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RADIO ENGINEERING

Vol. VII DECEMBER 1927 Number 12

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The Technical Magazine of the Radio Industry

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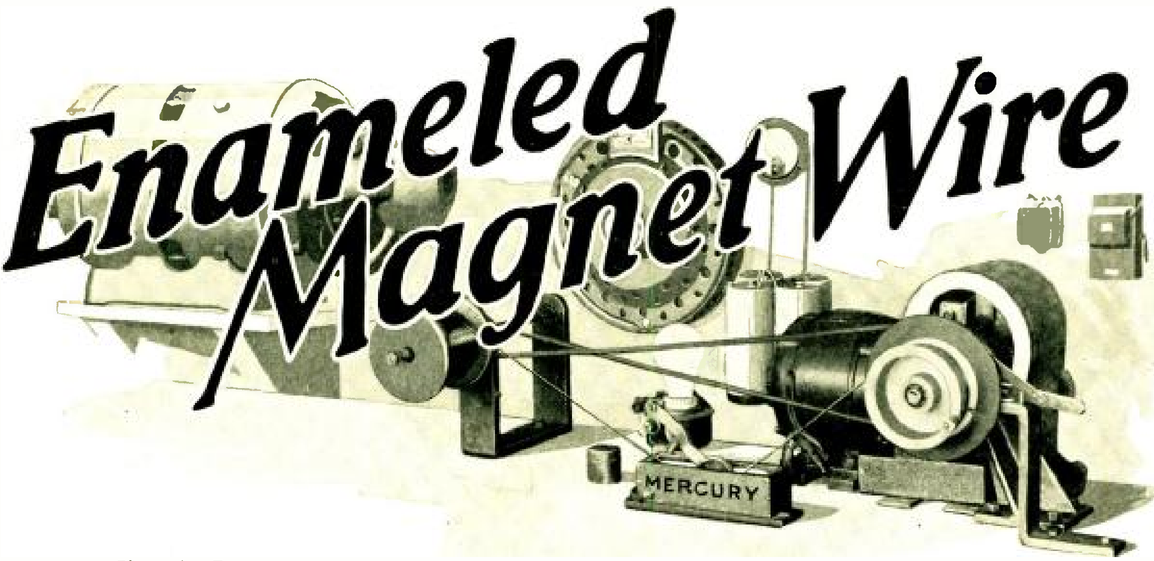

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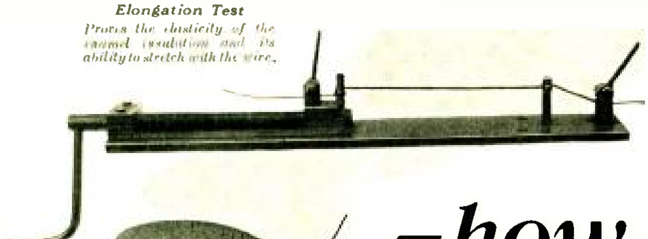

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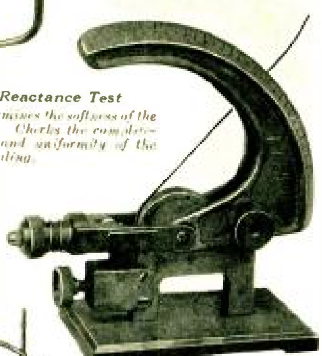

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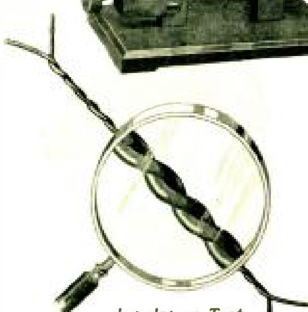

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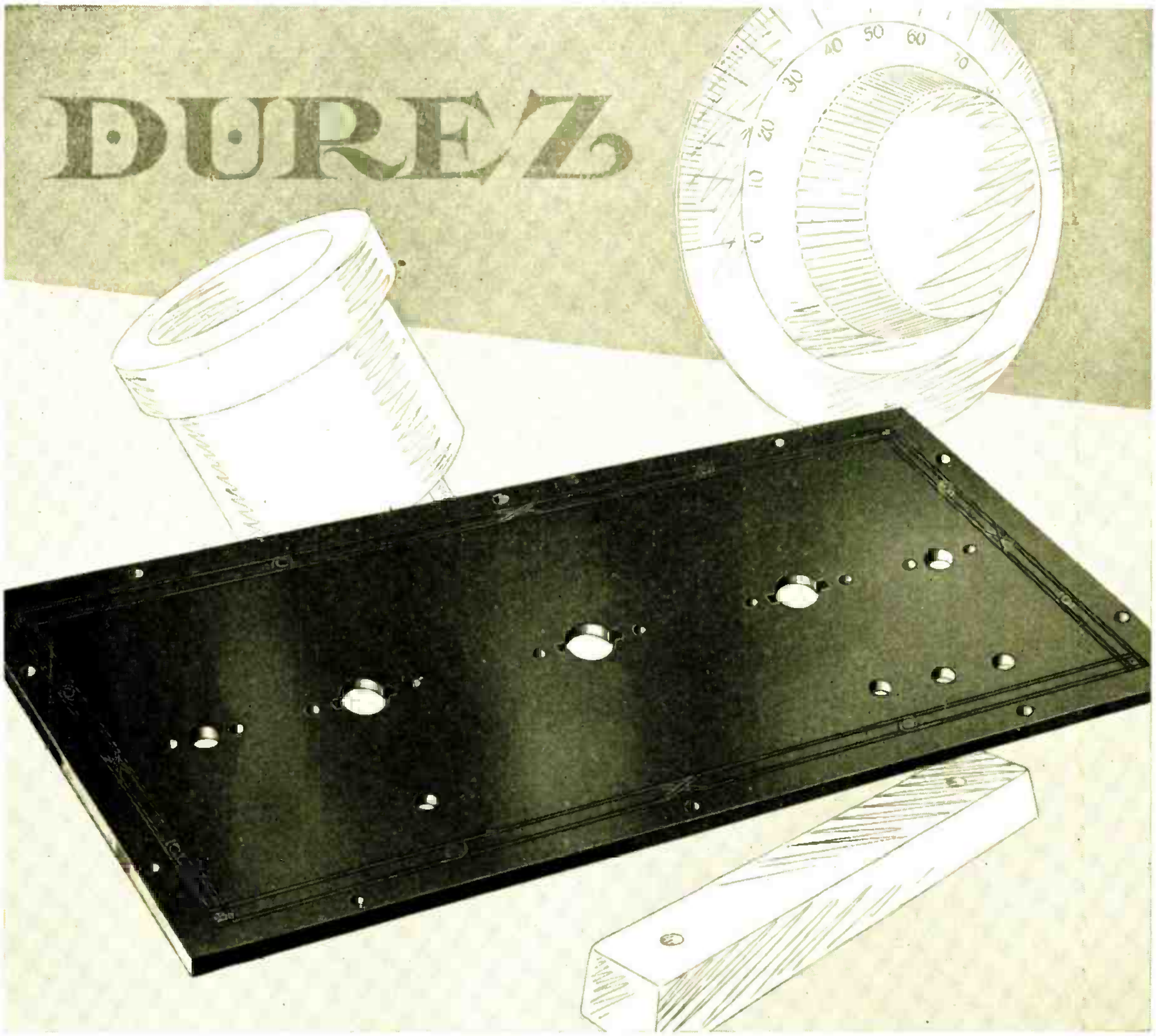

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RADIO ENGINEERING

52 Vanderbilt Avenue, New York, N. Y.

EDITED BY M. L. MUHLEMAN

Vol. VII DECEMBER 1927 Number 12

EDITORIAL

A WELL-KNOWN magazine dedicated to the art of advertising and selling has been indiscreet enough to publish on its first pages a morbid article entitled "Chaos in the Radio Market," which is alleged to be an up-to-the-minute analysis of the radio industry.

A careful survey of the article gives no indication of any relief. A brave and growing industry is allotted a black eye by the illustrious author who wrote the article *en route* to some place or another.

It is exceedingly difficult to understand why a magazine published in the interests of both advertising and selling should allow anyone to go through the motions of digging a grave in their own front yard.

The man who contrived this able piece of morbidity presumably felt that constructive criticism and intelligent suggestions were either out of order or beyond the limits of his pen.

What has happened is clearly indicated by the theme; the misguided writer has mistaken the reactions of a rapidly growing industry as chaos. If he had analyzed the situation at closer quarters, with his feet on terra firma, he would have found much to his astonishment that the present reactions are the result of a stabilizing force of which the average man connected with the industry is keenly aware.

For the benefit of the gentleman we might mention a few of the movements under foot which would have proved excellent material for the hind part of his wail.

Efforts of the Radio Manufacturers Association to bring about a single set of standards for the radio industry are at last achieving the desired results. All items on which there is no conflict shall be announced as Radio Industry Standards. On items on which there is a disagreement the American Engineering Standards Committee will endeavor to analyze the situation and establish the Industry Standard as rapidly as possible.

At a recent meeting of the RMA in Chicago Mr. C. C. Hanch, who was instrumental in bringing about stability in the automotive field through the formation of a patent pooling scheme worked out on the basis of cross-licensing, outlined in detail to members of the RMA exactly how the scheme was put over in the automotive field. A special committee has been formed to study the problem of patent pooling in other industries with a view towards a similar arrangement in the radio field. The Patent Pooling Committee is already functioning and undoubtedly will be in a position to submit a concrete report on the subject at an early date.

The Radio Parts Section of the RMA, a newly formed committee, is at present in full swing and their work is starting to show its good influence on business.

Together with the above are two major engineering developments which will shortly indicate their force on the economic situation.

We wish to re-state that there is no chaos in the radio industry. Present reactions are no more unusual than growing pains. The fact that there have been floods, cyclones and coal strikes, and a late season is certainly no indication that the radio industry is going to pot and it is decidedly obnoxious to have any scareheads tell ghost stories in our presence.

M. L. MUHLEMAN, *Editor*.

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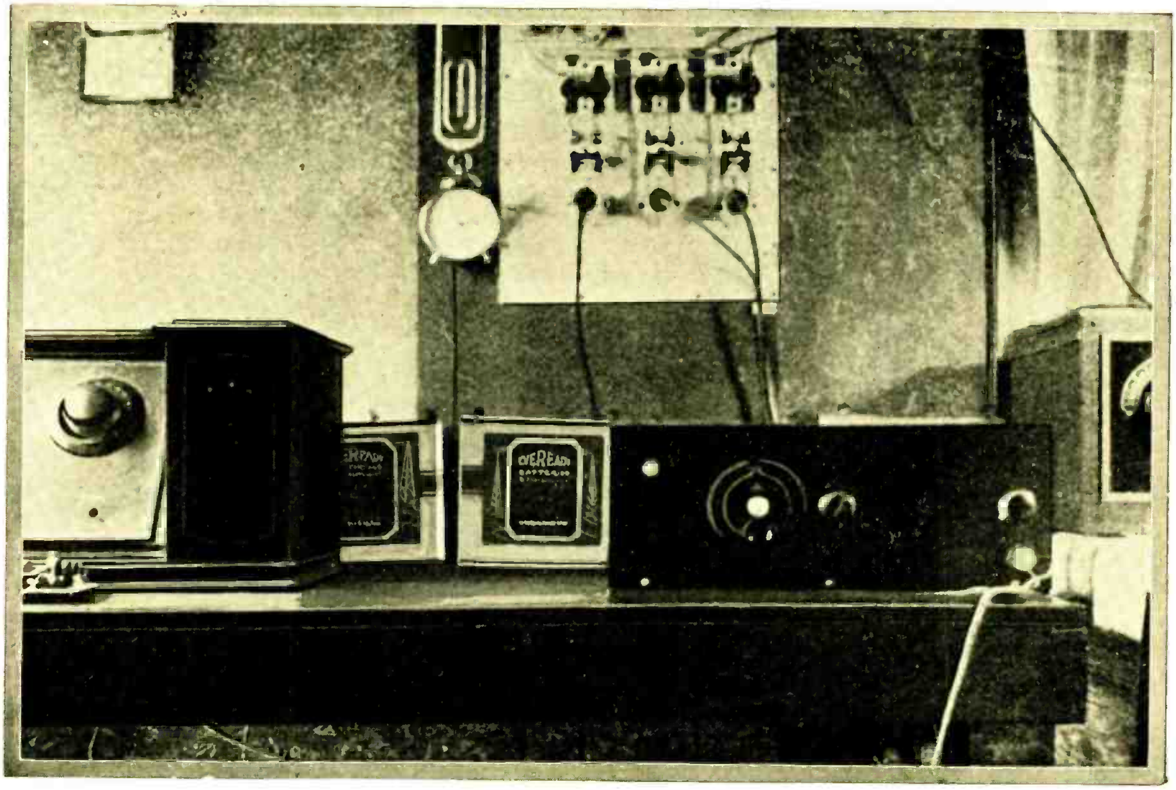

