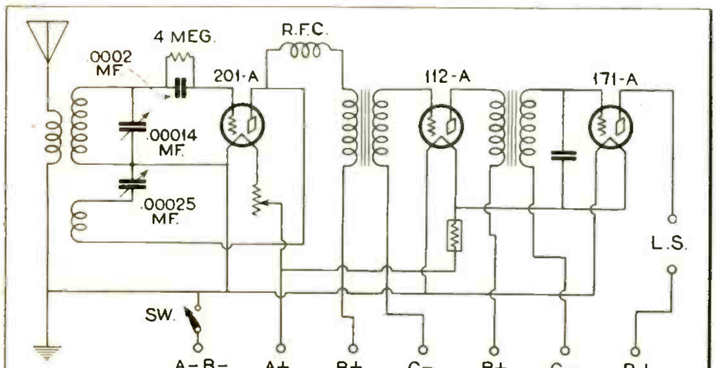
For example, you might be using the intermediate coil, and the tuning condenser approaches 40 on the dial. The plate variable condenser is being kept in synchronism for maximum regeneration. Suddenly you find that no amount of adjusting will give sensitivity. As you continue up the scale, you find that at 55 and on up to 100, perfect control is possible. Those wave-lengths falling between 40 and 55 could not be received over any great distance. There may be as many as three or four such dead bands if care is not used.

Placement of Parts

You will note that care has been taken to keep the inductances well back from the variable condenser, and the audio transformers with their large masses of iron, well to the left. They might possibly be another inch back from the left variable condenser, but as this is the feed-back condenser and not the grid circuit capacity, no difficulty has been noticed.

No metal other than that in the unit itself is near the right hand condenser (.00014 mfd.), and none is near the coils. The primary has all the needed room to permit swinging to clear out at right angles. Such loosening of the coupling is necessary in many cases to clear up dead spots due to peculiarities of the antenna installation.

The parts used in this circuit and the location of these parts in the layout are the result of a great deal of experimentation and should not be deviated from for best results.



Schematic diagram of the Karas Short-Wave Receiver, employing the Weagant circuit. With plug-in coils the set covers the wavelength range from 15 to 133 meters.

Tuning the Receiver

The two dials do not necessarily coincide in their readings; the left dial tunes the stations within the range of whichever plug-in coil you happen to use, and the right hand dial controls the amount of regeneration needed for the particular station. Turning up the rheostat also adds regeneration, as also does loosening the coupling of the hinged primary.

When receiving continuous wave (C. W.) code signals, you, of course, must use enough regeneration to bring about the whistle of the station. You will find the loudest signal occurs at the point just above oscillation for C. W. and at the point just below oscillation for phone reception.

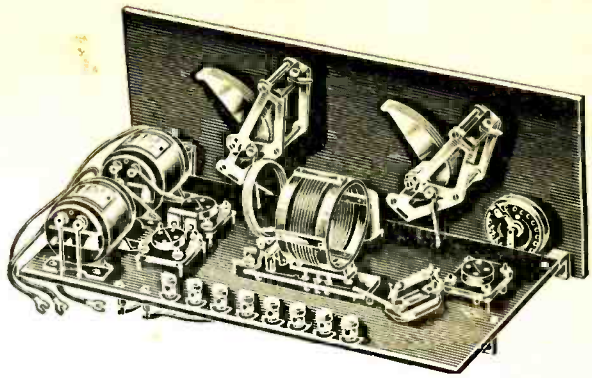
This point of oscillation is recognized as the point where you hear a soft click or "plump" as you rotate the right hand dial counter-clockwise. Always hover around the click for maximum sensitivity. Now you will also hear another click as the dial is rotated still farther. At this point you are working far beyond the point of oscillation and the circuit is thrown into an uncontrollable howl. Keep down away from this second click. Flip the left hand dial back and forth over the station and follow up with the other dial to the point of great sensitivity.

If you use these hints you will soon grasp the knack of tuning the stations in quickly and smoothly.

Harmonics of Antenna Circuit

Now, due to characteristics of your individual antenna installation, it is possible that a dead spot or two will be found due to the harmonics of the antenna circuit itself. At these harmonics it will absorb energy from the grid circuit surprisingly fast. Most of these spots can be eliminated by loosening the coupling of the primary to the secondary, but it may prove necessary to shift the natural period of the antenna circuit by inserting either a loading coil to raise it or a series condenser to lower it.

Rear view of the Karas Short-Wave Receiver. Note the plug-in coil arrangement. The receiver has two stages of A.F. amplification.



LIST OF PARTS REQUIRED

2—Karas Micrometric Dials 0–100.
1—Karas .00025 mfd. Var. Condenser.
1—Karas .00014 mfd. Var. Condenser.
1—Set Karas Sub-panel Brackets.
2—Karas Harmonik Transformers.
1—Short Wave Coil System.
1—60 Millihenry R. F. Choke.
1—20 Ohm Rheostat.
1—No. 10 Filament Switch.
2—Phone Tip Jacks.
3—Sockets.
1—No. 112 Amperite Unit.
1—4 Megohm Grid Leak.
8—X-L Binding Posts (6/32).
1—Bakelite Panel 7x18x3/16 inches.
1—Bakelite Subpanel 8x17x3/16 inches.
1—.0002 Fixed Condenser with Clip.
1—.001 Fixed Condenser.
1—Lot miscellaneous soldering lugs, screws, spade terminals, wire and sleeving.

Notes on the Design of the Sargent-Rayment Receiver

By Kendall Clough

PRIOR to the appearance of the Sargent-Rayment it was a generally accepted axiom that nothing but a receiver of the double detection type would produce enough sensitivity to go down to the noise level in a good location and still possess enough selectivity to make this great amplification useful centers in the congested broadcast for the reception of out-of-town signals. When this design was contemplated it was hoped to produce such a receiver, but by use of the tuned radio frequency circuit. In this way it was felt that, granting that the necessary sensitivity and selectivity could be attained, a further advantage would accrue—the elimination of the troublesome "repeat points" exhibited in the operation of most superheterodynes. That these standards have been realized has been repeatedly proven in many locations. In the congested Chicago area the receiver has brought in a station for each transmission channel over its range—a total of 100 stations in an evening. This represents true 10 kilocycle selectivity, on either side of every local station in the city. In addition the noise level has been reached in many locations where it had been impossible with other receivers. In Los Angeles City, Japanese and one Australian station have been tuned in. We will turn here to some of the points of technical interest in the design of the receiver.

The physical appearance of the receiver is conveyed by the photographs of Figs. 1 and 2. It will be noted that the aluminum pans which form the shielding also form the cabinet for the finished receiver. Previous experience indicated that within compartments measuring 12" deep x 6¾" high x 4⅛" wide, sufficiently good circuits could be constructed to produce a high order of gain per stage with the 222-type tube. A sample compartment of this size was built up for measurement of the gain in the single stage.

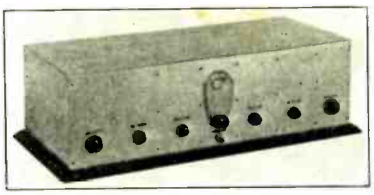


Fig. 1. Front view of the Sargent-Rayment Receiver.

The first measurements were made on a coil at hand that had proven to have a very high "factor of merit" when operated without shielding. This coil was 80 turns of No. 20 wire wound on a bakelite tube threaded 20 turns per inch. The whole stage was assembled just as shown in the left hand compartment in Fig. 2. The gain per stage, with various voltages on the screen of the tube, is shown for the broadcast band in the curve of Fig. 3. It will be noted that with 45 volts on the screen the amplification varies from 17 to 26 over the broadcast band, and the selectivity is 3.9 at 550 KC and 1.59 at 1100 KC. The selectivity figures represent the ratio of the amplification of the desired signal to the amplification of a signal 10 kilocycles off resonance. The above curves were made with a primary consisting of 35 turns of No. 34 D.C.C. wire, wound on a tube, 2½" in diameter slipped into the secondary tube at the filament end of the latter winding. The figures for the amplification may seem rather low for a screen-grid tube stage, but it must be noted that the primary is very small for use with a tube of such high impedance. By operating with such small coupling the amplification is very promising (particularly considering that several stages are to be used) while the selectivity is practically that of the secondary itself in the absence of the primary—an almost ideal condition.

A cursory design was worked out with the above stage as a basis to determine the general operating characteristics and the number of stages that would be necessary in order to meet conditions prescribed. This early model was constructed along the lines shown in the photograph, Fig. 2, and the circuit diagram, Fig. 4, omitting the stage on the left in either case. Isolation of the circuits was carried out just as shown in the diagram, each plate and screen circuit having a 2.5 mh. choke in series and a .25 mfd. by-pass condenser. The filament circuits of the screen-grid tubes are all in parallel from the battery and a common resistor and are by-passed at each end with 1.0 mfd. capacity. Previous experience of the designers indicated the importance of carry-

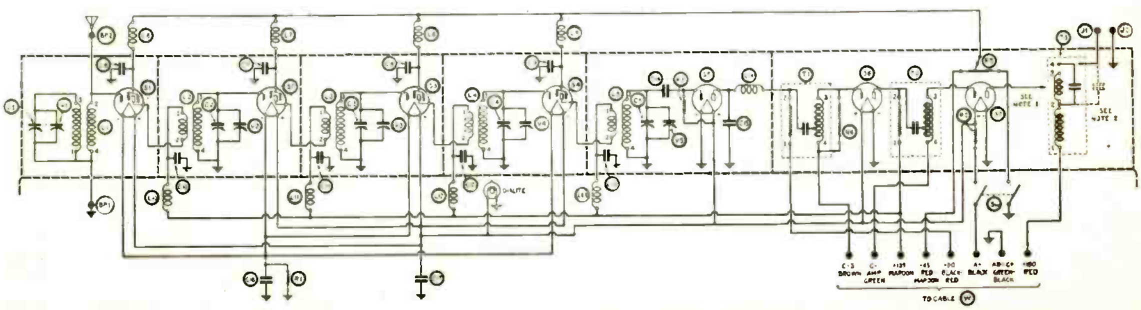


Fig. 4. Schematic diagram of the Sargent-Rayment Receiver. Screen-grid tubes are used in the R.F. stages.

ing each filament lead down to the condensers separately before allowing any of them to be common to two or more tubes, if freedom from coupling through the "A" battery was to be avoided. The compartment shields in this assembly were not as complete as shown in the photograph, lips being provided only at the front and back and not on the top and bottom, although they were arranged so that contact of these edges with the top and base resulted. With these arrangements the receiver was quite stable with voltages up to 30 on the screens.

The first evenings test was very gratifying, fifty out-of-town stations being logged, a performance which was not duplicated with this particular model again. On attempting to measure the overall gain of the radio amplifier it was found that the characteristics of the receiver changed widely with each slight jar to which it was subjected, though at no time could the performance of the receiver be brought up to the standard that it had previously enjoyed. It was subsequently found that sufficient oxidation had occurred to the shielding to prevent a perfect contact between the edges of the shields and the base and top. This allowed eddy currents to circulate in the base of the receiver, with a resulting interstage coupling that prevented the stages from cascading and prevented the large amplification that had been experienced on the first trial of the receiver.

The manner in which this defect was corrected is clearly shown in Fig. 2. The compartment dividers are formed up in the shape of a pan, so that they can be securely bolted to the base as well as to the front and back of the cabinet. After making this change no trouble was experienced from the variability of results although the characteristics of the receiver were permanently altered. The stability had become such that the full 45 volts could be used on the screens without oscillation, with the result that the selectivity was reduced and the amplification increased. The reduction in selectivity is shown in Fig. 3, where it can be seen that the selectivity changes from 4.5 to 3.9 per stage at 550 KC. as the screen potential changes from 30 to 45 volts. This effect was aggravated by the presence of regeneration in the one case and its absence in the other.

Complete stability of the amplifier seemed very desirable so that it was decided to add another stage of amplification rather than to resort to regeneration for the necessary selectivity. At the same time, while another model was being constructed, it seemed likely that the individual stages could be improved by a more careful study of the coil in relationship to its shielding. A small family of coils, each of approximately the same inductance as the original, was constructed and placed in the single stage unit for measurement. From this family it was found that with each decrease in physical size the amplification was increased. Constant coupling between the coil and the tube was maintained throughout these tests. The optimum coil of the family consisted of 72 turns of No. 25 enamel wire wound on a bakelite tube threaded 32 turns to the inch. When measured without a shield this coil was actually inferior to the original coil, but the measurements indicated that the original coil was affected to a much more marked degree by the presence of the shielding. This could be predicted by the fact that the original coil approached the size of the shielding. The new coil was found to be so far superior to the old from an amplification standpoint that the coupling could be decreased, with an increase in selectivity. A primary of 25 turns for the new coil was finally arrived at, and the measured results with this coupling are shown in the curve of Fig. 5. It will be noted that there is a considerable improvement in the amplification, while the selectivity figures have been greatly improved. Had a value of primary coupling been chosen that resulted in the same selectivity as the old coil, the amplification would have been correspondingly greater and would have attained such a high value with four stages as to be unusable except in the quietest of locations. In addition, troubles due to stray couplings from input to output of a radio frequency amplifier are aggravated as the amplification increases and it is unlikely that the oscillation could have been controlled with the larger value of coupling. All these considerations made it advisable to limit the amplification and to realize the figure of merit of the coil in terms of selectivity. The performance of the stage (Fig. 5) indicated that with four stages a selectivity of $(5.3)^4 = 790$ and an amplification of the order of 90,000 should be attained at 550 kilocycles, with the amplification increasing and the selectivity decreasing with the higher frequencies.

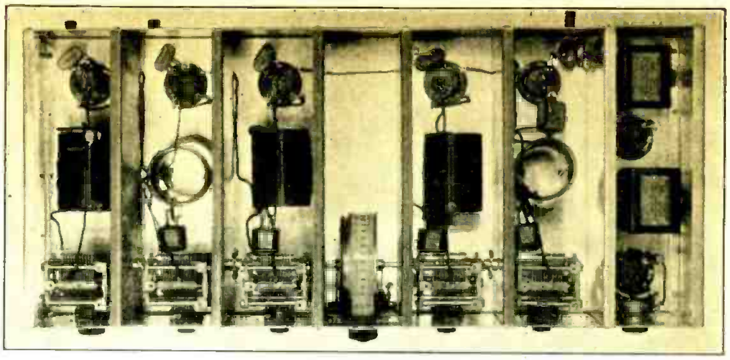


Fig. 2. Interior view of the Sargent-Rayment Receiver. Note position of R.F. coils and the elaborate shielding.

The new model with four stages of the new coils and the new shielding was built. In this, each of the coils was mounted in the horizontal position like the left hand coil in Figure 2. This receiver was found to be very sensitive and selective, but so unstable that it was impossible to operate the screens higher than 20 volts without the whole system bursting into oscillation. Additional isolation of the filament and plate and screen circuits was attempted, without any apparent increase in the stability of the system. In addition all the joints of the shields were carefully gone over with no greater effect. After these tests it became apparent that there were yet being created eddy currents in the shielding by the coils which caused interlinkages of flux between stages and attendant oscillation. The simplest manner of eliminating this was to turn the second and fifth coils to the vertical positions as shown in Fig. 2. This resulted in complete stability of the amplifier with 45 volts on the screen grids and 135 volts on the plates. The potentiometer shown in R5 in the circuit diagram was thereby rendered unnecessary as a stabilization device, but was still retained as an effective means of controlling the radio amplification.

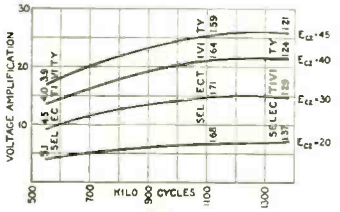


Fig 3

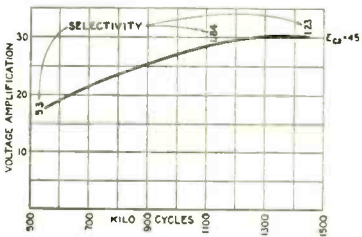


Fig. 5

Voltage amplification curves of the R.F. stages.

It will be seen in the photograph of Fig. 2 that although the condensers are all linked by means of a common shaft onto one drum dial control that there is an additional control on each tuning circuit. These are verniers to the main tuning condensers. Their inclusion was deemed advisable for this reason: The 112-A type detector tube has a higher input capacity than the 222-type tubes. Because of this, even though all of the condensers and coils were perfectly matched, it would be necessary to include some sort of a small capacity across the input circuits, of each of the screen-grid tubes in order to bring them up to capacity with the detector tube.

The performance of the completed receiver in this form were reported in the first paragraph and will not be dwelled on at greater length. It was felt that in a receiver of this class, the audio quality should be in keeping with the excellent performance of the radio end. With this in view the capacity of the grid condenser has been limited to .00015 mfd. rather than the conventional value of .00025 mfd., in order to conserve the high tones during the process of detection. The detector is followed by two stages of the well-known Clough tuned audio transformers. The power tube circuit is provided with a tapped output transformer, which adapts it for use with any of the standard output tubes. A special power pack is available for operation of the high voltage power output tube when desired.

LIST OF PARTS REQUIRED

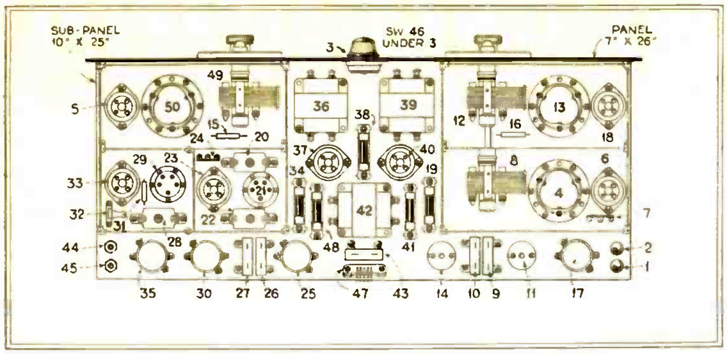
- C_1 to C_5—5 S-M variable condensers, 0.000035 mfd., type 320-R.
- C_6 to C_{13}—8 Polymet by-pass condensers, 0.25 mfd.
- C_{14}—1 Polymet by-pass condenser, 0.002 mfd.
- C_{16}, C_{17}—2 Potter by-pass condensers, 1.0 mfd.
- D—1 National Velvet Vernier Dial, type F, with illuminator.
- L_1—1 S-M antenna coil, type 141.
- L_2, L_3, L_4, L_5—S-M R. F. transformers, type 142.
- L_6 to L_{14}—9 S-M R. F. chokes, type 275.
- R_1—1 Carter resistor, 3 ohms, type H-3.
- R_2—1 Carter resistor, 1.0 ohm, type H-1.
- R_3—1 Grid leak, 2 megohms.
- R_4—1 Durham resistor, 150,000 ohms, with leads.
- R_5—1 Yaxley Junior potentiometer, 3000 ohms, type 53000-P.
- S_1—1 Yaxley Junior switch, double circuit (d. p. s. t.) type 740.
- SH—1 S-M aluminum shielding cabinet with control legends, type 705.
- T_1—1 S-M first-stage audio transformer, type 255.
- T_2—1 S-M second-stage audio transformer, type 256.
- T_3—1 S-M output transformer, type 251.
- V_1 to V_5—5 S-M midget condensers 0.000025 mfd. type 340.
- 1 S-M walnut finish base moulding, type 706.
- 1 S-M 10-lead battery cable type 708.
- 2 Cartons S-M hook-up wire, type 818.
- 7 S-M tube sockets, type 511.
- 2 Yaxley insulated tip jacks, type 420.
- 1 Set hardware (obtainable from manufacturer).

The accessories necessary to make the set operative are as follows:

- 4 CX-322 R. F. tubes.
- 1 CX-301A or preferably, CX-112A detector tube.
- 1 CX-112A first A. F. tube.
- 1 CX-371A power tube.
- 1 6-volt "A" battery or "A" power unit.
- 4 45-volt heavy-duty B batteries or a B-power unit (180 volts), such as the S-M 670-B Reservoir Power Unit.
- 1 40 ½-volt "C" battery.
- 1 4 ½-volt "C" battery.

The "Ultra Shield Grid Seven" Super-Heterodyne

By H. G. Cisin, M.E.



Constructional layout of "Ultra Shield Grid Seven."

THE "Ultra Shield Grid Seven" is a remarkably fine super-heterodyne. Due to careful design and especially to the correct use of the 222-type screen-grid tubes, this circuit is equivalent to a ten-tube super of the older types.

The various stations tune in quietly and the value of the intermediate frequency has been selected so as to do away with bothersome harmonics.

By referring to the schematic wiring diagram the technical features of the Ultra Seven can be readily observed. An R.F. transformer serves as the antenna coupler. Volume is controlled by means of a 75-ohm rheostat (3) shunted across the primary of the antenna coupler. Coupling between the R.F. stage and the modulator is accomplished by means of a screen-grid impedance coil (13). The oscillator coupler (50) is a 3-circuit tuner. The secondary of this tuner is used as the grid coil, while the fixed tickler is used as the plate coil. The rotable primary is not used and may be removed. The tuning condensers, shown at (8) and (12) are controlled by a single dial, while a second dial controls the oscillator tuning condenser (49).

The intermediate coils shown at (21) and (29) are special coils wound on Silver-Marshall midget coil forms so as to tune to 1,800 meters. The Silver-Marshall forms are provided with contact pins and plug into special S-M sockets. Both primary and secondary of the intermediate transformer (21) are shunted by small variable condensers of from .00015 mfd. to .0005 mfd. capacity. The radio frequency chokes used at various points in the circuit prevent interaction, or loss of energy due to intercoupling of various "B" supply circuits and hence allow greater amplification to be attained.

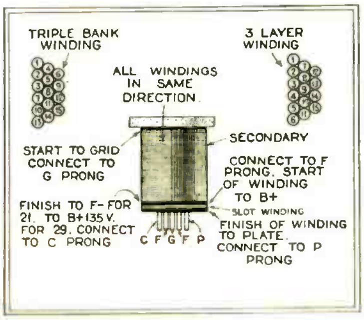
A non-regenerative detector (33) tends to prevent overloading, thus improving the operation of the receiver. A metallized resister grid leak is used, together with a mica grid condenser.

The audio circuit is conventional. It comprises two stages of transformer coupled amplification. The feature of this part of the circuit is the use of new high-quality transformers, resulting in superb tone quality. A choke is used with a condenser as a speaker filter.

Correct grid bias for the screen-grid tubes is obtained through the use of tapped resistors (7) and (24). Amperites give automatic filament control and hence simplify and improve the operation of the receiver.

Long wave coils (21) and (29) are wound on Silver-Marshall Midget threaded coil forms, so that they will tune to 1,800 meters. In winding coil (21) use No. 30 double silk covered wire for the secondary. This consists of 275 turns and should be triple bank wound for best efficiency. The illustration shows exactly how this winding is put on. If desired, a three layer winding may be used instead of the triple bank winding. This is easier to wind and will work, but is not quite as efficient as the triple bank winding. The primary of coil (21) consists of 100 turns of No. 40 double silk or enameled wire, wound in the slot. The start of the secondary goes to the grid and should be connected to the "G" prong or contact pin. The finish of the secondary connects to the "F" minus pin. The start of the primary, which connects to the grid of tube (5) is connected to the "F" plus pin. The finish of the primary going to the plate of tube (18) is connected to the "P" pin.

Coil (29) consists of a single winding of 275 turns of No. 20 D.S.C. wire. It may be triple layer or triple bank wound. The start of this impedance connects to the "G" contact pin, going to the grid



Winding details of the long wave coils.

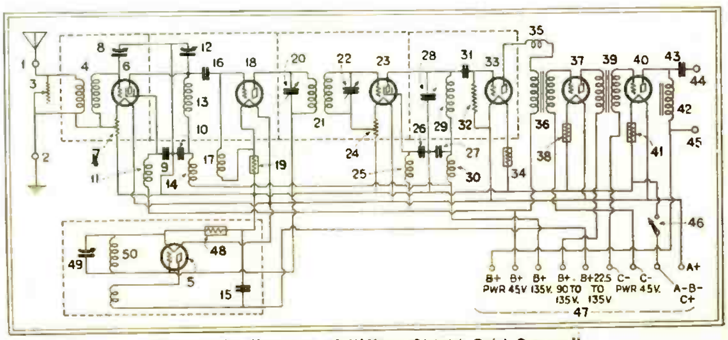
condenser and the plate of tube (23). The finish of the winding is connected to "F" minus contact pin, which in turn is connected through the coil socket to R.F. choke (30) and thence to "B" plus 135 volts.

Coil (50) is a 3-circuit tuner. The rotable primary is not used. The fixed tickler is used as the plate coil, while the secondary is used as the grid coil. In order for the secondary to tune from 220 meters to 450 meters, it is necessary to remove about 15 turns. Since the secondary is wound with 75 turns of No. 22 cotton-covered wire, the coil as used will have 60 turns.

(Note: Through an error, a .001 mfd. mica by-pass condenser was omitted from the diagrams. This should have been shown connected between the plate side of the R.F. choke (35) and "A" minus. In the top view illustration, it should have been shown soldered to one terminal of the R.F. choke (35).