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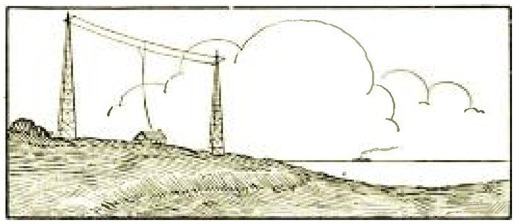


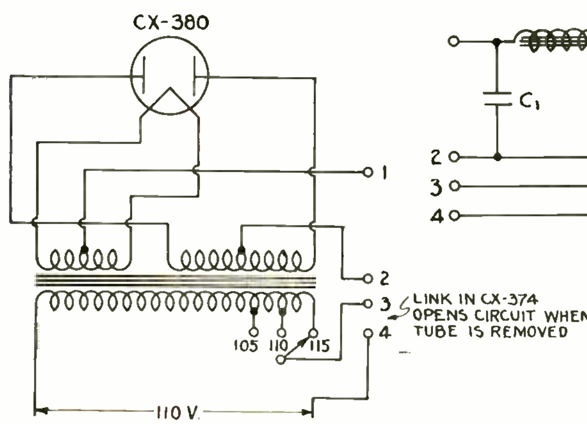
Filter Circuits for Filament Type Rectifiers

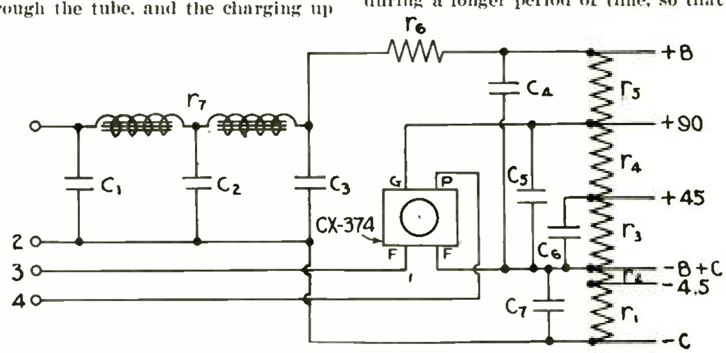
The Effect of Filter Design on the Operating Characteristics of the CX-380 and CX-381 Rectifier Tubes

By R. M. Wise*

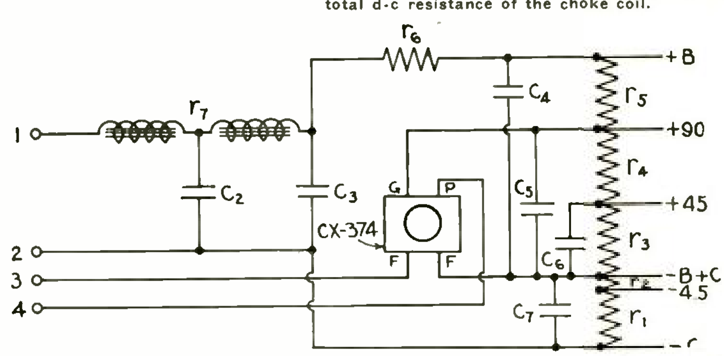
IN the course of experimental work in connection with the two new filament type rectifiers, CX-380 and CX-381, an oscillograph study of effect of filter design upon the load imposed upon the tube was undertaken. The results obtained were of exceptional interest, indicating that when the tubes are used as full wave rectifiers it is possible to greatly reduce the emission demand upon the filament, and the energy dissipated in the tube, by departing from the conventional circuit arrangements.

The circuit diagram, Fig. 1, together with Fig. 2-A, shows the conventional filter arrangement. In the series of experiments the following constants were used: inductances 10 henrys; condensers 4 mfd. each. With this circuit the peak current on the filament demand is very heavy. An oscillograph record of the performance of the CX-380 tube in this circuit, and operated at maximum rated output is shown in Fig. 3-4. The instantaneous transformer voltage is shown by the upper vibrator, the current through the tube by the middle vibrator and the load current by the lower one.





Left: Fig. 1. The transformer-rectifier circuit used in conjunction with the filter circuit 2-A, above, and 2-B, below. The values are: r_5 10,000 ohms; r_4 8,000 ohms; C_1, C_2, C_3, 4. mfd.; C_4, 2. mfd.; C_5, C_6, C_7, 1. mfd. r_6 prevents excessive voltage at the + Btap. r_7 is the total d-c resistance of the choke coil.



High Peak Current

This record shows that until instantaneous transformer voltage exceeds the first filter condenser voltage, no current flows through the tube. As the transformer voltage rises above this point, current starts flowing through the tube, and the charging up of the condenser causes a very heavy current to flow through the tube for a short interval of time, reaching a peak value of 310 m.a. Since the average current (equal to the load current) is only 125 m.a., the peak current through the tube reaches a value of 2.5 times the average current, a condition which must be taken into consideration in design of the filament of the rectifier tube. The filament must be capable of supplying this very high peak current and thus must be made heavier and longer than would be the case if the rectified current could be kept flowing during a longer period of time, so that the high peak current could be avoided. A very great improvement in this respect is made by using the filter circuit shown in Fig. 2-B, where the first filter condenser is omitted and the tube feeds directly into the inductance (or choke coil.) The oscillograph record, Fig. 4, shows clearly the very great reduction

* Chief Engineer, E. T. Cunningham, Inc.

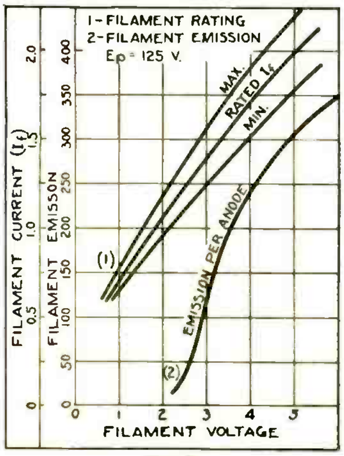


Fig. 5.

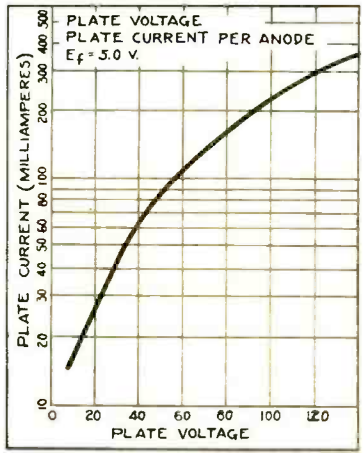


Fig. 6.

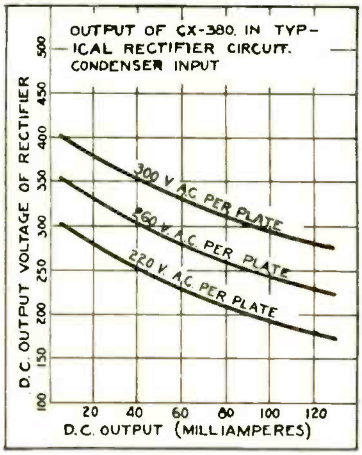


Fig. 7.

in peak current which is now only 140 m.a., or 1.1 times the average load current. The fact that the tube no longer feeds directly into a condenser and that the choke coil keeps the current flowing through one anode, or both, during the entire cycle, accounts for this change.

Choke Input Circuit

Some voltage is lost in the choke, but since this is a reactive load, it does not consume power and in fact the efficiency of the latter system is the higher of the two. Tabulated readings shown clearly bring out the superiority of the choke input circuit as regards tube operating conditions. The reduced peak current demand not only improves life because the filament is operated under better conditions, but also because the emission can fall to a very much lower value before the operating efficiency of the tube is impaired. Both factors tend towards longer tube life. A tube having a total available emission of 200 m.a. would be quite unsatisfactory with the circuit conditions of Fig. 2-A, but entirely satisfactory with those of Fig. 2-B.

The exact conditions under which the oscillograph records shown in Figs. 3 and 4 were taken are given in the tabulated data above.

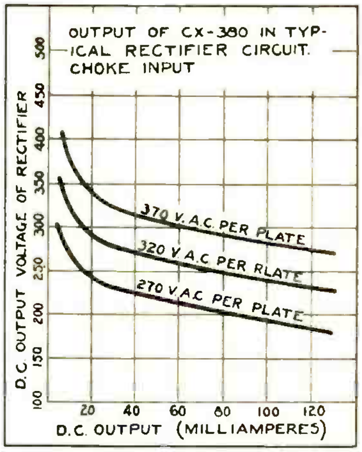
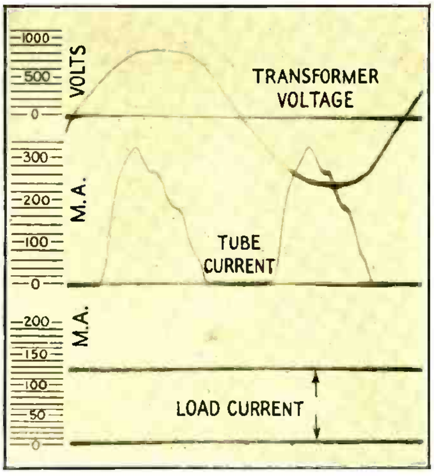


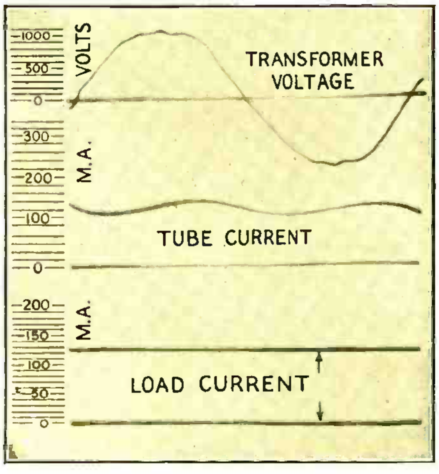
Fig. 8.

Fig. 3. (Below) Oscillograph record of output when using filter circuit of Fig. 2-A.

Circuit	Transformer Volts	Power Input Watts	Load Cur. M.A.	Load Volts	Power Output Watts	Efficiency
Usual Filter Figure 2-A.	300	62	125	300	37.5	60.5%
First Filter Condenser Omitted Figure 2-B...	360	59.5	125	300	37.5	63.%

Fig. 4. (Below) Oscillograph record of output when using filter circuit of Fig. 2-B.





Reduced Tube Losses

The slight difference in efficiency under the above conditions does not appear to be large enough to be of importance, but investigation shows that it is the result of reduced tube losses, the tube operating at an appreciably lower temperature with the choke input. (Further information on this point will be given in a second article.) Also the regulation is better with this arrangement, except at very low outputs, than with the condenser input, as shown by the curves of Figure 11, and by a comparison of the curves of Figures 7 and 8.

A summary of the relative merits of the two systems follow:

Condenser Input: (1) Maximum voltage output with fixed transformer voltage and (2) Better filter action.

Choke Input: (1) Improved regulation. (2) Improved efficiency. (3) Reduced emission demand on tube. (4) Reduced heating of tube and (5) (As a result of 2, 3 and 4) Improved tube life.

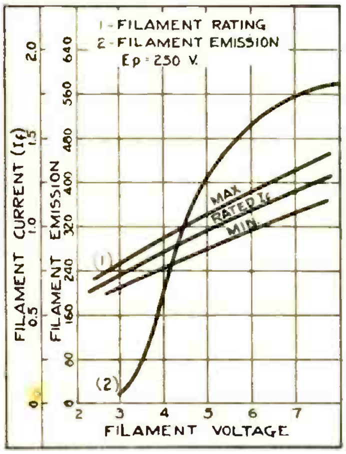


Fig. 9.

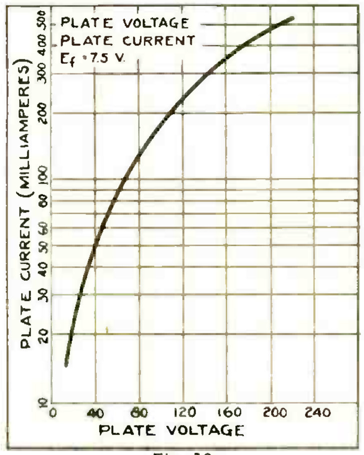


Fig. 10.

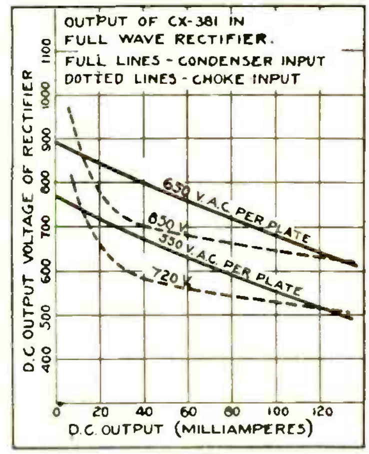


Fig. 11.

The circuit shown in Fig. 2-B, that is, the filter system in which the input filter condenser is omitted, cannot be recommended for half wave rectification, as the reduction in output current and voltage is quite severe and the operation of the filter is impaired. The usual circuit design should be followed, although a smaller input condenser, on the order of 1 mfd., will reduce the peak current demand on the tube without much reduction in output voltage.

The remaining figures show the average characteristics of the CX-380 and CX-381 rectifiers, for reference.

Fig. 5 shows the average filament current and average emission for this tube. It is evident that the tube can be operated slightly below rated filament voltage without affecting the output, as the change in emission current, above 4.0 volts on the filament, is small. These emission readings were also taken on the oscillograph, as it is not possible to allow the very heavy currents indicated to flow steadily for an appreciable length of time.

Figure 6 gives the plate current, plate voltage curve for an average CX-380 tube.

Figure 7 shows the voltage at the input to the filter with the usual filter arrangement. To obtain the output voltages the IR drop due to the filter

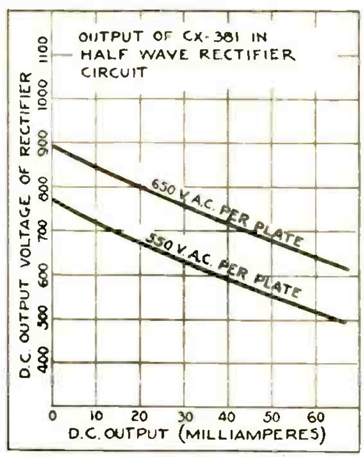


Fig. 12.

(choke) resistance must be subtracted. Thus as soon as the filter resistance is known the output voltage can be determined.

Figure 8 can be compared with Figure 7 showing as it does, the higher transformer voltage required by the choke input circuit, and also the superior regulation at current outputs above 20 m.a. As a matter of fact there is scarcely any change in output voltage from 25 m.a. to 125 m.a. although the IR drop in the filter chokes, if large, will impair this performance to some extent, although no more than in the case of the condenser input, Figure 7. In other words, if both Figures 7 and 8 were replotted to show the output voltage at the terminals of a filter having 1,000 ohms resistance, both would show a greater slope, but the curves of Figure 8 would still be superior.

In Figures 9 and 10 data similar to that presented on the CX-380 in Figures 5 and 6 is shown for the CX-381, while Figure 11 shows the comparative performance of a full wave rectifier using two type CX-381 tubes with the condenser (full lines) and choke (dotted lines) input circuits respectively. In a later article the effect of the change in filter design upon the ripple voltage in the output circuit, and the distribution of losses with especial reference to the energy dissipated in the tube, will be considered.

SELECT r_1, r_2, & r_3 FOR THE POWER TUBE TYPE AND VOLTAGE DESIRED.						SELECT (r_6+r_7) FOR THE TRANSFORMER & POWER TUBE TYPE SELECT r_6 FOR THE CHOKES. (r_7 IS THE TOTAL CHOKE RESISTANCE)							
						FILTER CIRCUIT "2A" (CONDENSER INPUT)				FILTER CIRCUIT "2B" (CHOKE INPUT)			
						TRANSF. SEC. VOLTS PER ANODE R.M.S.	TOTAL RECTIFIED OUTPUT*		(r_6+r_7) OHMS	TRANSF. SEC. VOLTS PER ANODE R.M.S.	TOTAL RECTIFIED OUTPUT*		(r_6+r_7) OHMS
POWER TUBE TYPE	+B VOLTS	-C VOLTS	r_1 OHMS	r_2 OHMS	r_5 OHMS		D.C. VOLTS	D.C. MILLIAMPS.			D.C. VOLTS	D.C. MILLIAMPS.	
1-CX-112A	160	-11.5	110	71	1270	220 260 300	226 271 327	63	865 1575 2470	270 320 370	215 258 303	63	690 1370 2090
1-CX-371	135	-27	317	63	818	220 260 300	217 263 320	71	775 1420 2230	270 320 370	210 253 297	71	677 1280 1900
1-CX-371	180	-40.5	480	60	1635	220 260 300	214 260 317	75	 527 1285	270 320 370	208 252 295	75	— 420 995
2-CX-371	160	-34.5	330	49	1270	220 260 300	200 248 302	91	60 587 1180	270 320 370	198 243 285	91	38 333 995
1-CX-310	250	-18	200	67	2900	220 260 300	222 268 323	67	— 0 820	270 320 370	212 256 300	67	— — 477

* *These values of d-c voltage and current from the CX-380 output curves shown in Figs. 7 and 8.*

A Unique Frequency Filter System

A Fundamentally New Method of Obtaining Radio Frequency Amplification

By E. A. Livingstone, M.E.*

IN systems for the selective reception of radio waves, it has hitherto been common practice to connect several tuned circuits in cascade by one of several coupling methods in all of which there was always an appreciable amount of reaction between adjacent circuits.

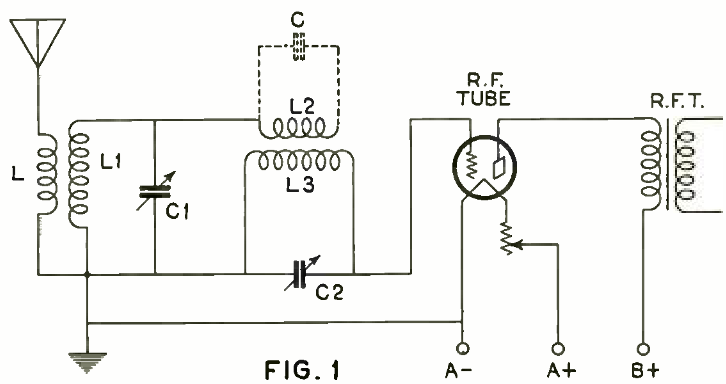


FIG. 1

Basic connections of the open primary circuit employed in Dr. Somersalo's frequency filter system.

The reaction between circuits destroys the selectivity of the tuned circuits and flattens out the resonance curve to such an extent that in extreme cases a double peaked resonance curve may result.

When direct coupling is employed, as in the filter circuits used by Stone in 1903, the coupling between circuits has to be very loose in order to prevent the reaction from destroying the selectivity. Loose coupling, however, prevents the efficient transfer of energy from one circuit to another.

After the discovery of the three-element vacuum tube by Dr. Lee De Forest in 1906, these tubes were used as coupling units, thus taking advantage of the supposedly unilateral coupling effect of the tube. This is the so-called tuned radio frequency system. However, it is now common knowledge that a vacuum tube relay is not unilateral in its coupling effect, due to the inherent capacity between the various electrodes, but will produce undesired reaction between the coupled circuits. If this reaction is not neutralized or suppressed, squealing and howling will result, thus causing interference and distortion in the reception of the signal.

As is common knowledge, the troublesome point in the tuned radio frequency system is the difficulty in properly stabilizing the circuits.

Obviously, the only way to overcome this difficulty was to design a system in which stabilization is unnecessary, a system, in fact, in which self-oscillations are unlikely to occur.

To the solution of this problem, Dr. George A. Somersalo, a well known Finnish Physicist, set himself several years ago, and as a result of his research and experimentation, he conceived and perfected a fundamentally new system which has in fact proven a complete solution.

Multi-Tuned Antenna System

In his system, Dr. Somersalo has entirely given up the idea of coupling two tuned circuits by means of a vacuum tube, which is the method adopted by Alexanderson and others and in which vacuum tubes with tuned input and tuned output circuits are used.

Vacuum tubes are, of course, used in the Somersalo system, but not between tuned circuits, as he found that self-oscillations are not likely to occur if only the untuned circuits are coupled by vacuum tubes. Therefore, in the Somersalo system, all the tuned circuits

* DeForest Radio Co.

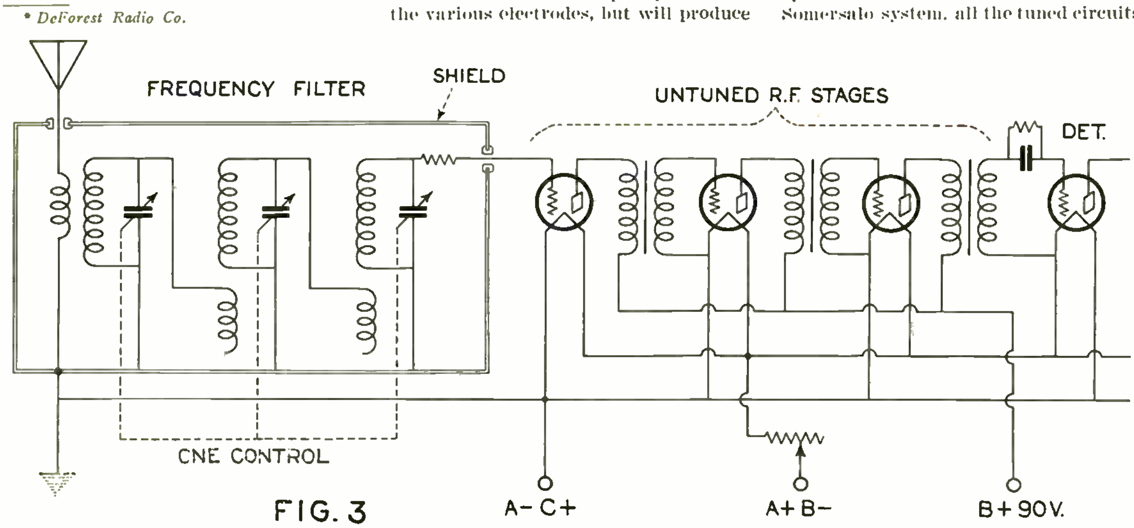
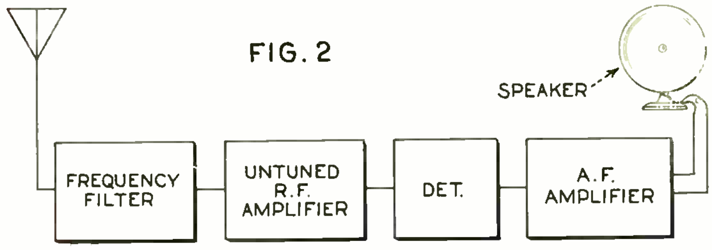


FIG. 3

Schematic diagram of the frequency filter, employing open primary circuits, and the untuned radio frequency amplifier.