LIST OF PARTS REQUIRED

3—.0005 mfd. Hammarlund "Mid-Line" variable Condensers (8, 12, 49).
1—Aero Screen-Grid Impedance Coil (without primary), type U-22 (13).
1—Aero Radio Frequency Regenerative Kit, type U-95, consisting of a Universal R.F. Transformer (4) and a Universal 3-Circuit Tuner (50).
1—Yaxley 75-ohm air-cooled Rheostat (3).
2—Yaxley "Pup" Jacks (44, 45).
7—Eby Sockets, new style, UX type (5, 6, 18, 2, 3, 33, 37, 40)
1—.00025 mfd. Polymet molded bakelite fixed mica grid condenser (31).
1—.0005 mfd. Polymet molded bakelite fixed mica condenser (16).
1—.001 mfd. Polymet molded bakelite fixed mica condenser (15).
4—½ mfd. Polymet "Hi Volt" Filter Condensers, type C-903 (9, 10, 26, 27).
1—1 mfd. Polymet "Hi Volt" Filter Condenser, type C-904 (43).
1—2-10 meg. Durham Metallized Resistor Grid Leak, with Durham Single Vertical Mounting (32).
2—Silver-Marshall Midget Threaded Coil Forms, with Contact Pins (type 130-T) (21, 29).
2—Silver-Marshall Midget Coil (or tube) sockets, type 512 (21, 29).
2—Silver-Marshall R.F. Chokes, type 276 (11, 14).
2—Thordarson Transformers, type R-300 (36, 39).
1—Thordarson Choke, type R-196 (42).
4—Amperites No. 1-A, with Mountings (19, 34, 38, 48).
1—Amperite, No. 112, with Mounting (41).
4—Hammarlund R.F. Chokes, type RFC-250 (17, 25, 30, 35).
2—Carter Center-Tapped Resistors, type JU 10-25 (7, 24).
1—Carter "Imp" Battery Switch (46).
2—Carter Shielded Wire Connectors No. 352, with Connector Caps No. 342.
2—Eby Engraved Binding Posts (1, 2).
3—Muter Variable Grid Condensers, type 1950 (20, 22, 28).
2—Hammarlund Shields, type HQS, Aluminum.
1—Yaxley 12-Conductor Cable, complete with Connector Plug and Mounting Plate (47).
2—Vernier Dials.
1—Can Kester Radio Solder (Rosin Core). By the Chicago Solder Co.
2—Rolls Wheeler Cell-O-Flex Hook-up Wire.
1—"Radion" or "Ace" 7" x 26" x 3/16 Hard Rubber Panel.
1—"Radion" or "Ace" 10" x 25" x 3/16" Hard Rubber Sub-Panel.
4—Brackets, 1" high.
2—Gold Seal Screen-Grid Tubes, type GSX-222 (6, 23).
4—Gold Seal Tubes, type GSX 201-A (5, 18, 33, 37).
1—Gold Seal Power Tube, type GSX 171 (40).



Schematic diagram of "Ultra Shield Grid Seven."

NEWS OF THE INDUSTRY

THIRD ANNUAL RMA TRADE SHOW

America's greatest industrial gathering, the annual trade show and Convention of the Radio Manufacturers' Association, comprising virtually all prominent makers of radio products and representing about 98 total national distribution, will again be held in Chicago at the Stevens Hotel. Next year the third annual trade show of the RMA and the sixth national convention of the RMA will be held at Chicago during the week of June 3d. This is the outstanding radio event scheduled for 1929 and last year the largest national industrial assembly occurred during the RMA events. About 25,000 persons interested in radio production, distribution and broadcasting, assembled in Chicago.

President Frost of the RMA and Mr. Morris Metcalf, Chairman of the Association's Show Committee, made a joint announcement that the RMA Board of Directors had selected Chicago and the week of June 3d for next year's premier radio event. The Stevens Hotel, the largest in the world, also was selected because of its excellent convention and show facilities. Several other cities, including Atlantic City, Detroit and Cleveland were bidders for the RMA events, but the central location of Chicago won the 1929 selection.

Efforts have been made, and will be continued by the RMA for the convenience of jobbers and dealers who handle both radio and music products, to induce the music trade industries to stage their annual show and convention at Chicago during the week of the RMA events.

During the week when Chicago will be the radio capital of the country, the annual RMA Banquet, possibly with its yearly super-star broadcast features, and the annual convention and election of officers are scheduled.

A radio assemblage fully equal to that of last June is expected and negotiations for reduced railroad fares for the radio visitors are in progress.

In addition to planning the RMA Trade Show, the Association's officers and Board of Directors also have arranged for continuance of the two annual public shows sponsored by the RMA held each fall, respectively, in Madison Square Garden in New York City, and the Coliseum in Chicago.

DR. PAUL T. WEEKS NOW CHIEF ENGINEER OF RAYTHEON

After being identified for many years past with the tube development activities of the Westinghouse organization, Dr. Paul T. Weeks has joined the Raytheon Manufacturing Company, of Cambridge, Mass., as Chief Engineer.

Dr. Weeks graduated from Oberlin College in 1913, and gained his Ph.D. degree at Cornell in 1917, followed by research work with the Bureau of Standards. During the war, he served in the Radio Development Section of the U. S. Signal Corps. In 1919, Dr. Weeks joined the Westinghouse organization and was assigned to radio tube and radio development work. Last May, he resigned in order to join the Raytheon organization for the purpose of developing improved filament and other types of tubes. Dr. Weeks has several patents on tube construction, which are to be incorporated in the Raytheon vacuum tubes soon to be introduced to the radio trade and public.

REPORT OF F. R. T. A.

The Board of Directors of the Federated Radio Trade Association held a very important meeting on Thursday, October 11. During this meeting preliminary plans were discussed for the Convention which will be held February 18-19-20, 1929, in Buffalo, and it was decided that the first day would be devoted to committee meetings and general assembly work. The second day to separate meetings of jobbers, dealers and manufacturers representatives and the third day to a general meeting with the election of directors and officers. Buffalo has made reservation for the Hotel Statler and have started their preparation to entertain the visiting radio trade.

An idea of prime importance to the industry which was started by the wholesalers association and which was discussed and endorsed by the entire Board was that of a serial number act to make it a misdemeanor to remove or deface serial numbers on radio merchandise. The executive offices just completed a survey of the entire states and they have found that there are no laws pertaining directly or applicable to the removal of serial numbers on radio apparatus. This fact is of importance to the public and to every legitimate radio distributor. The distributor has no way of tracing these sets through the dealers nor the public retracing stolen merchandise or requesting proper and practical guarantees. The association with the assistance of their attorney has drafted an act which will be submitted to all legislatures of the states with the hope that it will secure universal adoption.

The Board of Directors voted a resolution to be sent to the Federal Radio Commission and thank them for their untiring efforts to provide better broadcasting throughout the United States. It was felt that while their reallocation plan might be hard on certain broadcasting stations yet the Commission had the interest of the entire country at heart and was doing the best as they saw it. They recommended that no action be taken to delay the reallocation and that no opinion be stated until after the plan had been put into practical operation for at least 60 days.

Reports of the various sections were made showing the activities and growth of the Radio Wholesalers Association, the Radio Retailers Association and the Manufacturers Representatives Section of the Federated.

The executive offices announced the application of the Radio Trade Association of Southern California which now gives the Federated the two prominent trade associations on the west coast as their members.

REPORT OF RADIO WHOLESALERS' ASSOCIATION

The Board of Directors of the Radio Wholesalers' Association held a meeting on Wednesday, October 10 to discuss important problems affecting their organization at that time.

The tube situation and the change in discount of October 1 was discussed very thoroughly with a result that a second resolution will be drafted by the Radio Wholesalers' Association urging the manufacturers to provide adequate profit for both the wholesaler and the retailer and that while the Association appreciates cooperation and response from the tube manufacturers and that they have partially covered the situation, they recommend that they take further cognizance of the situation.

The meeting was adjourned at noon to enable the members to attend the luncheon with the Chicago Association of Commerce at which Major Herbert H. Frost was the honored guest and speaker.

The Board reconvening in the afternoon discussed very thoroughly the Traffic problems which are now present. They further instructed the Traffic Committee to do everything possible in order that the Association might secure better freight rates for our wholesalers as quickly as possible. The Committee is to work hand in hand with the Traffic Committee of the Radio Manufacturers' Association in an attempt to secure the passage and approval of the docket which was submitted in June. Great hopes were held by the members of the committee that a satisfactory reduction will be made within the near future.

President Sampson appointed a committee to investigate the insurance problem from all angles. A prominent trade association insurance man spoke at some length concerning the Radio Wholesalers' Association entering into the insurance field to provide all forms of insurance for members at a saving in premiums. The executive offices have been working on this proposition for the past six weeks and with the aid of the newly appointed committee will have complete insurance plans for adoption by the Association during their February meeting.

A national finance plan to enable all members of the Radio Wholesalers' Association to finance their dealer sales at a minimum amount of cost and loss was thoroughly discussed and a committee appointed to further investigate the proposition.

A new membership campaign is about to be inaugurated with nearly all the Board pledging themselves to secure five new members for the organization. A confidential survey which has just been completed among members, reveals the fact that the members of the Radio Wholesalers' Association are doing over $100,000,000 worth of radio business this year. It also shows the keen interest which the wholesalers have for a national insurance plan and one for financing dealer sales.

The executive offices announce the election of the following companies to membership: K. W. Radio Corp., New York, N. Y.; Specialty Service Corporation, Brooklyn, N. Y.; Frederick H. Thompson Company, Los Angeles, Calif.; Majestic Radio Corp., Kansas City, Mo.; Harrisburg Standard Electric Corp., Harrisburg, Ill.; Rochester Auto Parts Corp., Rochester, N. Y.; Starter & Ignition Service Corp., Rochester, N. Y.; B. W. Smith Co., Cleveland, Ohio; Charleston Electrical Supply Co., Charleston, W. Va.; Straus-Frank Co., San Antonio, Texas.

WORTHEN JOINS GENERAL RADIO

C. E. Worthen, a recent graduate of the Massachusetts Institute of Technology, has joined the engineering staff of the General Radio Co. As an undergraduate Mr. Worthen specialized in electrical communications, and will continue there in similar work on instrument development. He is at present engaged in the design of a 400-cycle fork-driven oscillator of good wave-form, similar to the G. R. standard 1,000 cycle unit.

EDGAR FELIX JOINS NEMA STAFF

Edgar H. Felix, technical writer, broadcasting and merchandising consultant and author of "Using Radio in Sales Promotion," has joined the staff of the National Electrical Manufacturers Association to specialize in radio problems, according to an announcement by Alfred E. Waller, managing director.

Mr. Felix was for several years in charge of public relations of station WEAF while it was owned and operated by the American Telephone & Telegraph Company and was subsequently associated with N. W. Ayer & Son, advertising agents, serving some of the leading manufacturers in the industry. During the last few years, Mr. Felix has maintained an independent consulting business in connection with commercial broadcasting and broadcast allocation. He is contributing editor to several radio and advertising publications and is well known throughout the industry.

PFAFF JOINS TEMPLE ENGINEERING STAFF

Mr. E. R. Pfaff, well known in engineering circles of the radio industry, has joined the organization of Temple Inc., of Chicago.

Mr. Pfaff was formerly associated with the Western Electric Company, Silver-Marshall Inc., and for the last two years was Chief Engineer of the Carter Radio Company.

His new work with the Temple organization will be on development.

REPLOGLE APPOINTED CHAIRMAN OF R.M.A. TELEVISION COMMITTEE

D. E. Replogle well-known engineer and engineering representative of the Raytheon Manufacturing Company of Cambridge, Mass., has accepted the chairmanship of the Committee on Television Standards of the Radio Manufacturers Association. This Committee has been formed for the purpose of studying the wide range of television practice now confronting the radio industry, the nondescript collection of components, and the loose and often meaningless terms used in attempting to describe television systems. The Committee plans to adopt certain television standards and television terms in bringing definite order out of the present experimental chaos. Definite standards are to be worked on for such features as scanning disks, scanning disk speeds, neon tubes, photo-electric cells, and so on. The members of the Committee have been selected with a view to securing the best representation of present-day television practice.

MAGNAVOX REPORTS PROFIT

Magnavox Company reports a net profit for the quarter ended September 30 of \$252,000, after taxes, interest, depreciation and reserves, equal to 34 cents a share earned on 730,800 shares of stock.

HAZELTINE LICENSES A. T. & T.

The Hazeltine Corporation has sold a non-exclusive license to the American Telephone and Telegraph Company and the Western Electric Company to use Hazeltine patents in all fields of communication with the exception of radio broadcast receivers.

The consideration for the license is \$150,000, of which \$50,000 represents advance royalties.

STEINITE RADIO REPORT

The Steinite Radio Company reports earnings of \$103,527 for September, compared with \$17,682 for the same month of 1927 and \$451,114 for the full year ended August 31, 1928. Shipments for September totaled \$417,900, compared with \$125,000 for September of 1927.

DE FOREST ANNOUNCES LOWER PRICES

As the result of production economies effected by the installation of the latest tube-making equipment and methods, the DeForest Radio Company announces at this time lower list prices for certain Audions on which production costs have been lowered, as follows:

Audion Type 412-A, from \$4.00 to \$3.25; Type 426, from \$3.00 to \$2.75; Type 427, from \$6.00 to \$5.00; Type 471-A, \$4.00 to \$3.25; Type 480, \$6.00 to \$5.00; Type 481, \$10.00 to \$8.50.

The list prices of other DeForest Audions remain as previously announced.

FRESHMAN AND FREED-EISEMANN CONSOLIDATE

C. A. Earl, President of Chas. Freshman Co., has announced the consolidation of Freshman with Freed-Eisemann.

Mr. Earl said: "The merger of these two companies will make it possible to effect very advantageous savings in the general operation of the combined business.

SLEEPER RADIO CORP. ELECTS OFFICERS

Announcement recently of the re-election of Gordon C. Sleeper as president of the Sleeper Radio & Mfg. Corp., of Long Island City, was made. Howard M. Van Cleaf, formerly metropolitan sales manager, assumes new duties as vice-president while Louis Del Oppenheimer, well known financial man takes the position of treasurer. E. A. Ducasse is the secretary and assistant treasurer.

The above with the addition of A. E. Doyle are directors for one year.

ZENITH RADIO REPORT

The Zenith Radio Corporation during the first six months of the current fiscal year reports net earnings after charges of \$1,100,000. This is at the rate of \$11 a share on the outstanding stock for the first six months and compares with net earnings of \$727,000, or \$7.27 a share, for the last fiscal year.

NEW TRICO PLANT

Trico Products Corporation of Buffalo, long identified with the production of windshield cleaning devices, since the introduction of the Trico Cameron Antenna have found it necessary to add to their plant facilities. The new Trico building is six stories high and it extends the depth of an entire city block, giving the plant a total area of 180,000 square feet.

In the recently completed new building a large part of the space is being devoted to the manufacture of the Antenna which is meeting with great success and having widespread distribution.

NEW ROLA PLANT

The Rola Company of Oakland, Calif., are opening up a new assembly plant at 2570 East Superior Ave., Cleveland, Ohio, in charge of H. S. Tenny, the President of the Company. Both the New York and Chicago sales offices will be consolidated with headquarters at Cleveland in charge of Mr. L. Golder, formerly of the Chicago office.

NEW DIAMOND PLANT

The Diamond Vacuum Products Co., 4049 Diversey Ave., Chicago, Ill., are adding an extension to their manufacturing plant which will enable them to double their production. The Diatron line includes the "Shieldplate" screen-grid tube and a full line of D. C., A. C. and Rectifier Tubes.

NEW ATWATER KENT PLANT

Bids for the erection of a huge additional manufacturing plant for the Atwater Kent Manufacturing Co., were opened Monday, October 29.

The new plant, the largest in Philadelphia, will cover sixteen acres directly across Abbottsford Ave., from the present fifteen and a half acre plant. It will connect with the present plant by means of a bridge across the avenue.

The addition will be a one story improvement of brick and steel with saw tooth roof construction similar in design to the older building. It is planned to begin construction about November 1, and it is hoped to have the structure ready for occupancy by early spring. The Wissahickon Ave., properties will thus consist of thirty-one and a half acres devoted to the manufacture of Atwater Kent Radio.

POLYMET WORKING DAY AND NIGHT

The Polymet Manufacturing Corporation, are operating a full night force. Large commitment orders for electric set parts received from many of the largest radio manufacturers in the field, have made this move necessary, in order that production keep pace with delivery dates.

The officials of the Polymet Manufacturing Corporation view this unprecedented volume of business which has been placed, as an indication that the Radio Manufacturers are anticipating a tremendous public demand for electric receivers this season, as every indication certainly points to this fact.

BURTON GREENE MADE PRESIDENT OF ERLA

Burton Greene, vice president and general manager of Electrical Research Laboratories, Inc., succeeds George A. Pearson as president of that company. Greene was formerly president of the Greene-Brown Manufacturing Company, recently merged with Electrical Research Laboratories, Inc.

RADIO AND ASSOCIATED STOCK QUOTATIONS

(November 2, closing prices)

Company	*Oct. 3*	*Low*	*Last*	*Company*	*Oct. 3*	*Low*	*Last*
Acoustic Products	19½	20½	20¾	Kolster	74¾	82½	83
All-Am. Mohawk	19½	39	39¾	Magnavox	4	14⅜	15½
American Bosch	33⅞	34⅝	34⅝	Polymet	35½	.....	.....
Bruns-Balke Collen (Com.)	57⅜	52½	52½	Radio (Com.)	209½	227	228½
Crosley "A"	59	63	63	Raytheon	51⅜	53	53½
Davega	34	38¼	38¼	Sangamo	32½	34	34
De Forest	14¾	20¾	21	Sonatron	114¾	127	127
Dubilier	4¾	5	5	Sparks-Withington	146	160	160
Erla	24	23	24⅛	Stewart-Warner	103¾	104½	105½
Fansteel	16¾	15½	15⅞	Utah	61¾	58	59½
Formica	25	24¾	24¾	Tower	3⅛	3½	3½
Freed-Eisemann	4⅞	4¾	4¾	Union Carbide (Com.)	188½	188¼	191
Freshman	11⅞	12	12⅜	Vesta Bat	12½	.....	.....
General Elec. (Com.)	164¾	166¼	167	Victor (Com.)	109⅝	120¼	121⅜
Gold Seal	8¾	9½	10	Westinghouse	104⅞	113⅛	113⅝
Grigsby-Grunow (new)	312	110¼	111	Weston (Com.)	25½	21¼	22¾
Hazeltine	16	21⅛	21⅛	Weston "A"	33½	33½	33½
Kellogg	14½	17½	17¾	Zenith	110	193	193
Kodel "A"	27	19½	20				

FRESHMAN ANNOUNCES NEW SALES PERSONNEL

Announcement is made at this time by the Chas. Freshman Co., Inc., of the appointment of J. A. Frye as Sales Manager, and of C. A. Earl, Jr., as Assistant Sales Manager.

Mr. Frye joined the organization some time ago as assistant sales manager, and with the advancement of Harry A. Beach to vice-president in charge of sales, he has now become sales manager.

C. A. Earl, Jr., comes to the Freshman organization with an extensive merchandising training gained in the automobile industry, and follows in the footsteps of C. A. Earl, Sr., President of the Chas. Freshman Co., who has also left the automobile ranks to enlist in radio.

J. W. HORTON NOW CHIEF ENGINEER OF GENERAL RADIO CO.

Announcement is made at this time by the General Radio Company of Cambridge, Mass., that J. Warren Horton has joined that organization in the capacity of Chief Engineer.

Mr. Horton hardly needs to be introduced to the radio industry and engineering circles. After graduating from the Massachusetts Institute of Technology in 1914, he remained for two years as an instructor in physics, going from there to the research department of the Western Electric Company, now known as the Bell Telephone Laboratories, in New York City.

A vast variety of problems have occupied Mr. Horton's attention. His work includes submarine-detection devices, precise frequency-standardization apparatus, the transmission of pictures by wire, television, and the manifold problems associated with carrier-frequency telegraphy and telephony. Mr. Horton has been granted many patents. He is the author of numerous technical articles which have appeared in scientific journals.

F. W. WATTS JOINS DUBILIER SALES

The Dubilier Condenser Corporation, of New York City, announces an important addition to its sales organization in the person of Frank W. Watts, who has been appointed Sales Manager of the Industrial Division. This branch of the Dubilier activities includes power-factor correction equipment, lightning protection devices, interference prevention equipment, spark suppressors, carrier-current condensers, and other products that fall outside the radio field.

Having been identified with public utility problems for more than twenty years, Mr. Watts is quite familiar with the needs of power companies and consumers. He has long been a keen student of the power-factor situation in various industrial centers. He was identified with some of the earliest work on carrier-current telephony. Prior to joining the Dubilier organization, Mr. Watts directed the Modernola Company of Johnstown, Pa., manufacturers of radio sets and phonographs.

F. P. HART JOINS MAJESTIC

Mr. Frank P. Hart, for many years a well-known figure in sales work throughout the Middle West, has joined the staff of Grigsby-Grunow Company, as assistant to the General Sales Manager, Mr. Herbert E. Young.

NEW FEDERAL WHOLESALERS

The Federal Radio Corporation, Buffalo, N. Y., has completed arrangements with the following new wholesalers to distribute Federal Orthosonic radio receiving sets in their respective areas:

W. W. Conde Hardware Co., Watertown, N. Y.; The Dyke Motor Supply Co., Pittsburgh, Pa.; The Amana Society, High, Iowa; W. E. Fuetterer Supplies Co., St. Louis, Mo.; Globe Supply Co., Syracuse, N. Y.; Packard Service Station, Albuquerque, New Mexico and J. Lawrence Hill Co., Rochester, N. Y.

ROLLER-SMITH CO. APPOINTMENTS

The Roller-Smith Company, 233 Broadway, New York City, announces the appointment of Wise & Braisted, General Motors Building, Detroit, Michigan, as its District Sales Agent in the State of Michigan.

This Company also announces the appointment of Arthur H. Abbott, Inc., 88 Broad Street, Boston, Mass., as its District Sales Agent for the New England Territory.

K. E. REED MADE ASST. TO PRES. OF FEDERAL

Kenneth E. Reed, sales manager of the Federal Radio Corporation for the past two years, has been made assistant to the president, it has just been revealed by Lester E. Noble, president of the corporation.

Mr. Reed has spent his entire business career with the music and radio industries. For fifteen years, prior to joining the Federal organization, he was associated with the Victor wholesaling division of M. Steinert & Sons at Boston. He was manager of that department for eight years subsequent to joining the sales staff of Federal in June, 1926. He served in the field for six months, winning promotion to special representative and sales manager successively.

AMY, ACEVES AND KING FORM ENGINEERING FIRM

Ernest V. Amy, Julius G. Aceves, and Frank King have just joined hands in the formation of the firm of Amy, Aceves & King, Inc., consulting engineers specializing in radio, with offices at 55 West 42nd Street, New York City.

Ernest V. Amy, for the past seven years, has been engaged in transmitter and antenna design development for the Radio Corporation of America. Julius G. Aceves, for the past fifteen years, has served as personal assistant and research engineer for Prof. Pupin of Columbia University. He has also been with the Bell Telephone Laboratories for two and a half years, and holds patents on A. C. radio reception. He is an authority on audio amplification and sound reproducers. Frank King served as officer in charge of Aircraft Radio Laboratory during the war, and has been identified with radio engineering and industrial progress. The three men are graduate elecrical engineers.

The firm aims to serve radio manufacturers, broadcasters and others in the capacity of consulting engineers, designers, and research staff. A well-equipped laboratory has been established at 91 Seventh Avenue, with a staff, for testing, research and development work for clients.

GRIGSBY-GRUNOW ANNOUNCES ADDITION TO STAFF

The Grigsby-Grunow Company of Chicago announce the appointment of Mr. Jack Mueller as Manager of the Franchise Department of the company. This is a new department created to build up a closer contact with Majestic dealers and distributors. Mr. Mueller has had twenty-three years sales experience, calling on dealers direct, and has had fifteen years experience as a sales manager and general manager for two distributors electrical and automotive equipment. He has also been Eastern Sales Manager for a prominent manufacturer of radio equipment before joining the Grigsby-Grunow organization. In this work, Mr. Mueller will work in close personal contact with Mr. H. E. Young, General Sales Manager of Grigsby-Grunow Company.

R. B. ROSE BECOMES GREBE REPRESENTATIVE

Robert B. Rose, identified with radio merchandising since the inception of broadcasting, has been appointed manufacturers representative for A. H. Grebe & Company, Inc., effective immediately. His territory will include all of New York City and eight counties. They are: Westchester, Sullivan, Dutchess, Orange, Putnam, Rockland, Nassau and Suffolk.

Mr. Rose, because of his long experience in the radio field, has acquired a large number of friends in all branches of the trade. For several years he conducted the radio departments of a number of large New York Stores. Also as a result of this fact he has gained wide experience in radio merchandising.

As representative for Grebe, Mr. Rose will employ five trained and experienced salesmen.