Disposition of the units in Dr. Somersalo's new circuit.

are placed ahead of the first tube, thus forming a frequency wave filter. As a consequence, we have a multi-tuned antenna followed by an untuned R. F. amplifier.

To obtain both efficiency and selectivity with such an arrangement, every kind of filter was tried out including the old filters devised by Stone. It was found that in all these filters, connected direct in the antenna circuit, either efficiency or selectivity was absent. In other words, these filters could not be made to produce both efficiency and selectivity at the same time.

Open Primary Circuit

After further research, it was decided to use an open primary winding, as shown in Fig. 1.

In this arrangement the distributed capacity C causes a current to flow in the primary coil L2. This comparatively small current induces a field around the secondary winding L3, and sets up a far greater current. It is generally necessary to avoid mutual capacity between the windings, since this capacity tends to reduce the efficiency in the transfer of energy. In this system, the loss of energy is comparatively small as there is hardly any loss of voltage caused by the action of the step-up transformer. The signal, after passing through the filter, is about as strong as it was in the antenna provided the open coupling coils are large enough.

Considerable importance is attached to the size and design of these coils. If extreme care be not taken in this regard, the efficiency of the system is greatly impaired. Consequently, old coils, as used in ordinary T.R.F. amplifiers, cannot be used without modification.

Principle of Operation

Let us now trace a signal through the Somersalo system. After being intercepted by the antenna in the usual manner, it passes through the filter without any appreciable loss, then through the radio frequency amplifier to the detector whence it goes through an audio frequency amplifier to the speaker.

The process of "selection" is concentrated in the filter and that of "magnification" in the amplifier. Thus these two processes have been separated, making selectivity and amplification quite independent of each other. If it is desired to increase the selectivity, one extra filter stage is added to the circuit. If greater efficiency be required, one R.F. amplifier stage is added. Dr. Somersalo claims that this is not only more logical but more efficient than the tuned radio frequency system.

It has been demonstrated that squealing is conspicuous by its absence. The amplifier tubes do not require balancing or neutralizing. In the first tube, however, a peculiar effect may sometimes be experienced. If the feedback, due to inherent gridplate capacity is too great, the energy in the last filter stage is increased and made far greater than in the preceding filter stages. This may impair the tuning in all except the last stage, but is easily remedied by the insertion of a resistance in the grid lead of the first tube to reduce the feed back.

The circuit diagram shows a method of controlling the feed-back in the first tube, but any other control system may be used. This control is not critical, and it is quite difficult, even by manipulating the feed back control, to make the circuit squeal. The main object of this control is, of course, to vary the volume.

A practical application of the Somersalo system is shown in the circuit diagram Fig. 3.

The method of tuning or "selection" is clearly shown in the shielded filter system on the left. After passing through the filter without any appreciable loss in the overall amplification, the selected signal is amplified by the untuned R.F. stages, whence it passes to the speaker in the usual manner via the detector and A.F. amplifier.

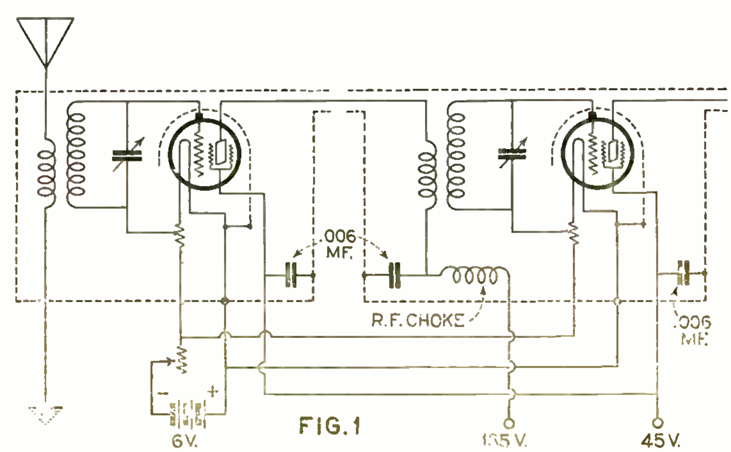
More Details on the Screen Grid Tube*

The Technical Characteristics, and Its Use in Radio Circuits

THE screen grid tube is a distinct departure from the conventional type of three element radio tube. The unusual characteristics and performance obtained from this tube are made possible by the introduction of a second grid, of novel design, which extends between the usual grid and the plate, and is also carried over outside the plate. Thus the plate is completely shielded or screened from the control grid by the second grid.

If the plate is left disconnected, and the screen grid used as the plate electrode, the tube operates in a manner exactly similar to the usual three element tube, having an amplification factor of 6.5 and a plate resistance of 15,000 ohms.

In operation as a four element tube



Tuned R.F. amplifier employing the screened plate tubes. Contrary to previous arrangements R.F. transformers are used. Note the shielding around the tubes.

* Engineering Dept., E. T. Cunningham, Inc.

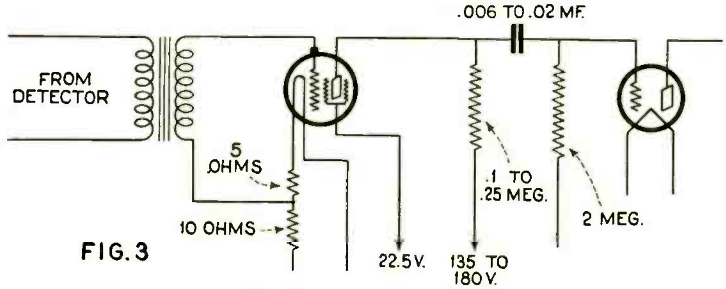


FIG. 3

As indicated, an A.F. transformer can be used for coupling the detector to the screened plate tube but due to the excessively high output impedance of the latter tube resistance coupling between this tube and the power tube is advisable.

a voltage of approximately 45 volts is applied to the screen grid, and a higher voltage (90 to 135 volts) is applied to the plate. The effect of this method of use upon the performance of the tube is explained in the paragraphs below, dealing with the use as an amplifier.

The filament provided in the CX-322 is rated at 3.3 volts .132 amperes. For use as a five volt tube see rheostat recommendations. When used as an R.F. amplifier only, the filament may be operated from an A.C. source by means of a step down transformer.

The Elements

The control grid, cylindrical in form, is arranged in a manner similar to that of the '99 type tube, except that the connection to this element is brought out at the top of the bulb. The screen grid is interposed between the cylindrical plate and the control grid, completely surrounding the plate as described above, and eliminating almost completely all electrostatic capacity between control grid and plate. The plate is also cylindrical and larger in diameter than that used in type '99.

The somewhat complicated mechanical structure requires unusual skill in design to secure a rigid structure. The design has been very carefully worked out and the tube is more rugged than the average type of receiving tube.

Use as Detector

The tube may be used as a detector with grid leak and grid condenser or with grid bias. Resistance coupling with connections similar to those shown in Fig. 1, is recommended as giving the most satisfactory frequency characteristics because of the high internal resistance of the tube.

Use as a Radio Frequency Amplifier

This tube has been especially designed for use as an R.F. amplifier. When so used the most important advantage gained is elimination of all feed back through coupling between grid and plate, due to capacity between these elements. It is also possible to obtain higher voltage amplification per stage, 25 to 50 in the broadcast range as compared with the usual range of 5 to 12 per stage with three element tubes.

In the operating range the plate current does not vary appreciably with changes in plate voltage, this being due also to the screening effect of the second grid. As a result the amplitude of the plate current change, caused by a signal voltage impressed on the grid is scarcely affected by an increase in load resistance. Thus it is of advantage to use a very high resistance or impedance in the plate circuit, in order to obtain high voltage amplification.

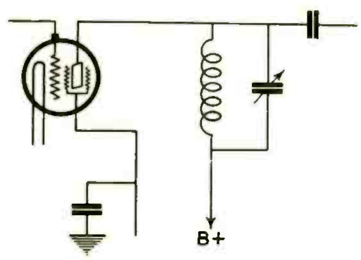


FIG. 2

Optional method of R.F. coupling, employing a tuned plate circuit and grid coupling condenser.

The voltage amplification depends only upon two factors:

1. The mutual conductance of the tube, which determines the amplitude of the plate current change, resulting from a signal voltage impressed on the control grid.

2. The load impedance. The voltage across the output load is directly proportional to the local impedance, since the amplitude of the signal current remains unchanged with an increase in impedance. This is unlike the condition with three element tubes, where an increase in load resistance results in a decrease in the amplitude of the signal current.

At low radio frequencies, 50 to 100 kilocycles, it is possible to build up a very high load impedance by using a tuned plate circuit, and a voltage amplification of 200 per stage is obtainable. At broadcast frequencies it is not possible to obtain a sufficiently high load impedance to realize maximum voltage amplification, and the values quoted above represent average results (25 to 50 per stage).

Since the voltage amplification depends only upon the load impedance and mutual conductance it may be quickly computed when these values are known. The voltage amplification obtained with a load impedance of 100,000 ohms, using a tube having a value of mutual conductance of 350 micromhos (.00035 mhos.)

Av—100,000 x .00035—35 per stage with 250,000 ohms.

Av—250,000 x .00035—87 per stage.

It is possible to obtain the desired high load impedance by use of a tuned circuit connected in series with the plate, but it may be preferable to use a transformer connection with a ratio of 1.1 or slightly lower so that low frequency disturbances do not reach the grid of the succeeding tube and to facilitate the use of ganged condensers for uni-control. Both connections are shown in the circuit diagrams of Figs. 2 and 3.

Shielding

Although the internal shielding prevents feed back through the tube interelectrode capacities, this is only one source of coupling between stages, and it is also necessary to shield the input circuit from the output circuit. The amount of shielding necessary will depend upon the voltage amplification per stage and the circuit design. A metallic shield enclosing each tuned stage is usually sufficient, as indicated in the circuit diagram. It may be necessary if the voltage amplification is high, to place a metal cap over the tube, extending to the base, and connected to ground. Clearance for the grid connection must be provided at the top.

Use as an Audio Frequency Amplifier

The tube may be used as an audio frequency amplifier with resistance coupling, the connections being the same as when the tube is used for radio frequency amplification, except that the screen grid voltage should be lowered to compensate for the voltage drop in the load, unless a high plate voltage is available. With this connection a voltage amplification of 35 per stage may be readily obtained with perfectly flat frequency characteristics down to 50 cycles and below (the lower limit is fixed only by the size of the blocking condenser); and extending on the high frequency and well above 10,000 cycles.

Characteristics of Tube

Filament Volts	3.3
Filament Amperes	.132
Control Grid Volts (Average)	—1.5
Screen Grid Volts (Average)	45.
Plate Volts	90 to 135
Mutual Conductance *(micromhos)	300
Plate Resistance (*ohms)	1,000,000

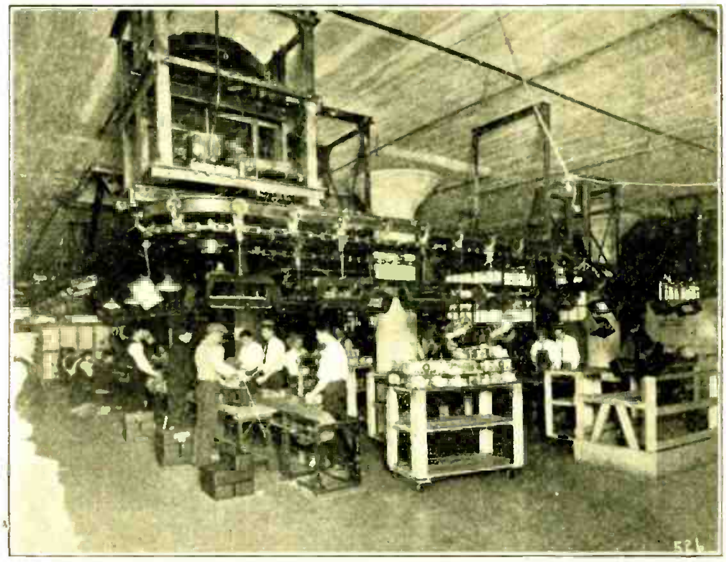
Interelectrode capacity, plate to control grid (max.). .025 mmf

*Grid voltages as specified above, plate voltage 135.