RCA OPENS BRANCH SALES OFFICE IN TEXAS

A new branch sales office has been established by the Radio Corporation of America in Dallas, Texas. M. S. Tinsley, a native of Texas, and formerly connected with the New York office, will be in charge as Southwestern District Sales Manager. In addition to the executive offices, large warehouse space has been engaged in Dallas, from which shipments of radio apparatus will be made direct to the southwestern territory. The states which will be served by the new sales and distribution center include Arkansas, Oklahoma, Texas, New Mexico and the western part of Louisiana. District offices of the Radio Corporation are now located in New York, Chicago, San Francisco and Dallas.

VAN HORNE CO. REORGANIZED

The Van Horne Tube Company is to take over the assets and business of The Van Horne Company, which has been through a receivership.

The officers of the new company will be Stephen Gilman, President and Treasurer, J. S. Van Horne, Vice-President and General Manager, and Mark Bridge, Secretary.

The new company will resume operations at once in producing tubes in the old plant.

J. Q. GAUBERT JOINS DURHAM

Mr. John Q. Gaubert has been placed in charge of the production of the International Resistance Company.

Mr. Gaubert has had previous valuable production experience, having been connected with the Ward-Leonard Electric Company, and, just previous to his connection with this company, with the Westinghouse Electric & Mfg. Company of East Pittsburgh, in connection with their cost reduction development work.

PRICE OF KINO-LAMP REDUCED

The Raytheon Manufacturing Company, Kendall Square Building, Cambridge, Mass., have reduced the price of the Kino-Lamp from a list of $12.50 to a list of $7.50. Undoubtedly, television experimenters everywhere will appreciate this effort to lessen the cost of apparatus.

ACOUSTIC PRODUCTS ACQUIRES BRISTOLPHONE

P. L. Deutsch, president of the Acoustic Products Company and the Sonora Phonograph Company, Inc., announced that Acoustic has acquired the rights and interests of the William H. Bristol Talking Picture Corporation, Asher, Small & Rogers Corporation, Gotham Bristolphone Service Corporation and Lesser Warner Productions in the world-wide Bristolphone patents.

"A new corporation will be formed," said Mr. Deutsch, "that will probably combine the names of Sonora with Bristolphone, will have exclusive distribution rights for the world, and will have sole rights for licensing of producers to employ the Bristol process of synchronizing sound with pictures. Acoustic will manufacture the machines the new company will sell."

RADIO BROADCAST'S DATA SHEETS

In a new radio book just published, entitled "Radio Broadcast's Data Sheets," practical technical data is supplied in a novel form. A wide variety of radio subjects is covered and each data sheet, treating of a different subject, is prepared for ease in reading and reference. One hundred and ninety radio data sheets comprise the new book which is published, at $1 net, by Doubleday Doran & Company of Garden City.

During the past two years, the technical staff of *Radio Broadcast* has been gathering the information making up these data sheets which are designed to be of greatest practical benefit to radio service men, engineers, home experimenters, amateur operators and others.

Among the wide variety of subjects covered, there are 26 data sheets on vacuum tubes, 10 data sheets on power supply devices, 5 dealing with loud speakers, 12 data sheets with information on audio amplifying systems, and 16 data sheets on radio circuits and receivers. In addition, many sheets in this book are devoted to the handy presentation of constantly useful data which usually is never at hand when wanted.

POWERIZER HAND BOOK

The Radio Receptor Company, Inc., 106-7th Ave., New York City, have just published a very valuable bulletin with directions for applying Powerizers to any radio set.

The first part of the bulletin covers general directions for connecting standard powerizers to radio sets, including the various systems of volume control which can be used.

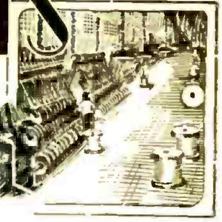
The rest of the bulletin is given over to specific directions for powerizing 46 standard makes of radio receivers. A very valuable chapter on additional operating hints is included in the back portion of the bulletin.

Copies of this bulletin (No. 2003) can be obtained free of charge from the Radio Receptor Company.

A FOLDER ON TELEVISION CONTROL

For those interested in television reception, there has just been issued a practical folder on the control of the scanning disk and the kino-lamp or neon glow tube. There is described the clarostat speed control which is ideally adapted to the accurate manipulation of the usual scanning disk motor, as well as any other small, variable speed motor. An ingenious method of obtaining the greatest possible contrast between lights and shadows of the television image while still retaining maximum sensitivity and responsiveness, by means of a standard clarostat in the plate circuit, is also described and illustrated. The folder will be sent to any one addressing the Clarostat Mfg. Co., Inc., 285-7 North Sixth St., Brooklyn, N. Y.

NEW DEVELOPMENTS OF THE MONTH



RADIART STEP-DOWN TRANSFORMER

Radiart Laboratories, Inc., of Cleveland, Ohio, have placed on the market a new adjustable step-down transformer. With this new unit the A. C. receivers and eliminators as manufactured in the United States are made applicable for use in all the foreign markets.

The novel feature of this transformer is that it is equipped with a special four-point switch which is connected to the transformer and is positive in action. The switch is readily accessible, and full instructions are given on the nameplate that is on each transformer.

Only two transformers are required to cover the range of 130 to 250 volts. One transformer has the primary wound so as to convert either 130 volts, 150 volts, 170 volts or 190 volts to 110 volts. The other transformer is wound to convert either 200 volts, 220 volts, 240 volts or 250 volts to 110 volts. In a good majority of countries one transformer will cover the voltage range so that standard 110 volt radio sets or electrical appliances may be operated from prevailing sources of power supply. If necessary to go outside the range of one type, the other type will cover any range of voltage encountered.

Radiart Step-Down Transformer.

Each transformer is supplied on the primary side with eight feet of cord and connecting plug for connecting to the power supply line. The 110 volt secondary side is equipped with two feet of cord and special receptacle so that the connecting cord to the appliance can be readily plugged into this receptacle just as if it were a standard wall receptacle. The transformers are totally enclosed, and the windings are impregnated to protect them against moisture. Bushings protect the cord entering the enclosing container, and all leads are enclosed.

The National Sales Representative for the Radiart Laboratories, Inc., is John C. Hindle, who is located at 122 Greenwich St., New York City.

THE RADIO WORLD TIME CLOCK

The Radio Time Clock, recently placed on the market by George B. Gardner, 923 Hutchinson Court, Brooklyn, N. Y., is an ingenious and useful device and one that promises to be popular.

The clock is designed for the radio receiving set, to enable users to follow the programs, not only of their local stations, but of all the stations their receiving set will reach.

As seen from the illustration, there is a secondary dial listing the principal time localities. The listings are: Eastern, Central, Mountain, Pacific, Alaska, Hawaii, Berlin, London, Canary Islands, Azores, Rio de Janeiro, and Atlantic, thus completing the time circle.

The Radio World Time Clock.

With this arrangement one can immediately determine the local time in any part of the world, by reading the hour opposite the name.

The secondary dial is rotable and therefore can be set for use anywhere.

The price of the standard model clock is $3.75.

GENERAL RADIO TYPE 320 TEST OSCILLATOR

The General Radio Type 320, 180 K.C. Test Oscillator consists of a radio frequency oscillator having three frequencies, and a fixed modulation frequency. A milliammeter is provided to assist in making receiver adjustments. It is not connected in the oscillating circuit. A non-metallic screw driver, leads and coupling coil are supplied with the oscillator. A standard tube with the heater circuit open-circuited, but with the elements in position is required for neutralizing. This is not included in the oscillator equipment.

The Type 320, 180 K.C. Test Oscillator is particularly adapted to the servicing of the Radiola 60 or other superheterodynes operating on 180 kilocycles (eg. Brunswick-Type 5 NO and Graybar Type 330 receivers), a 180-kilocycle frequency being provided for adjustment of the intermediate frequency stages of that receiver. The 180-kilocycle frequency is accurately set. Complete instructions for using the oscillator in servicing the Radiola 60 are contained in instructions issued by the R.C.A. for this receiver.

The Type 320, 180 K.C. Oscillator consists of two oscillator coils with a selector switch for shifting frequency, and three condensers. Modulation is accomplished by means of a grid leak and condenser. Three radio frequencies are provided, 180 kilocycles, 640 kilocycles and 1,400 kilocycles. The 180-kilocycle oscillator is accurately adjusted to that frequency in order that it may be used in lining up condensers in an intermediate-frequency amplifier operating on this frequency.

While the Type 320 Test Oscillator is so designed as to be particularly useful in the testing of superheterodynes operating on a 180-kilocycle intermediate frequency, its use is not limited to the testing of such receivers. The two radio frequencies, one at each end of the broadcast band, may be used as a source in neutralizing and aligning any type of receiver.

The variable condenser is supplied in order that the intermediate frequency may be swung slightly to either side of 180 kilocycles as required in adjusting the intermediate-frequency amplifier. The frequency is accurately adjusted to 180 kilocycles with this condenser set on the indicator.

X-L LINK

The X-L Radio Laboratories announce a new unit that makes possible the complete operation of a radio set from the light socket, including antenna and ground.

The unit that makes this possible is called the X-L Link, and provides antenna and ground, voltage regulator, double receptacle outlet, switch to control sets using A and B power units, and a fuse that protects the set. This is all encased in a small, compact, attractive unit that can be instantly connected to any set operating from the light socket.

Antenna and ground are obtained by specially balanced capacities coupled to the light wires.

The voltage regulator is manually controlled with a single knob and definitely protects the tubes of the set from overload caused by variation in line voltage.

Two outlet receptables are provided so that both a B-eliminator and A-power unit, or A.C. Converter can be attached. The line voltage regulator will operate just as effectively on these units as on the A.C. set.

The New X-L Link.

A switch is inserted in the extension cord so that the set can be controlled therefrom if no other control has been provided.

The unit is equipped with a fuse as advised by the Fire Underwriters, which protects the set from accidental injury caused by the breaking down of any one device.

The X-L Link can be installed anywhere convenient to the receiver or inside of the cabinet if desired.

CHICAGO - JEFFERSON TUBE CHECKER FOR A.C. TUBES

The Chicago-Jefferson Fuse & Electric Company, Chicago, have added to their line of radio products, a Tube Checker for testing A.C. tubes.

This checker No. 291 will enable the set-owner or the dealer to locate the worn out or paralyzed tubes.

The checker is equipped with a meter, two sockets, for the four and five prong tubes, a rheostat and a push button.

The test is simple—insert tube in socket,

Tube checker for A.C. tubes.

set rheostat to predetermined reading given on instruction sheet, and take readings with button up and down. The difference in the readings shows the condition of the tubes.

DEJUR RADIO FREQUENCY CHOKES

A radio frequency choke suitable wherever radio frequency currents are to be retarded, rated at 85 millihenrys and very low D.C. resistance, is now being manufactured by the DeJur-Amsco Corp. The unit is completely encased in bakelite, is hermitically sealed and furnished with two metal binding posts. Mounting holes are located on the base permitting baseboard or sub-panel location. The electrical design of the unit is such that its effective resistance and distributed capacity are very low, the latter being approximately 2.5 micromicrofarads.

THE EISLER 24 HEAD AC AUTOMATIC EXHAUST MACHINE

Great difficulty in the manufacture of A.C. tubes on a production basis has been overcome through the use of the Eisler Automatic A.C. exhaust machine. The old method required a good deal of time. In the exhausting operations, double bombarding is necessary and tubes finally had to be tipped off by the hand method. In all, the manufacturer could not produce enough tubes by this method to supply his demand and production costs were too high.

The Eisler Engineering Co., Inc., 740-772 South Thirteenth Street, Newark, N. J., of which Charles Eisler is executive head, manufactures about everything and anything that tube, lamp, and neon sign makers need in the way of equipment and raw material. They have adapted their twenty-four position A.C. automatic exhaust machine for this purpose, making many improvements in design to meet this new A.C. condition. The machine is equipped with a variable step transformer and lighting filament during the exhaust period; also double bombarding, air cooling and automatic tipping off of exhausted tubes.

Directly connected to the machine is a battery of Eisler high vacuum pumps. These pumps play an important part in securing the high vacuum so necessary in A.C. tubes.

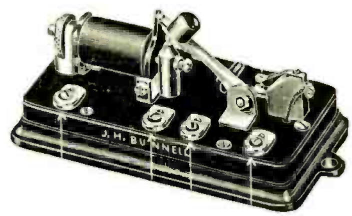
BUNNELL OVERLOAD RELAY

J. H. Bunnell and Company, 32 Park Place, New York City, have introduced a new type of overload relay designed principally for the protection of transmitting tubes, secondaries of high voltage transformers and the windings of choke coils. The relay is inserted in the negative "B" lead as a series proposition so that in the event of overload it will open the negative "B" supply.

The instrument is approximately 6" long, 4" wide and stands about 4" high. It is mounted on a slate base and iron sub-base.

The relay contacts are of silver and are so arranged that the overload condition not only opens the negative "B" supply but also opens the coil of the circuit breaker, thus protecting it.

A set of alarm contacts is installed on the extreme right of the instrument so there is a visual telltale of the functioning of the circuit breaker. These circuit breakers are also manufactured with an additional set of contacts normally closed.



Bunnell Overload Relay.

which is in series with the 110 volt input at the transmitter and arranged so that when the circuit breaker trips, it opens the 110 volt supply.

The circuit breaker may also be used as a protective device in circuits wherein are connected galvanometers, meters of all types, photoelectric cells, etc.

These relays are of real value in the laboratory for the protection of expensive measuring and testing equipment.

THE I. C. A. TELEVISION KIT

The Insuline Corp. of America, 78-80 Cortlandt St., New York City, have introduced a very complete television kit, which can be used in conjunction with any good radio receiver for the reception of television transmissions.

The I. C. A. Television Kit includes a 48-hole Bakelite scanning disc, a universal motor for revolving the scanning disc, a speed control for the purpose of synchronization, a motor chuck, viewing telescope with two lenses, screws and lense bracket, Bakelite subbase for motor, receptacle cord and plug, subbase with socket for neon tube, picture frame shield, Bakelite pillars, all necessary hardware and a four stage

The Insuline Corp. of America Television Kit.

resistance coupled amplifier. The tubes are not supplied with the kit.

The price of the I. C. A. Television Kit outlined is $52.50.

FERRANTI RADIO METERS

Ferranti, Inc., 130 W. 42nd St., New York City, announce the introduction of a new line of radio meters now available for distribution. Three types are available, a portable of 1,000 ohms per volt with 3-scale ranges of 10-50-250 volts and a second 3-range, 200 ohms per volt portable with voltage scales of 7.5-150 and milliampere scale of 15 mills.

The latter instrument is equipped with a switch for changing from one range to others, and a fuse which protects the meter from being burned out in case a high voltage lead is connected to the milliampere scale by mistake.

The third type consists of a flush pattern milliammeter which is available in ranges of 100 and 200 milliamperes. All of these meters are of the D'Arsonval moving coil type. The moving element has highly polished steel pivots running in sapphire bearings and girder type pointer of very light and strong construction with knife edge to facilitate accurate reading.

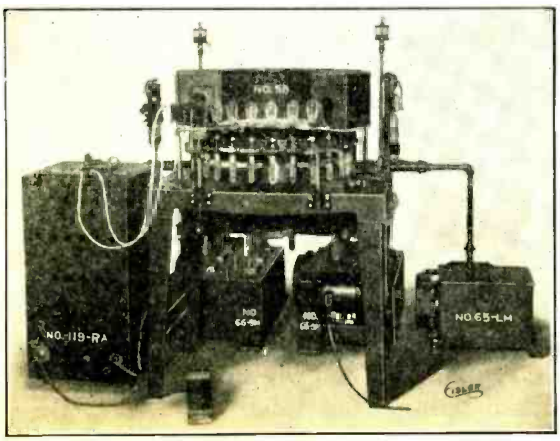
GENERAL RADIO TYPE 287 OHMMETER

There are many occasions in laboratories, service stations and factories where an approximate measurement of resistance is required. The type 287 Direct Reading Ohmmeter is designed for the quick determination of resistance where an approximate value is sufficient.

The Type 287 Ohmmeter consist of a battery and meter in series with a resistance which protects the meter from damage at short circuit, and provides a zero adjustment. The dial is calibrated directly in ohms Clip leads are provided for convenience in attaching the instrument.

One of the greatest uses of the Ohmmeter is the checking of apparatus and tracing of circuits. Its indication of the actual resistance of the circuit makes the Ohmmeter useful when the battery and telephone method of tracing circuits is of little use. This feature makes it possible to detect not only open and short circuits, but also wrong connections, since the resistance between two points will indicate the instruments in circuit.

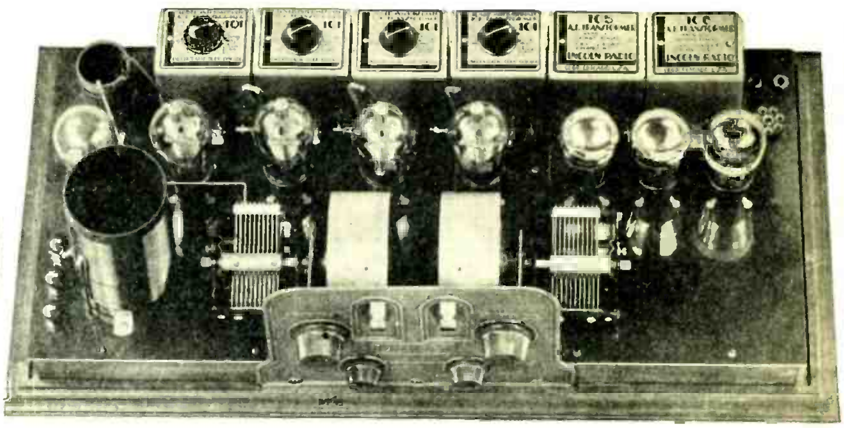
Dimensions 6¾" x 5¾" x 4½". Weight 2½ lbs.



A complete Eisler 24 head A.C. automatic exhaust machine installation. A battery of high vacuum pumps is connected directly to the machine.

Here's Proof! BUILDERS ALL REPORT *COAST TO COAST* with *Tremendous* Volume

LINCOLN 8-80



JUST stop and analyze every Super on the market, and compare it, point for point with the Lincoln 8-80. Where-else can you find the new features which have made the Lincoln 8–80 a tremendous success?

One Spot above 220 meters.

Intermediate stages perfectly matched, manually, while in operation.

Perfect 10 KC separation with full power.

Absence of squeals or howls, caused by regeneration. (If regeneration was present in the least degree, four screen-grid tubes could not be operated without shielding).

Clough system of Audio Amplification registering complete musical frequencies and giving 50% more amplification.

Simple to build.

Compact in size.

Economical to operate.

Universal reports on the Lincoln 8-80 prove it to be the *most powerful receiver on the American market*, and at the same time the simplest, lowest priced super you could build.

A WORD TO THE CUSTOM SET BUILDER

You can out-demonstrate, out-perform any competitive equipment in your territory. You can pull in station after station in every degree of the dial with perfect tone quality of your local station. All this without a squeal, and only using a small part of your available power, and at a price without competition. You can convince your customer in one short demonstration.

The price of complete kit for the Lincoln 8–80 is $92.65. Due to the new principles involved every 8–80 works exactly alike, and you can get the same results as our finest laboratory model.

If you want an evening full of straight-from-the-shoulder super-heterodyne dope written by an engineer who has played with every super going in the last few years, send 25 cents for Wm. H. Hollister's "Secret of the Super" using the coupon below.

LINCOLN ENGINEERING SERVICE ON STANDARD KITS

DO **YOU** KNOW THAT **you can buy the really finer standard kits—those that have come up to the rigid standards of performance set by the Lincoln Laboratories at standard prices, and at standard discounts if you are a professional setbuilder or dealer? The Lincoln Engineering Service means a lot. You have the assurance of factory inspection, plus Lincoln inspection—and Lincoln offers you only complete kits that exhaustive tests have proved to be right—and then fully guarantees each to you.**

Order today for immediate shipment any of the following Lincoln—Guaranteed complete kits:

Sargent-Rayment Seven (S-M 710) kit	$120.00	Tyrman 80-super-less power pack	$131.50
S-M 720 Screen Grid Six	72.50	Tyrman 72 receiver kit	98.50
S-M 720 Screen Grid-Six-Factory wired	102.09	Tyrman 72AC with power pack	153.50
1929 Laboratory Superheterodyne	95.70	H.F.L. Isotone, 10-tube super	195.00

LINCOLN RADIO CORPORATION
329 SOUTH WOOD ST. — CHICAGO - ILLINOIS.

Authorized Distributors for Lincoln 8–80

WESTERN RADIO MFG. CO.
128 W. Lake St., Chicago
WALTER ROWAN CO.
833 Washington St., Chicago
ELECTRIC & RADIO SUPPLY
22 N. Franklin St., Chicago
KLADAG RADIO LABORATORIES
Kline Bldg., Kent, Ohio

LINCOLN RADIO CORP. 329 S. Wood St., Chicago., Dept. RE.

Send me your big free catalog listing a complete line of 1929 kits for custom building.

Enclosed find 25c for which send me Wm. H. Hollister's new book, "The Secret of the Super."

Name ....

Address ....

Town........................ State............

Authorized Distributors for Lincoln 8–80

RADIO SUPPLY COMPANY
912 Broadway, Los Angeles
WHOLESALE RADIO SERVICE
6 Church St., N. Y. City
CHICAGO RADIO APPARATUS
415 S. Dearborn, Chicago
HORACE HILLS
533-39 Market St., San Francisco

A RADIO RECEIVER IS NO BETTER THAN ITS CONDENSERS ~ THEREFORE **BE SURE TO SPECIFY**

BEE CEE

FIXED CONDENSERS

DEPENDABILITY
QUALITY
LIFE
SERVICE
PERFORMANCE

RMA — RADIO MANUFACTURERS ASSOCIATION MEMBER

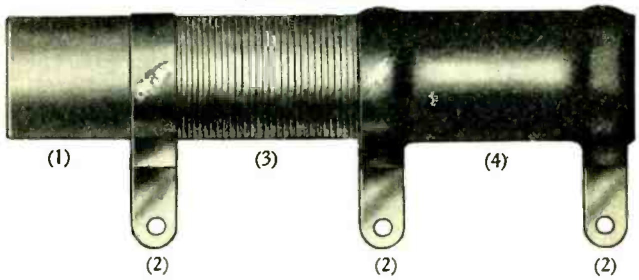
BROWN & CAINE INC.

2317-21 CALUMET AVENUE
CHICAGO, ILLINOIS

NEW

L. M. C. Silver Welded Resistors

(Patents pending)



1.—Bare Refractory Tube

2.—Copper Terminals with welded connections shown

3.—L.M.C. Special Resistance Wire

4.—L.M.C. Special Heavy Enamel

From the metallurgical laboratories of Lautz again comes a meritorious contribution to the radio production field.

The new silver welded L.M.C. resistor makes a *permanent, solid* contact — practically does away with terminal joint trouble — has a much lower operating temperature coefficient — and absolutely establishes and maintains an average increased working life of over 100%. They cost no more than the average resistor.

Sample inquiries and specifications invited from manufacturers

LAUTZ MANUFACTURING COMPANY, INC.

Electrical Alloy Products—Controlling Devices

245 N. J. R. R. Ave. Newark, N. J.

New Air-Cooled DeLuxe

RESISTOVOLT

AUTOMATIC VOLTAGE CONTROLLER

Checks all line voltage in excess of 110 Volts, protecting tubes and set wiring. Embodies new efficient principles of construction, all metal, air-cooled regardless of overload.
Price **$1.75**

ANTENNA-VOLT—Combination of the Air-cooled Resistovolt and a perfect light socket aerial. It is the talk of Radio Engineers!
Price **$2.25**

TELEVISION

ICA KITS & ALL PARTS

Four Models for the Experimenter:

Model 65 (complete with Television Tube and Television Amplifier) . . List $65.00
Model 52 (Same as 65 less tube) . . . . List 52.50
Model B-1 (without amp. or tube) . . . . List 37.50
Model 45 (Same as B-1 but with improved motor) . . . . List 45.00
Also Discs, Television Lamps, Motors, Lenses, etc., etc.

WRITE FOR CATALOG
Get on our mailing list for future announcements.

INSULINE CORP. of AMERICA
RADIO— *Standard Products Since 1921* —TELEVISION
70-80 Cortlandt St., N. Y. C.

Making it GOOD— Then PROVING it!

How Hammarlund Drum Dials Are Tested

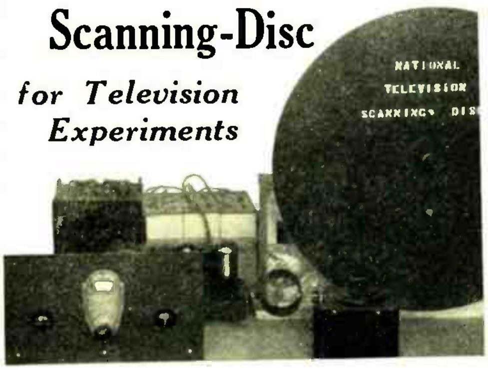
THE driving mechanism of the new Hammarlund Knob-Control Drum Dial will outlast the receiver in which it is installed. *It will stand more than fifty years of normal use.*
In laboratory tests, made on the machine pictured above, the special silk and linen cable that drives the drum withstood 363,600 full-range movements of a heavy, four-gang condenser. No fraying, no breaking, no slipping, no backlash. We knew it was good—now we have PROVED it.
Unique design permits the control knob to be placed anywhere on the panel for attractive balance. Standard knobs are used so that rheostats, volume control and other panel instruments can be exactly matched.
The escutcheon is mottled bronze, richly embossed. Its shape is graceful and well-proportioned. It adds dignity and beauty to the finest receivers. *Ask Your Jobber Or Write direct to us.*

HAMMARLUND MANUFACTURING CO.
424-438 W. 33rd Street, New York

For Better Radio
Hammarlund
PRECISION
PRODUCTS

A Perfected Scanning-Disc

for Television Experiments



A rugged metal television disc of improved design made with segmental scanning aperture. Suitable either for transmission or reception. 24 inches in diameter with 48 holes and equipped with large bushing for attachment to the motor with one-half inch shaft.
Size of receiving image 1½ by 1½ inches.