"Mile-a-Minute" Production*

An interesting story of production in the plant of a large radio set manufacturer

FROM the commencement of his activities in the radio field, Powel, Crosley, Jr., has held the conception that radio receivers should be sold at popular prices made possible by advanced methods of production. When it is considered that the factories of the Crosley Radio Corporation are now manufacturing some four thousand of receiving sets of one type alone each day, it will be readily apparent that raw materials of which these sets are constructed can be purchased in tremendous quantities, which, of course, greatly lowers the unit price. Coupled with this in bringing down the cost of receiving set construction is the fact that the personnel and the time consumed per operation is brought down to the minimum by machinery of the most modern design and highly progressive and efficient production methods.



Where cabinet and chassis meet—showing the overhead conveyor.

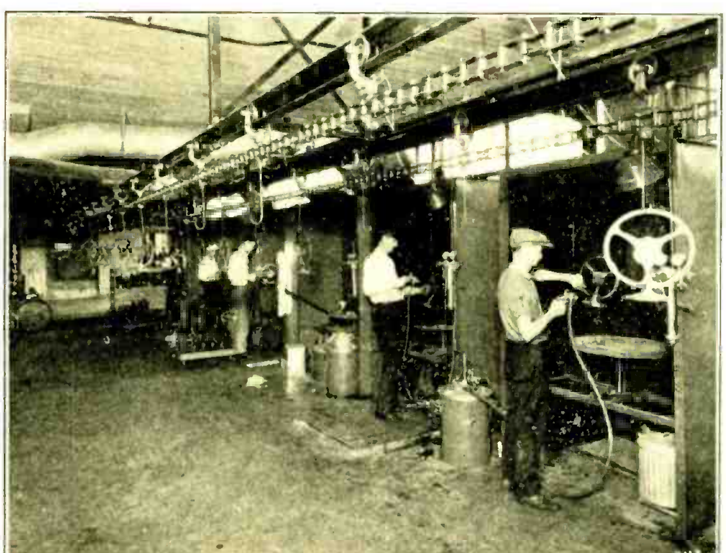
Crosley production, so far as receiving sets are concerned, now is concentrated upon one model, the six-tube single control set, which, however, is made in two types, one for battery operation and the other for operation direct from the lamp socket. In addition to receiving sets, the corporation manufactures loud-speakers in three designs, power units for the socket-powered receiver; a low-wave unit, which when attached to a radio set will provide short-wave reception; and an electrical pick-up device for connecting a phonograph to a radio set and loud-speaker, giving the former the advantages of electrical reproduction. All of these products are manufactured in the Crosley factories in Cincinnati, comprising four buildings.

* *Courtesy of The Crosley Radio Corp.*

Description of Plants

In the main building, known as Plant No. 1, the sets are assembled. Here also the loud-speakers, low-wave units, power converters and electrical pick-ups are manufactured. This plant is, in reality, two buildings joined together, a capacious, six-story reinforced concrete structure having been added recently to the original building. The studios of the Crosley super-power broadcasting station WLW, and the general offices of the corporation, also are located at this plant.

Production, however, really begins in Plant No. 2, which formerly was the main plant. Here rheostats (in three types), filament switches, sockets (in three types), dial lights, audio frequency transformers, radio frequency coils, various filament resistances, grid-leak mountings, balancing condensers, antenna choke coils, power converter transformers and chokes, and other parts are produced. Practically all of the parts used in the sets, it may be noted in passing, are manufactured by the corporation.



The spraying booths where the metal cabinets and loud speaker frames are painted by air brush.

Production Facilities

One's first impression upon entering the main plant is one of tremendous activity. Conveyors click merrily along overhead; others carry sets and parts through long aisles of workers. There are approximately 1,500 feet of overhead conveyors in the Crosley factories, and 1,200 feet of endless belt conveyors. In addition, there are 500 feet of gravity conveyor. Where-ever it is possible for machinery to

The "English Roundhouse", where 3,000 sets are balanced and tested daily.

enable work to be done better and faster than it could be performed by hand, machinery is used.

The first stages of the assembly of a receiver take place on the sixth floor of Plant 1. Here the variable condensers for tuning the receiver to the desired frequencies are made. In the mass production of these condensers, the "die casting" process is utilized. A battery of ten huge die-casting machines was installed early in 1927, this work having been done previously on the outside. The familiar rotor and stator plates of the required number to make up either two complete rotor or stator sections are placed in this machine by the operator, who then, by proper manipulation of the controls, causes the injection of molten "white metal" at 800 degrees Fahrenheit into the die housing the individual plates. This seals or fixes them in the proper position with respect to each other. It also provides uniform spacing between them as well as perfect electrical contact, thereby reducing to a minimum losses and the possibilities of short-circuiting.

It is interesting to know that this metal is forced into the die and about the plates at a pressure of some 380 pounds to the square inch, the entire operation of injection taking place virtually instantly, and seeming not unlike the loading and firing of a gun, a sharp air pressure exhaust explosion taking place at the time.

After being washed and trimmed, the condensers are assembled on the frame of the chassis, which is taken by the conveyor to another part of the same floor, where the dial and other appurtenances are affixed. The conveyor then takes the embryonic chassis to the fifth and fourth floors, where the major portion of the assembly work is carried on.

Checking and Testing

Assembly of the chassis being completed, the next step is the "neutrodyning" or balancing and the inspection. The assembled chassis is conveyed to the third floor where a novel testing booth, only recently has been erected. This is known as the "English Roundhouse," a name given it because of its narrow and elongated appearance.

In England, locomotives are not housed and serviced in circular roundhouses as is the case in this country, but they are lined up in long sheds.

The "English Roundhouse" is divided into two compartments, one for balancing and one for testing. There are thirty neutrodyning or balancing positions in the one compartment and twenty-one checking or testing positions in the other. There is an aisle in the center and a line of employees on each side. Each worker has an individual and replaceable test table containing all the apparatus necessary for the work, together with an individual electric light and a locker to hold the tube and fixtures for connecting the set to the test rig. Behind the two lines of test tables run belt conveyors. These conveyors bring the receiving sets first to the balancers. When the balancing operation is completed, the worker places the set on the same conveyor and it is taken to the checkers where it is completely tested and its performance measured on especially designed instruments.

Three thousand sets a day can be balanced and tested by the workers in this booth. A system of vari-colored labels is used by the checkers in routing tested sets.

Painting by Air Brush

In the meantime on the second floor men are busily engaged in spraying a brown finish on the metal cabinets in which the sets are furnished, also on the loud-speaker frames. This is done in fourteen modern, individual spraying booths to which the cabinets and frames are brought by overhead conveyors. After the spraying the cabinet goes by conveyor to a large oven which is divided into two closed sections, one for producing the crystalline effect and the other for baking the finish. It then passes through a third section which is exposed, allowing the metal to cool before being handled. The same treatment, of course, is given the loud-speaker frames.

When the cabinet becomes cool enough to handle, it is again placed on an overhead conveyor and taken up to the third floor where it is attached to the chassis and inspected. After a final inspection the set is ready for packing. In this process the belt conveyor is also used. When the packing process is completed, the sets travel on the belt conveyor to a gravity conveyor which deposits them in the shipping room on the first floor. On this same floor is located the Receiving Department, also the departments in which all parts are cadmium plated. This prevents rusting and gives the part a bright surface. Each set requires five square feet of cadmium plating.

Special Machines

Much might be written about various phases of the manufacture of Crosley sets and concerning some of the novel machines employed in the work. Among these is an automatic tempering or hardening furnace, heated by electricity and used for hardening the steel magnet segments employed in the loud speakers. The individual unit is fed into the machine automatically, heated to a red hot temperature and dropped into an oil bath which hardens the steel. It is then conveyed to a washing compartment where the oil and scale is washed off. This completes the operation, the whole taking place in the one machine in a period of three minutes. A number of individual segments undergoing the treatment simultaneously, of course, as many thousands are needed for producing the thousands of complete loud speakers marketed.

At the present time the Crosley Radio Corporation employs more people than any other industry in Cincinnati.

The Mathematics of Radio

The First of a Series of Articles Covering the Use of Mathematics in Everyday Radio Work

By John F. Rider, Associate Editor

THE "Mathematics of Radio" is somewhat of a misnomer although it is descriptive of what is to follow. At first glance one would immediately construe this paper to be a technical discussion of the theoretical considerations of radio; a discussion of radio phenomena. Such, however, is not the case. We intend to consider technical phases of radio, but not along generally accepted lines. Transmission and reception phenomena will be ignored, but the mathematical calculations of the units associated with transmission and reception phenomena will be accorded detailed consideration.

It is customary nowadays in every day radio literature to introduce and discuss various formulae associated with the subject at hand. The formulae presented in the text is however, very seldom discussed, with the result that the average reader does not fully assimilate the subject matter. Consequently the value of the article is lost, and the author's efforts partially wasted. The reader on the other hand is somewhat disappointed, discouraged at his failure to comprehend ... Perhaps he has heard about the subject discussed in the article. He viewed the article with delight ... at last he would understand. He reads the article only to meet with failure ... He cannot follow the formulae ... Why did the author fail to give an example of the function of the formula, to illustrate the use of the series of figures and symbols.

The "Mathematics of Radio" is intended to clarify just such situations; to function as a medium whereby the reader will obtain information of a mathematical nature which will make possible the assimilation of information contained in radio discussions and periodicals. We do not mean to say that a study of the contents of this series will make the average radio man, a mathematician. Neither will it permit of the comprehension of the complex and intricate formulae encountered in radio design and theoretical discussion. It will, however, give this man the knowledge and information required in order that he be in a position to fully comprehend the simple details of design of the average radio receiving equipment, and to fully assimilate the information contained in the everyday radio article found in the present day radio press.

The greatest fault to be found with the average radio man, appertaining to the comprehension of technical details and formulae, is an unnecessary inherent fear of the subject. Not that the individual approaches the subject with trepidation, but rather that he considers it above his mental calibre and capabilities. He is very desirous of a thorough grounding in the subject, yet fears to enter its realm ... This fear should be dispelled. This text is not purported to be a psycho-analytical discussion, but experience with numerous men has conclusively demonstrated to the writer that the average radio man can thoroughly master many of the technical details which he considers beyond his comprehension.

Another great fault found among radio men, which hinders understanding, is a distorted idea or image of what the subject portrays. They meditate upon a paragraph or a quotation by some author. If the picture does not agree with that in their minds, no attempt is made to alter the erroneous image. They just pass the subject. Upon the arrival at an associated subject, which would be perfectly clear, were they thinking along the correct lines, they are hopelessly befuddled. An essential to comprehension is to view things with an open mind. Not that the reader should not attempt to visualize, he should do so by all means, but not to entertain a fixed idea which cannot be changed.

Some of the material contained in this series will strike the reader as being old, rehashed. If it is, pass it by. It cannot be omitted because it is new material to many others, and we must consider all; not a select few.

> **The Problem of Power Supply**
>
> Radio Engineering is pleased to announce a series of educational articles covering the problem of power supply, by Conner Crouse who is one of the leading authorities on the subject.
>
> There will be six articles in all, dealing with the technical considerations surrounding the following:
>
> 1. The effect of various types of Power Supply on the Radio Receiver.
> 2. Rectification.
> 3. Filters.
> 4. Condensers.
> 5. Transformers and Inductances.
> 6. General Summary.
>
> The first article will appear in the January issue.

The Properties of Wire

Radio, while a method of transmitting intelligence from one point to another without the direct aid of wire as a linking medium, utilizes a great deal of wire in the equipment which produces the forces utilized in the transmission and the reception. Hence the first important consideration is wire.