Segmental Holes Give 27 Percent More Light

While segmental apertures are much more difficult to cut, they are highly desirable, as they give 27 per cent more light and much clearer reception.

List Price $15.00

Furnished also with 12-inch diameter, 48 holes or 6-inch diameter, 24 holes.

Write for Bulletin 133RE

NATIONAL
RADIO PRODUCTS

NATIONAL CO. Inc. W. A. Ready, *President* MALDEN, MASS.

Where the Human Eye Cannot See

G.M. Electrical "Eyes" Function Perfectly

Of high sensitivity and long life, G-M Visitron Photo-electric Cells are of utmost utility in television, talking movies, telephotography, photometry, illumination control, burglar and fire alarms, grading materials, detection of flaws, counting and timing machines, optical relays and many other devices.

G-M Visitron Photo-Electric Cells
(Alkali Metal Hydride Type)

In some applications, duplicate — even surpass the functions of the human eye. As such, they have long been used by leading engineers and scientists. Instantaneous response, even to slightest changes of light intensity and color. Write for new technical bulletin PE-14 and prices.

G-M LABORATORIES INC
1805 GRACE ST., CHICAGO, ILL.

WHY THEY SELL BETTER!

Velvet-like tone; no microphonic noises; nationally advertised; made in all standard types, A. C. and D. C.

Write for full description and prices.

Televocal Corporation
Televocal Building
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Televocal
Quality Tubes

AMERTRAN
TRADE MARK REG. U.S. PAT. OFF.

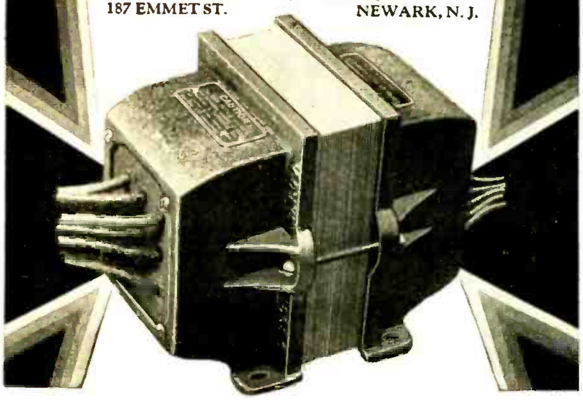
PF-250 Power Transformer for UX 250 Power Tubes

A husky transformer built for doing the job, not for looks. The PF-250 is rated at 1200-600 Volts plate, 7½ Volts power tube, 7½ Volts rectifier tube filament. Center taps are provided on each of the filament windings. Continuous rated capacity of plate winding, 160 MA., continuous rated capacity of each 7½ Volt winding, 3 Amperes. DC plate output with two UX281's full wave, up to 450 volts with sufficient excess for "C" Bias.

Ask for Bulletin No. 1033 describing fully the PF-250

PRICE, EACH $30.00
Slightly higher West of Rocky Mountains

American Transformer Company
Transformer Builders for more than 28 years
187 EMMET ST. NEWARK, N. J.



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"Bath-Tub" Type CONDENSERS

Now comes the Amsco "Bath-Tub" type. This new Amsco feature saves time in assembling, saves space, and assures greater rigidity and finer accuracy in single-control tuning. It has been adopted by the largest manufacturers of sets and kits and is specified in all the leading circuits.

Write us for complete descriptive literature, prices and discounts.

AMSCO PRODUCTS
Broome & Lafayette Sts.,
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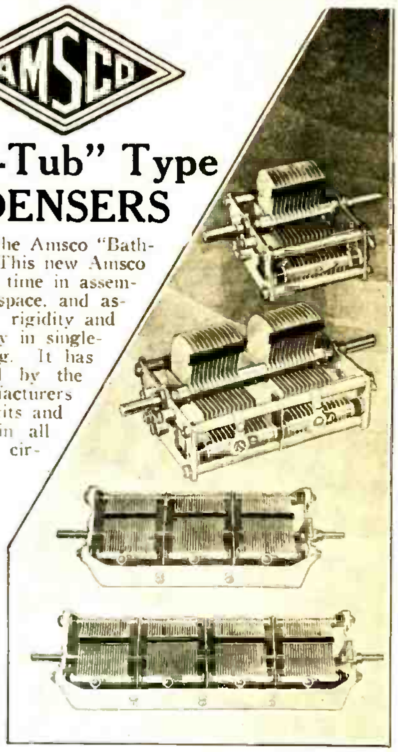


The Standard Resistor Adopted by Leading Set Manufacturers

HY-WATT

Calorohm Vitreous Enameled Resistors
Metallized Resistor
Flex. Wire Grid Suppressors.

"Calorohm" are made in a wide range of resistance value and wattage ratings to fit every power supply need. These resistors are designed for all power work.

HY-WATT Metallized Resistors can be supplied in ohmages up to 10 megohm; and wattage ratings up to 25 watts. These units will dissipate their rated power without excessive heating, or change in resistance value.

NOTE TO MANUFACTURERS: Special tapped resistors in either vitreous enameled or metallized types can be supplied on order to manufacturers only. In ordering please specify number of taps resistance per section and current drain.

Electro Motive Engineering Corp.
127 W. 17th St., New York

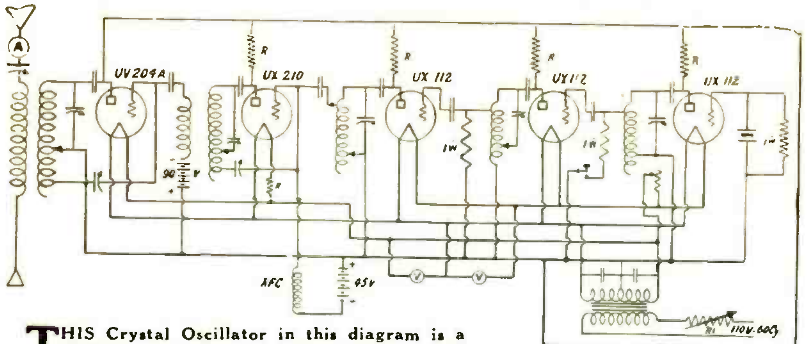
--POWER TRANSFORMERS--
for the UX 250 Power Tube

TYPE 565-A TRANSFORMER
(200 watts)
Price **$13.50**

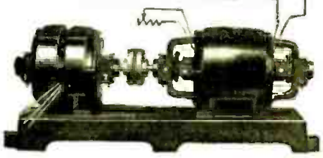
The General Radio Type 565 Power Transformers consist of two models for both half and full-wave rectification utilizing the 281 type of rectifier tube. The Type 565-A Half-Wave Transformer illustrated consists of one 600-volt secondary, two secondaries of 7.5 volts and one of 2.5 volts. It is designed for 105 to 125-volt, 50 to 60-cycle lines.

Bulletin No. 931 will be sent on request.

GENERAL RADIO CO.
30 STATE ST., CAMBRIDGE, MASS.
274 Brannan St., San Francisco, Calif.



THIS Crystal Oscillator in this diagram is a UX112, controlled by a 320 meter crystal for 80 meter operation, or a 160 meter crystal for 40 meter operation. Assuming a 320 meter the first UX112 oscillates at 320 meters. The second UX112 at 160 meters. It also amplifies at this wave-length. The third UX112 oscillates at 80 meters. The UX210 acts as an amplifier. This last tube also acts as a driver for the 204A, which is tuned to the wave-length of the UX210. The plate supply comes from an "ESCO" Item No. 26.



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Mark **"ESCO"** Trade

411 South Street — Stamford, Conn., U. S. A.

Manufacturers of Motors, Generators, Motor-Generators
Dynamotors and Rotary Converters, for Radio and Other Purposes

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When the leading set manufacturers of the country choose Yaxley parts there is something more than even an outstanding reputation at work.

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FERRANTI
Audio Frequency
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Real audio transformers with flat curves.
Special output transformers for all speakers and tubes.
High grade iron core chokes for "B" Eliminators.
Three range portable meters. 1,000 ohms per volt. 10/50/250 scale.
Three range portable meters. 200 ohms per volt. 150/7½ volt and 15 Mill. scale with switch.
By-Pass condensers—2 MF—400 volt and 200 volt.

Circulars sent on request

Detailed instructions for building the Ferranti Straight Line Push-Pull Universal Power Amplifier and Power Unit for all power tubes up to and including 250 type sent prepaid for $1.00 net.
Instructions for building the SKYSCRAPER, $1.00 net.

Send 15c in coin for copy of 1929 Ferranti Year Book

FERRANTI, INC.
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New York, N. Y.

FERRANTI, LTD.
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Toronto, Canada

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

Published monthly at Albany, N. Y., for Oct. 1, 1928.

State of New York
County of New York } ss.

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

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

Sworn to and subscribed before me this 1st day of Oct., 1928.
(Seal) J. A. WALKER, Notary Public.

Kings County.
Kings Co., Clerk's No. 390.
Kings Co., Registers No. 9100.
New York Co., Clerk's No. 159.
New York Co., Registers No. 9166.
Commission expires March 30, 1929.

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

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

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

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

BASES, VACUUM TUBE:
Formica Insulation Co.

BINDING POSTS:
General Radio Co.

BRACKETS, ANGLE:
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Scovill Mfg. Co.

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

BROADCAST STATION EQUIP'T:
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General Radio Co.
Radio Engineering Laboratories

BUTTS:
Scovill Mfg. Co.

CABINETS, METAL:
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Copper and Brass Research Assn.
Radio Engineering Laboratories

CELLS, PHOTOELECTRIC:
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G. M. Labs. Inc.
Photo-Electric Devices Co.
Raytheon Mfg. Co.

CERIUM:
Independent Labs.

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

CHASSES
Aluminum Co. of America.
Copper and Brass Research Assn.
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General Radio Co.
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Thordarson Elec. Mfg. Co.

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

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

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Electrad, Inc.
Scovill Mfg. Co.

CLIPS, SPRING:
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Scovill Mfg. Co.

COIL FORMS:
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Silver-Marshall, Inc.

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Dudlo Mfg. Co
Westinghouse Elec. & Mfg. Co.

COILS, IMPEDANCE:
Dudlo Mfg. Co.

COILS, INDUCTANCE:
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Cardwell, Allen, D., Mfg. Co.
Dresner Radio Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Radio Engineering Laboratories
Silver-Marshall, Inc.

COILS, MAGNET:
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COILS, RETARD:
Hammarlund Mfg. Co.

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

COILS, TRANSFORMER:
Dudlo Mfg. Co.

CONDENSER PARTS:
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Scovill Mfg. Co.

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Allen-Bradley Co.
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Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
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Muter, Leslie Co., Inc.
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Dongan Electric Mfg. Co.
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Muter, Leslie Co., Inc.
Polymet Mfg. Co.
Radio Engineering Laboratories.
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Allen-Bradley Co.
Brown & Caine, Inc.
Burt, A. G., Jr.
Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier condenser Mfg. Co.
Electrad, Inc.
Electro Motive Eng. Co.
Fast, John E., & Co.
Muter, Leslie Co., Inc.
Polymet Mfg. Co.
Radio Engineering Laboratories
Yaxley Co.

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

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Scovill Mfg. Co.
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United Scientific Laboratories

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National Co.
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United Scientific Laboratories

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ELIMINATORS, B BATTERY:
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General Radio Co.
Kodel Elec. & Mfg. Co.
Muter, Leslie Co., Inc.
National Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.

ELIMINATORS, A-B-C:
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General Radio Co.
Karas Electric Co.
Kodel Elec. & Mfg. Co.
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Electrad, Inc.
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Silver-Marshall, Inc.

JEWELL

Test Tubes without Batteries

Pattern No. 150
Tube Tester
Operates from A. C.

Obviously, the elimination of A, B, and C batteries in tube testing would save a lot of time and trouble in making connections, getting the right voltage combinations, besides saving cost of batteries.

But that is what the Jewell Pattern No. 150 A.C.-D.C. tube checker does. No batteries whatsoever are needed. All that is required to prepare it for testing tubes is to plug the attached cord into a 110 volt, 60 cycle outlet, thus making use of alternating current.

Filament voltage is read on a 0-4-8 A.C. voltmeter and plate current is read on a 0-15 milliammeter, which also gives a second reading when the grid shift is used.

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

This new tube tester is fully described in our descriptive circular No. 2004. Write for a copy.

"28 Years Making Good Instruments"

JEWELL

Electrical Instrument Co.

1650 Walnut St., Chicago

How Many Lives has a TELEVISION TUBE?

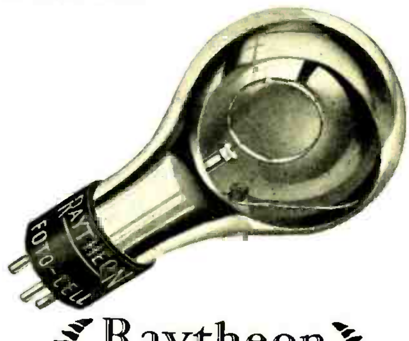
List Price
$7.50

Raytheon Kino-Lamp

The name Raytheon on any type of tube assures a service-life so long that it is often equivalent to the lives of two or three ordinary tubes.

The principles of sturdiness and strength developed in the production of Raytheon sound-reception tubes have been applied to the manufacture of Raytheon television tubes.

The Raytheon Kino-Lamp is the long-life television receiving tube—adapted to all systems, and made in numerous types.



Raytheon Foto-Cell

The long-life television sending tube, in either hard-vacuum or gas-filled types, and in two sizes of each.

Information and Prices upon application

Correspondence is invited from all interested in television.

RAYTHEON MANUFACTURING CO.
CAMBRIDGE, MASS.

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NUTS:
Shakeproof Lock Washer Co.

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

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Carter Radio Co.

PLUGS:
Carter Radio Co.
General Radio Co.

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

RECEIVERS, ELECTRIC:
United Scientific Laboratories.

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

REGULATORS, VOLTAGE:
DeJur Products Co.
Muter, Leslie Co., Inc.
Radiall Co.

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

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Allen-Bradley Co.
Carter Radio Co.
Central Radio Laboratories.
De Jur Products
Electrad, Inc.
Electro Motive Eng. Co.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Lynch, Arthur H., Inc.
Mountford, C. E., Co.
Polymet Mfg. Co.

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

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

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

SCREW MACHINE PRODUCTS:
Aluminum Co. of America
Scovill Mfg. Co.

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

SHIELDS, TUBE:
Carter Radio Co.

SHORT WAVE APPARATUS:
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General Radio Co.
Radio Engineering Laboratories.
Silver-Marshall, Inc.

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SOLDER:
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Westinghouse Elec. & Mfg. Co.

SOUND CHAMBERS:
Amplion Corp.
Temple, Inc.

SPEAKERS:
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Temple, Inc.

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

SUBPANELS:
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Westinghouse Elec. & Mfg. Co.

SWITCHES:
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Electrad, Inc.,
General Radio Co.
Westinghouse Elec. & Mfg. Co.
Yaxley Co.

TAPPERS
Eastern Tube and Tool Co.

TELEVISION PARTS:
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Clarostat Co., Inc.
Insuline Co.

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

TESTERS, TUBE:
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Jewell Elec. Inst. Co.

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

TESTING KITS:
Jewell Elec. Inst. Co.

TESTING LABORATORIES:
Electrical Testing Labs.

TINFOIL:
Reynolds Metals Co., Inc.

TOOLS:
Eastern Tube and Tool Co.

TRANSFORMERS, AUDIO:
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Ferranti Ltd.
General Radio Co.
Karas Electric Co.
Muter, Leslie, Co., Inc.
National Co.
Samson Electric Co.
Silver-Marshall, Inc.
Scott Transformer Co.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Victoreen Corp.

TRANSFORMERS, B-ELIMINATOR:
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Ferranti, Ltd.
General Radio Co.
Muter, Leslie, Co., Inc.
Silver-Marshall, Inc.
Scott Transformer Co.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Tyrman Co.
Victoreen Corp.

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Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.

TRANSFORMERS, OUTPUT:
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Karas Electric Co.
Muter, Leslie, Co., Inc.
National Co.
Silver-Marshall, Inc.
Scott Transformer Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.
Tyrman Co.
Victoreen Corp.

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General Radio Co.
Muter, Leslie, Co., Inc.
National Co.
Scott Transformer Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Tyrman Co.
Victoreen Corp.
Westinghouse Elec. & Mfg. Co.

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

TUBES, A. C.:
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Armstrong Elec. Co.
Ceco Mfg. Co.
Cunningham, E. T., Co.
De Forest Radio Co.
Gold Seal Elec. Co., Inc.

TUBES, RECTIFIER:
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Armstrong Elec. Co.
Ceco Mfg. Co.
Cunningham, E. T., Co.
Gold Seal Elec. Co., Inc.
Raytheon Mfg. Co.

TUBES, TELEVISION
(See Cells, Photoelectric.)

TUBES, VACUUM:
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Armstrong Elec. Co.
Ceco Mfg. Co.
Cunningham, E. T., Co.
Gold Seal Elec. Co., Inc.
De Forest Radio Co.
Raytheon Mfg. Co.

UNITS, SPEAKER:
Amplion Corp.
Temple, Inc.

VOLTMETERS, A. C.:
General Radio Co.
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.

WASHERS:
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Scovill Mfg. Co.
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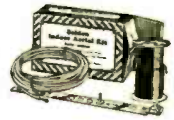

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Ideal for set hookups and wiring. Flexible and easily fitted. Different colored rubber insulations make circuit wiring easier. Tinned stranded wire and cotton serve under Colorubber keep wire free from rubber and make stripping and soldering easy.

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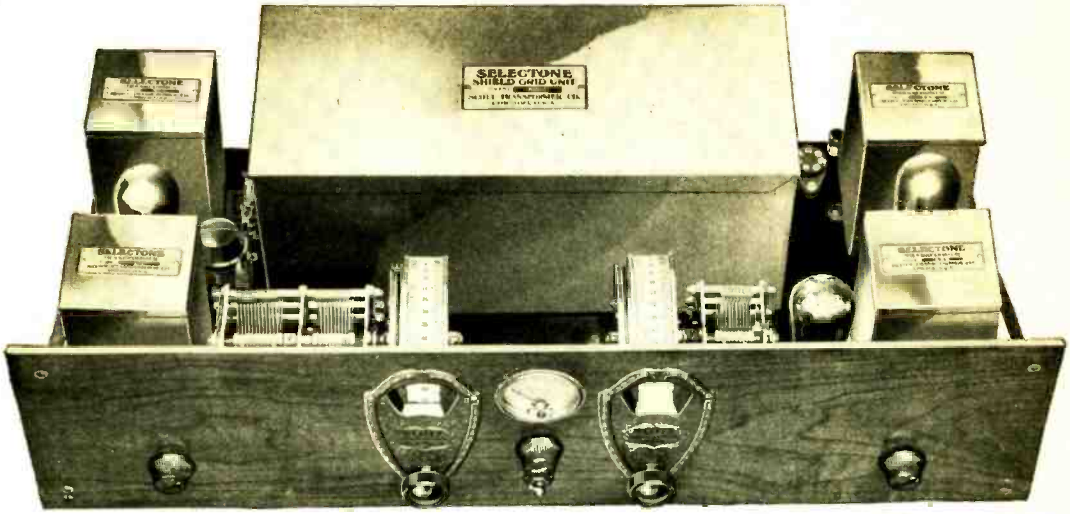

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Gives You Hair-Line Selectivity -- Wonderful Tone -- Tremendous Volume

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Here's a set with no tricky adjustments. You can build it in 4 hours easily. Panel and sub-panel are drilled to receive each part. Simply wire it up—plug in—and you have your receiver operating at maximum efficiency. Shielded Grid Amplifier Unit comes fully tested and wired. Transformers are perfectly matched, with no exterior adjustments to make.

Tuned R. F. and Shield Grid Long Wave R. F. Give Amazing Results

The output of the Scott Shield Grid Nine is much greater than the average good "super" for two fundamental reasons. First, the completely shielded stage of high gain T. R. F. delivers an input to the Shield Grid Amplifier equivalent to the output of the best 4-tube T. R. F. receivers. This gives the Shield Grid Amplifier a much stronger signal to work with, than in the ordinary straight "super"—a tremendous advantage obtainable in no other "super." The second reason for the greater output, is the design, construction and complete scientific shielding of the Scott Shield Grid Long Range Amplifier, affording this unit a far greater amplification factor than any existing screen grid long range amplifier.

Extreme Selectivity *Always Obtainable*

The tremendous output of the New Scott means extreme selectivity—not "fussy" uncertain selectivity, but razor-edge sensivity obtained in a stable circuit condition with tubes operated at normal voltage.

Precision Matching of Parts

The *New* Scott uses shield grid tubes in an improved circuit with new power pack and amplifier. All parts of this amazing receiver are designed especially for this set, and are matched with absolute precision. The extreme care taken in testing and matching of parts is one of the reasons why the New Scott outperforms in all competitive tests of distances, selectivity, volume and tone. All stations come in at one point only on the dial; a further improvement is evidenced in the fact that both dials track together.

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The *New* Scott Shield Grid Nine can be economically operated with dry batteries, and will give ample volume for the average home. The eight tubes incorporated in the receiver draw only 29 mils. Maximum volume is obtained by the use of the Scott Power Pack and Amplifier incorporating the ninth tube for the second stage of audio. This is the latest 250 power tube giving tremendous volume with perfect tone quality.

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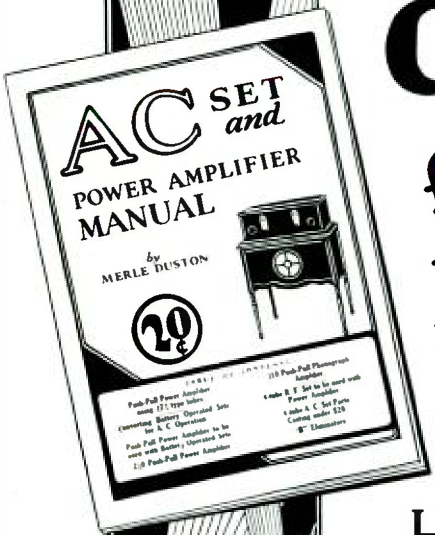

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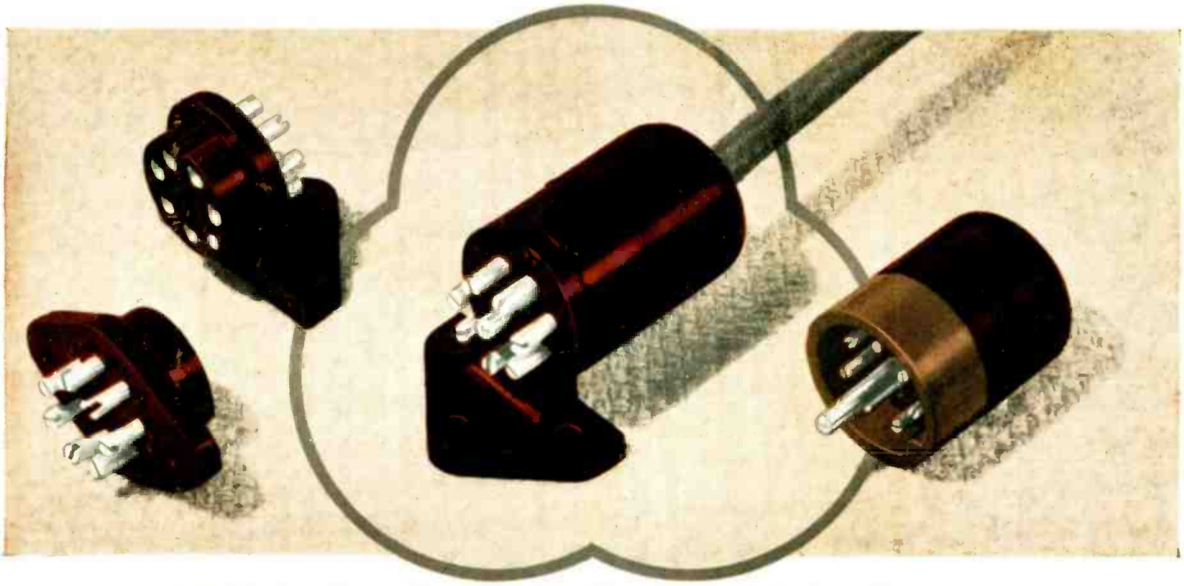

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