Wire is classified in two ways. First, we have wire which conducts electricity easily or is a good conductor and second, we have wire which is a poor conductor of electricity. The second category is usually listed as being resistance wire. The question now arises relative to the conductivity properties of the wire. Why should one wire conduct better than another? The average answer would consider the substances comprising the wire. We know that to be true ... We know that certain metals will conduct electricity better than others. We also know that certain combinations of metals will offer a great resistance to the flow of electricity. That, however, is not the basic difference. The reason is believed to be the atomic structure of the wire. The atomic structure consideration applies to all substances as well, but since we are discussing wire, we will apply it directly to wire. The substance or substances constituting the wire consist of molecules in a certain formation, each molecule in turn consists of a number of atoms in a certain formation, and each atom in turn consists of a number of electrons revolving around an ion. The molecules in any substance are in a continual state of agitation, and in this state of agitation collide with each other. During the process of collision, electrons are detached from the atoms and drawn into other atomic structures which have lost an electron. The ease with which an atom parts with an electron is considered to be indicative of the suitability of that material as a conductor of electricity. Consideration of the molecular activity in a wire explains why a thick wire is a better conductor of ordinary A. C. and D. C. current than a thin wire. Assuming any one conductor made up of one or more metals, the greater the density of that conductor the greater the possibility of collision between molecules and the greater the possibility of electronic activity. The possibility of more molecular collisions is founded upon the fact that more molecules are found in a thick wire than in a thin wire, assuming, as has been mentioned above that the materials constituting the wires are the same, differing only in amount.

Temperature Coefficient

Temperature displays an effect upon the wires by altering the molecular construction, and by altering the molecular construction changes the conductivity properties of the wire. Since it changes the conductivity, it changes the resistivity. The change in resistivity with temperature is known as the temperature coefficient of the wire. This term is frequently mentioned in radio text, particularly in the discussion of resistances subjected to heat, such as in battery eliminators. A substance which increases in resistance with increase in temperature, is said to have a positive temperature coefficient, and conversely a substance which decreases in resistance with an increase in temperature is said to have a negative temperature coefficient. All pure metals have positive temperature coefficients. Alloys have lower values of positive temperature coefficient than pure metals.

The following table gives the temperature coefficients of various metals and the methods of determining the resistance at various temperatures of materials will be discussed.

Table No. 1 (Smithsonian Table)

Metal or Alloy	*Standard Temperature Centigrade*	*Temperature Co-efficient*
Aluminum Hard Drawn	18 deg	plus .0039
Brass	20 deg	plus .002
Climax	20 deg	plus .0007
Constantan Advance Eureka	12 deg	plus .000008
Copper Annealed	20 deg	plus .00393
" Hard Drawn	20 deg	plus .00382
German Silver 18% Ni	20 deg	plus .0004
Gold Pure Drawn	500 Deg ann'ld	plus .0035
Iron 99.98% Pure	20 deg	plus .005
Lead	20 deg	plus .0039
Manganin 84Cu 12Mn 4 Ni	12 deg	plus .000006
Mercury	20 deg	plus .00089
Molyodenum Drawn	25 deg	plus .0033
Nichrome	20 deg	plus .0004
Nickel	20 deg	plus .006
Platinum	20 deg	plus .003
Silver 99.98% Pure	20 deg	plus .0038
Steel Manganese	20 deg	plus .001
Piano Wire	0 deg	plus .0032
Tantalum	20 deg	plus .0031
Tin	20 deg	plus .0042
Tungsten	18 deg	plus .0045

The formula for determining the resistance of a certain metal at a given temperature is

Rgt = Rs (1 plus As x (t — ts) (1)

Rgt is the resistance at the given temperature

Rs is the resistance at the standard temperature

As is the temperature coefficient given in Table No. 1

t is the given temperature in degrees Centigrade

ts is the standard temperature given in Table No. 1

Suppose we wish to determine the resistance of a length of Nichrome wire at 100 degrees centigrade. It is 1000 ohms at 20 degrees centigrade. Substituting in the formula above we have

Rgt = 1000 x (1 plus .0004 x (100 — 20))
= 1000 x (1 plus .0004 x 80)
= 1000 x 1.032
= 1032

Rgt = 1032 ohms

Suppose we have brass wire. It has a resistance of 3 ohms standard temperature. Current is passed through it and its temperature goes up to 48 degrees Centigrade. What is the increase in resistance?

Substituting in the formula we have

Rgt = 3 x (1 plus .002 x (48 — 20))
= 3 x (1 plus .002 x 28)
= 3 x 1.056
= 3.168

Rgt = 3.168 ohms

The above formula applies to all metals and not only to the ones utilized in the illustrations. The same is true of temperature values. As a matter of information all pure metals decrease in resistance as the temperature is lowered and at —276 degrees Centigrade (absolute zero of temperature) all pure metals would have zero resistance.

The increase in temperature can be determined if the resistance at the unknown temperature is known. The formula is as follows:

$$t - ts = \frac{Rgt - Rs}{As \times Rs} \qquad (2.)$$

Suppose we know that the resistance of the brass wire increased from 3 ohms to 3.168 ohms. What was the rise in temperature? Substituting in the formula we have

$$t - ts = \frac{3.168 - 3}{.002 \times 3}$$

= 28

t — ts = 28 degrees C (rise in temperature)

ts = 20 degrees C (standard temperature)

t plus ts = 48 degrees C (operating temperature)

This figure checks with the above. Let us check back the Nichrome wire.

$$t - ts = \frac{1032 - 1000}{.0004 \times 1000}$$

= 80

t — ts = 80 rise in temperature

ts = 20 degrees C (standard temperature)

t plus ts = operating temperature
= 80 degrees C plus 20 degrees C = 100 degrees C

This figure checks with the first test. Incidently, another method of determining the value of operating temperature is as follows. Assuming the formula used if

t — ts = 80 degrees C

and

ts = 20 degrees C (standard temperature)

t = 100 degrees C (temperature desired)

since 100 — 20 = 80

With respect to substances possessing negative temperature coefficients, these include glass, carbon, quartz and porcelain. In other words when the temperature is increased, the resistance of these materials decreases.

In close association with wire in every day radio practice we come in close contact with Ohm's law as applied to D. C. circuits. Ohm's law is also applied to A. C. circuits but with some modifications and will be considered later in the text. Ohm was a physicist who propounded laws covering voltage, current and resistance; voltage to be expressed as volts, current as amperes and resistance as ohms.

Expression of Fractions

The volt is the unit, but ofttimes mention is made of fractions of a volt and expressed as a *millivolt* or a *microvolt*. The prefix *milli*, is used to denote a thousandth part and a *millivolt* is therefore a thousandth part of a volt. Likewise the prefix *micro* denotes a millionth part of a volt and a *microvolt* is a millionth part of a volt. The term *kilo*, is used to denote thousands and one *kilovolt* would be 1000 volts.

Very often units are expressed as powers of 10, being negative or positive according to the sign associated with the figure denoting the power. When it is positive the plus sign is omitted, but when it is negative the minus sign is always included. Expressing figures in this manner is a decided convenience and space conserver. For example, if we wished to express the term 10,000 volts. As a power 10 it would be shown as

10^4 or 10 to the fourth power, = 10x10x10x10.

1,000,000 would be 10^6 or 10 to the

sixth power, = 10x10x10x10x10x10.

If it were 2,462,000 it would be shown as

$2.462 \times 10^6 = 2.462 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10.$

When the figure is greater than 1 the power sign is always positive as illustrated above, but when the figure is a decimal part of 1 the power sign is negative, for example a 10,000th part of a volt would be expressed as 10^{-4}. It can also be shown as a fraction or as a decimal as for example $\frac{1}{10{,}000}$ or .0001. A millivolt which is a thousandth part of a volt when expressed as a power of 10 would be shown as 10^{-3} volt. An uneven fraction such as 3.24 millivolts would be expressed as 3.24×10^{-3} volt. The decimal for this equivalent would be .00324 volt.

The same methods apply to show current and the same prefixes are used.

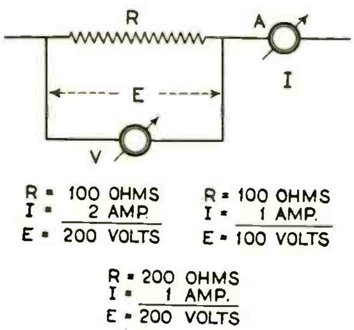


FIG. 1

Representative electrical circuit which demonstrates the functions of Ohm's Law.

One tenth of an ampere = .1 ampere
One hundredth = .01 = 10^{-2}
One thousandth = 1 milliampere = .001 = 10^{-3}
One millionth = 1 microampere = .000001 = 10^{-6}
One hundred amperes = 100. = 10^2
One thousand = 1 kiloamperes = 1000. = 10^3

Resistances in ohms are shown in the same manner, but resistances greater than 10,000 ohms are usually figured as a fraction of 1,000,000 ohms or fractions of a *megohm*. The prefix *meg* is used to denote a million. For example a 20,000 ohm resistance would be shown as

20,000 ohms = .02 megohm = 2×10^4 ohms
200,000 ohms = .2 megohm = 2×10^5 ohms
2,000,000 ohms = 2 megohms = 2×10^6 ohms

Ohm's Law

As a matter of convenience and as a means of conserving space it is customary to express certain electrical values by letters or symbols. For example, voltage is designated by the capital letter E. Current is designated by the capital letter I and resistance is designated by the capital letter R. We will use these designations in discussing Ohm's law. Ohm showed a definite relationship between voltage, current and resistance in D. C. circuits and expressed it as follows:

Voltage (E) = Current (I) x Resistance R or

$$E = I \times R \qquad (3)$$

and

$$I = \frac{E}{R} \qquad (4)$$

and

$$R = \frac{E}{I} \qquad (5)$$

Applications

Let us consider the first of Ohm's laws, that pertaining to voltage. According to the formula, voltage equals current times resistance. Voltage, therefore, is the IR drop across two points in a D. C. circuit. Since voltage is the product of current times resistance and one remains constant, it varies directly as the other. For example, in Fig. 1. If the resistance is equal to 100 ohms and the current is equal to 2 amperes the voltage across

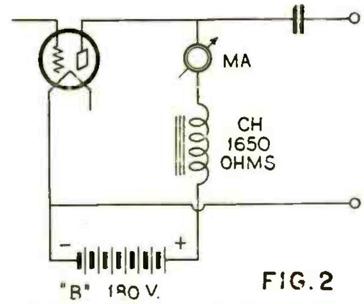


FIG. 2

Illustrating the calculation of voltage drop across the impedance CH.

the resistance is IR or 200 volts. If we maintain the resistance constant to half its original value, the voltage will decrease in exactly the same manner, to halve its original value. If we raise the resistance to 200 ohms and the current remains constant at 1 ampere the voltage across the resistance will increase directly as the increase of resistance, namely to twice its previous value. The voltage across the resistance is the voltage drop across the resistance. The current indicated by the ammeter is the current flow through the resistance, hence the resistance times the current is the voltage drop across the resistance.

We can apply this to practice in every day radio circuits. As an example, we have the plate output choke used in conjunction with power tubes. This choke carries the D. C. plate current for the tube and since it possesses a certain amount of D. C. resistance, a certain D. C. voltage drop will take place across this choke, reducing the effective plate voltage. See Fig. 2. Suppose the voltage of the battery is 180 volts and the plate current is 18 mils and the D. C. resistance of the coupling choke is 1650 ohms. We can determine the voltage drop across this choke by applying formula No. 3. Substituting our figures we have,

E = 1650 x .018
E = 29.7 volts drop across the choke.

(To be continued)

Operating Hints on Tuned Audio Amplifiers

RADIO Fans who are using the Hiler system of tuned audio frequency amplification will doubtless be interested in the following operating suggestions.

The design of these units is such that a peak or "bump" is found on the low frequency end of the amplifying characteristic curve, the function of this preponderance of amplification being to compensate for the low frequency deficiency of the average speaker, and bring out the harmonious, deep chords. Sometimes, the design of the complete receiver-speaker installation is such that less low frequency amplification is desired. This state can be attained in an easy, inexpensive manner. Simply insert a 25,000 ohm variable resistance in series with the filament end of the grid choke, between the terminal marked F and the negative filament lead, if C batteries are not used, and between the terminal F and the C minus, if a "C" battery is employed. The function of this resistance is to lower the amplitude of the resonant peak. Vary the resistance control until the desired amount of low frequency amplification is being obtained.

Retuning the Amplifier

By reversing the connections to the plate and grid chokes of the tuned double impedance unit, it is possible to retune the system by inserting a new coupling capacity. When the original connections are reversed, the effect of the coupling capacity within the case is nullified, and an external coupling capacity between the plate of one tube and the grid of the succeeding tube can be added. When the standard units are reversed, in order to try various values of coupling capacity, the series resistance mentioned in the previous paragraph, should be connected between the grid of the tube and the new grid terminal, otherwise the coupling capacity within the case will nullify the effect of the variable resistance.

A Resonance Indicator

This Instrument is Invaluable for Matching the Electrical Values of Coils, Condensers or Radio Frequency Circuits

By W. H. Hoffman and F. H. Schnell*

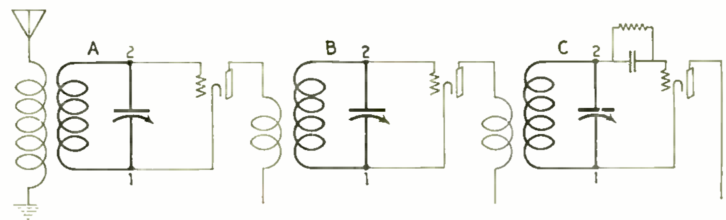
IN any radio receiver employing two or more tuned radio circuits, and more especially the radio receiver employing a single manual control for these tuned circuits, resonance in each circuit is essential. Unless each tuned circuit is in exact resonance with the others, there will be a loss in sensitivity and selectivity. Therefore, when exact resonance is obtained, that is, when the electrical values of every tuned circuit match the others, maximum sensitivity and selectivity are obtained. It means simply this: with a coil of known value of inductance and a condenser of known value of capacity and where two or more such combinations are used as tuned circuits in a radio receiver, the condenser usually is the variable means for changing the period of frequency or point of resonance. With a given setting of the condenser or with a given value of capacity in the tuned circuit, the point of resonance is determined and all other tuned circuits should have exactly the same electrical values for maximum efficiency.

To reduce the number of controls of a radio receiver, for the sake of simplicity, there are several types of receivers employing but a single manual control, although the receiver is made up of several tuned circuits. The controls of the tuned circuits are so arranged that by means of mechanical coupling the single manual control operates the several tuned circuits in such a way that resonance is maintained over the entire range of frequency or band of wavelengths—at least that is what is supposed to take place. Many times a receiver does not function as it should simply because there is a very slight difference in the "resonant frequency" of two or more tuned circuits. Properly used, the Resonance Indicator will show what is necessary to correct such receivers, and the accuracy in obtaining the points of resonance is of the order of one-tenth of one per cent.

* In consultation, Burgess Battery Co.

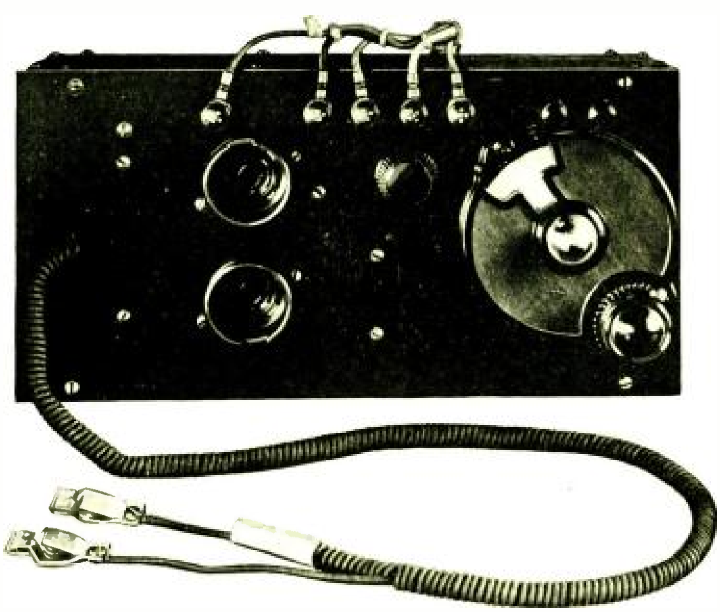
Matching R. F. Circuits

The Resonance Indicator is an instrument used for the final adjustment or matching of circuits—it is the means of putting on the final "polish" for the best operation of the receiver. It is best adapted to work of this kind in comparing coils, condensers and circuits. When the electrical values of coils, condensers or circuits are approximately the same, the Resonance Indicator becomes of real service and value in matching them exactly. Because it is not a wave meter, it cannot be used to measure the electrical values of inductance or capacity.



Three tuned circuits, A_2, B_2, and C_2, are represented by the heavy lines. These must come into resonance at exactly the same condenser capacity when the circuits are properly matched.

Here is an instrument that should be in the laboratory of every manufacturer of broadcast receivers, unless some other instrument of like purpose is now in use. Too much stress cannot be placed on the necessity of accuracy in aligning condensers in multituned single control receivers. For the jobber and dealer who desires to render service along with his sale of radio receivers, the Resonance Indicator becomes an instrument of decided value. There are times when radio receivers are jarred in shipment or handling which causes a slight shift in one or more condensers. Instead of returning the receiver to the manufacturer, thereby losing considerable time and a possible sale, the jobber and dealer should be equipped to make such slight adjustments as will make the receiver function properly.



Top view of the completed Resonance Indicator. Note the shielding on the flexible leads.

Construction

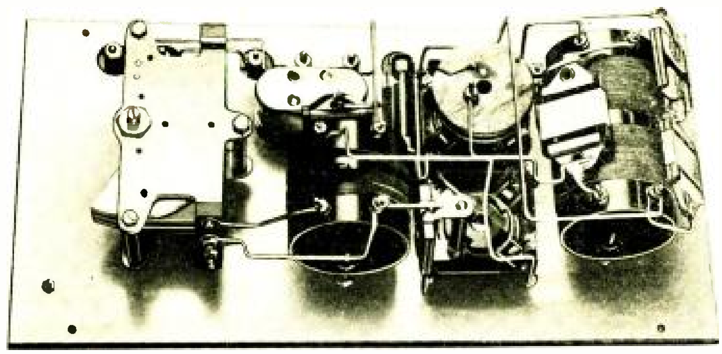
The two oscillators in the Resonance Indicator are assembled in an aluminum case, 12″ long, 6″ wide and 4″ deep. The metal case forms a shield which reduces body capacity and the effects of other surrounding objects.

One oscillator is made up of coils and condensers of fixed values, having a natural or constant resonant period of about 360 meters (830 kilocycles).

A pair of fixed leads is connected across one of the condensers used in this tuned circuit. It is important that these leads be shielded. A clip is the terminal end of each lead, both of which come out through the top of the case. When these leads are connected to the coil or condenser under test, very tight coupling is obtained. Therefore, a slight change in the circuit under test causes a corresponding change in the oscillator circuit.

The other oscillator is made of a fixed value of inductance in the form of a coil, and a variable tuning condenser. It has a tuning range from 30 to 60 meters (10,000 to 5,000 kilocycles). This circuit acts as a short wave receiver, in addition to its function as an oscillator. When oscillating, it produces the beat note in the ear-phones which are connected in the plate lead. At some settings of the tuning condenser, C4, squeals or howls are produced in the ear-phones. To prevent this squealing or howling, the variable resistor, R2 should be adjusted properly when the squealing or howling will stop.

This Resonance Indicator employs the principle of two tuned oscillating circuits. A change in the constants of one circuit affects the resonant frequency period of the other. If the tuned circuit under test is made a part of one of these two circuits, or tightly coupled to it, a change of value of capacity or inductance will change the frequency of the oscillator. This change may be observed by adjusting the second oscillator until the energy from it sets up an audio beat (in the ear-phones) with the oscillator and circuit under test. If the two oscillators are adjusted to the same frequency or if one is a harmonic of the other, there will be no audible sound because the period of resonance is at "zero beat."

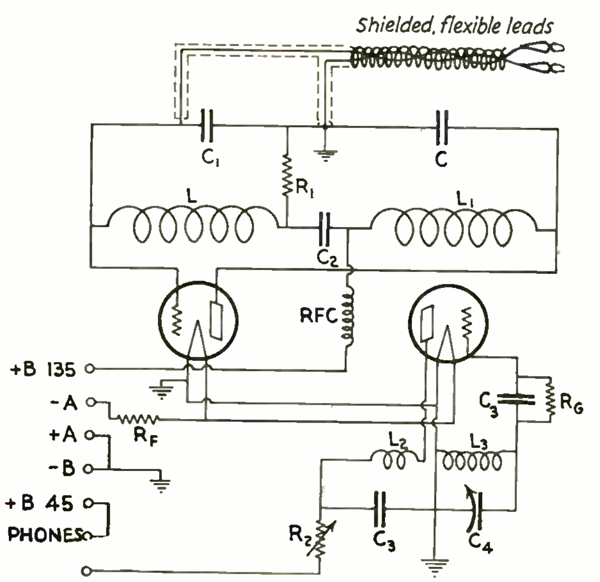


Inside view of the Resonance Indicator. The panel is covered with a copper sheet and the container box is also lined with copper.

Under this condition of "zero beat" and when a change is made in the circuit under test when the audible signal is produced it may be observed by the use of ear-phones connected in the plate supply of either oscillator.

The wiring diagram, with a list of parts used, is given in Fig. 1. The arrangement of the various parts, as mounted is shown in Figs. 2 and 3.

In constructing the Resonance Indicator, care should be used in the arrangement of the various parts. Each part should be firmly mounted and all connections should be of sufficiently heavy wire to insure stability, being sure that all joints are well made and soldered.



Schematic diagram of the Resonance Indicator. It is necessary to have the entire unit shielded. Note that the flexible leads are also shielded. The leads are insulated from the "B" voltage by the condensers C and C_1. These two condensers also provide the correct shunt capacity.

Legend

C	Fixed mica condenser 0.001 mfd.
C1	Fixed mica condenser 0.0005 mfd.
C2	Fixed mica condenser, 0.01 mfd.
C3	Fixed mica condenser 0.00025 mfd.
C4	Variable air condenser 0.00015 mfd.
L & L1	32 turns each No. 22 D.C.C. wire wound on tube 2" in diameter, both coils wound on same tube with ¼" space between coils.
L3	9 turns No. 22 D.C.C. wire wound on tube 2" in diameter.
L2	4 turns No. 22 D.C.C. wire wound on same tube with L3, spaced 3/16" from L3.
R1	Grid leak resistor 10,000 ohms.
Rg	Grid leak resistor 8 megohms.
Rf	Filament resistor.
RFC	200 turns No. 30 D.S.C. wire wound on spool 1¼" in diameter.
R2	Variable resistor 10,000 to 100,000 ohms.
	Standard sockets.
	Vernier dial.

Operation

Insert one 201-A type vacuum tube in each socket. Connect a six volt battery to the filament binding posts marked A + and A —. Connect "B" batteries, 135 volts between B — and B + 135 and tapping off at 45 volts for B + 45, using the first block of 45 volts above the B —. Connect a pair of ear-phones between the binding posts marked "phones." By turning the dial of the condenser, C4, beat notes between harmonies of the 360 meter oscillator and the short wave oscillator will be heard at every few degrees on the dial. If the beat notes are not heard or if there is a squealing or howling, adjust resistance, R2, until the beat is heard or the squealing or howling stops. Then connect the grounded lead to the rotary plates of the condenser and the other lead to the fixed or stationary plates. Next, set the receiver dial at the point to be checked. Then adjust the tuning dial of the Resonance Indicator until a beat note is heard in the ear-phones; carefully adjust to zero beat, when no signal will be heard. Without making any further change in the Resonance Indicator, remove the clips from the first tuned circuit on which the point of resonance has been found and clip on to the next tuned circuit. Then turn the dial of the receiver very carefully until the point of zero beat against the Resonance Indicator is again obtained. This zero beat should be obtained at exactly the same dial reading as in the first tuned circuit, otherwise these two circuits are not matched and best results cannot be obtained until they are matched. If there are more than two tuned circuits, each one should be tested in the same manner. To obtain best results and greater accuracy, a number of tests should be made, at different points on the dial.

When comparisons between a number of circuits are being made, it is important that the coupling between the circuit under test and the Resonance Indicator shall be the same in each case. When the circuits under test form the tuned circuits of a radio receiver (tuned radio frequency, etc.) the tests should be made without disturbing the wiring or arrangement of the associated parts in the receiver, if possible. Connections across condensers or coils of the tuned circuits by means of clips is one of the best ways of securing the same degree of coupling in each instance, being sure each clip is in the same relative position.

If the circuits are not properly matched as indicated by tests above, the Resonance Indicator can then be used to determine whether the trouble is in the condensers or the coils of the tuned circuit. To make this test it will be necessary to disconnect the condensers and coils from other associated parts in the receiver. After disconnecting the condensers, they can be tested in the same manner as the tuned circuits outlined above.

However, in testing the inductances, it will be necessary to vary the tuning dial of the Resonance Indicator while the clips are attached to the two ends of the coil under test. The point of zero beat, for each coil, should be at the same dial reading of the Resonance Indicator. Unless this condition is obtained, the coils are unmatched. To correct the coil it will be necessary either to remove or add wire as the case may be. If the coils are of equal value of inductance, the zero beat will be found at exactly the same dial setting on the Resonance Indicator.

When there is a great difference in the electrical values of the coils, care should be taken that the same harmonic is used for the measurement of each coil. In moving the Resonance Indicator dial, a different harmonic will be found every eight or ten degrees. It is only intended for matching coils when their electrical values are approximately the same.

The Budlong-Smith Wavelifter

A New Frequency Conversion System Which Permits Short Wave Reception on a Standard Receiver, and Remote Tuning Control

*By Bert E. Smith**

PART II

THE theoretical properties of the Budlong-Smith Frequency Conversion System or "Wavelifter" are comparatively elementary and the circuit arrangements are not at all complicated.

The basic idea can be more readily understood by reference to the diagram of Fig. 1. The first unit is a standard single tube short wave receiver. The output of this unit is fed back through a throttle capacity to reinforce the incoming signal and the audio frequency component fed into a modulator which is really nothing more than an A. F. amplifier. This can be likened to a speech amplifier in a broadcast transmitter. The rectified signal, after being amplified at audio frequency in the modulator unit is fed into a third unit which is an oscillator adjusted to oscillate at any desired frequency in the broadcast band. These R. F. oscillations are modulated by the amplified audio frequency component from the modulator.

Obviously, the output of the oscillator is in the form of a carrier wave, modulated by the original signal as picked up and rectified by the short wave unit. Consequently, if the broadcast receiver is tuned to the frequency of the oscillator the modulated carrier will be received in the same manner as if the receiver were connected to an antenna system and tuned to receive a station transmitting on an identical broadcast frequency.

Basic Circuit

The basic circuit diagram of the wavelifter unit is shown in Fig 2 and it will be observed that there is nothing extraordinary about the connections.

This whole system will, in effect, allow audio frequency amplification at radio frequencies, which may seem to some extent a paradox, but its worth can be readily observed from the fact that the only reason audio frequency amplification is not used in a greater number of stages than at present is because of the tremendous amplification of tube noise in straight low frequency repetition, while by using the Budlong-Smith system of intermediate amplification we can accomplish all the advantages of multi-stage audio frequency amplification without amplifying tube noises, and the only limit is in the actual ability of tubes to operate with a signal of the unusual magnitude which is built up by this method.

More economical operation could be secured by the use of only one tube which could be so connected as to perform all of these functions, but the connections would be so complicated that the average builder would never get the thing in operation. Greater amplification could be obtained by divorcing the low frequency amplifying tube from the layout, but difficulty from noise would probably be found. The three tube unit, which we have finally decided on after nearly two years of experimentation, combines the virtues of being so extremely simple to construct that it is practically fool-proof with very efficient operation.

Essentials

The only critical thing in the construction of the unit is the absolute adherence to the specified parts and layout. For example, the initial tuned circuits *MUST* be of extremely low resistance and, therefore, the leads, particularly those which are of high r. f. potential, must be very short and placed in careful juxtaposition with the instrument so that no currents will be induced in them which may impede the tiny r. f. impulses. The variable condensers should be selected for their mechanical and electrical characteristics without any regard to full floating rear axles or the beautiful lacquer and nickel plating which frequently serve to divert the builder's mind from the real job of a condenser.

The radio frequency circuit of the last tube is also critical as to the leads and condenser and coil selections. If these are not placed well apart from

* *Allen D. Cardwell Mfg. Corp.*

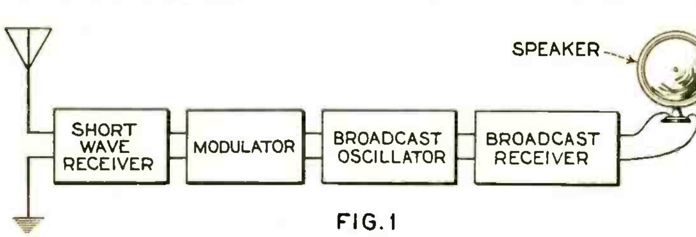


FIG. 1

General arrangement of the units composing the Budlong-Smith Wavelifter. The short wave receiver is the control unit; the broadcast receiver is set at a definite frequency.

other radio frequency leads in the receiver and if the arrangement of the wiring is not carefully duplicated, the circuit from which we derive our broadcast frequency wave will be troublesome to everyone within some distance.

Used as Remote Control

Probably the most interesting advantage of the Budlong-Smith system is in its ability to operate as a remote control unit for any broadcast receiver.

Many of us have frequently wished that our living room need not be encumbered by a cabinet of the massive size necessary to contain a modern radio receiver, and at the same time we still wish to be able to sit in our easy chair and select a program. By dividing the Budlong-Smith Wavelifter Unit into two sections we can relegate our present broadcast receiver to a closet or the cellar together with all of its batteries, eliminators, and other appurtenances, and retain in the living room only a small cabinet necessary to contain a single tube and its associated instruments. At the same time we have now only one station selector control and one volume control, and the three wires which are requisite to connect this with other instruments can be inconspicuously led through a single cable to the closet where the rest of the material is installed. Any number of such units can be placed in various parts of the house or apartment, and the set can be operated from any one of them, although no two of them can be used at one time. The circuit is shown in Fig. 3 and the constants are as follows:

Control Units—(Each)

L1—Short Wave 3-Circuit Tuner.
L2—R. F. Choke, 85 M. H.
C1—.00015 Mfd. Variable Condenser.
C2—.00025 Mfd. Variable Condenser.
C3—.00025 Mfd. Fixed Condenser.

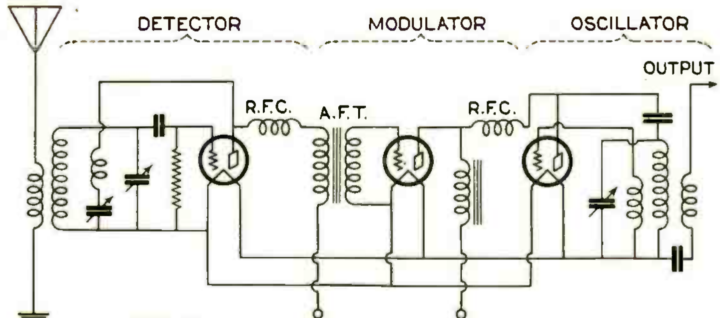


FIG. 2

The basic circuit diagram of the Wavelifter. This consists of a short wave receiver, a modulator and an oscillator.

R1—9 Megohm Grid Leak.
1 U. X. Socket.
1 Vernier Dial.
1 Filament Switch.

Wavelifter Unit

C8—.006 Mfd. Fixed Condenser.
C5—.0005 Mfd. Variable Condenser.
C4—.006 Mfd. Fixed Condenser.
C6, C7—4 Mfd. Bypass Condenser.
T1—A. F. Transformer, High Impedance Primary.
T2—30 Henry Plate Choke.
L3—R. F. Choke, 85 M. H.
L4—Broadcast Wave 3-Circuit Tuner.
R2—Filament Resistance, ½ Ampere.
2—Sockets.
1—Dial.
7—Binding Posts.
1—Relay. *Any of the Relays intended for "B" eliminators can be attached.*

In this instance we have cut the demodulating tube apart from the balance of the unit, in order to save space and number of leads. No filament resistance is used in the control unit as the resistance of the leads will be sufficient to give a voltage drop of one volt. The cable containing the two filament leads and the output lead can consist of an ordinary twisted triplet, such as is used in telephone wiring, or can be made from three strands of bell wire twisted together. It is not advisable to use wire smaller than No. 20 or its equivalent.

Adjustment

The balance of the Wavelifter Unit, consisting of the modulator tube and oscillator, is then built up in a small box and can be placed in the closet or near the regular broadcast receiver. C5 can then be permanently adjusted for the frequency on which the broadcast receiver is to operate. After this adjustment is made and the broadcast receiver is tuned to the frequency of circuit C5-L4, no further attention need be paid to the broadcast receiver, although if desired it can be operated as previously, with aerial and ground, without regard to the fact that the remote control units are attached.

A relay of the conventional "B" eliminator type can be inserted in one of the filament leads of the control units and the filament circuit of the Wavelifter Unit and receiver connected with the contacts which would ordinarily be used to close the "B" eliminator circuit. This will automatically take care of lighting the tubes all through the circuit when the controll unit switch is turned on.

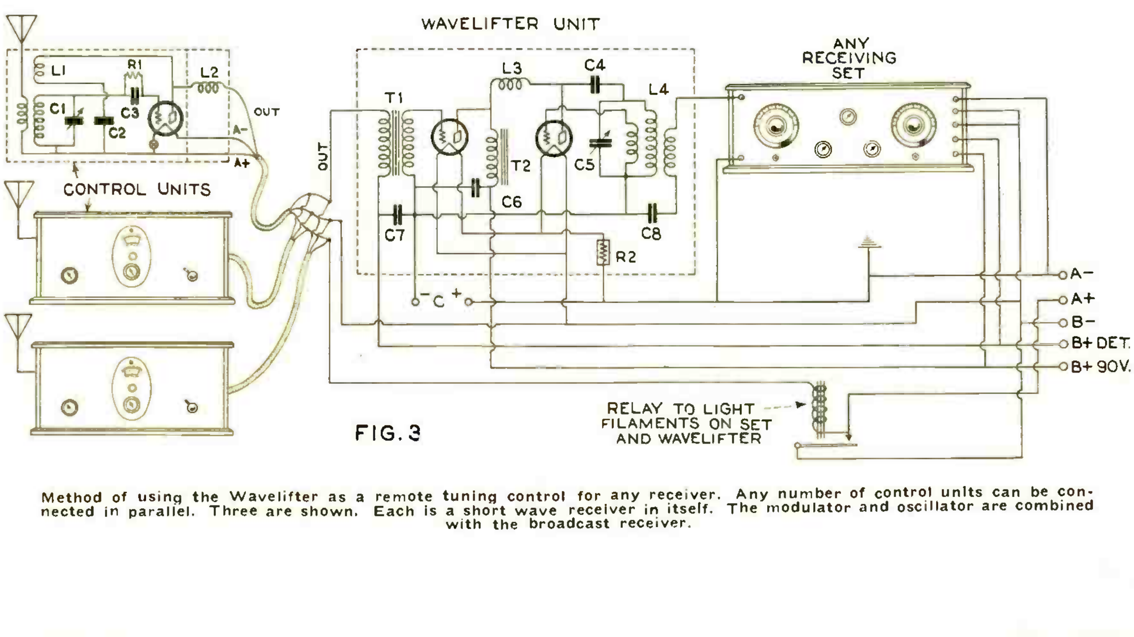


FIG. 3

Method of using the Wavelifter as a remote tuning control for any receiver. Any number of control units can be connected in parallel. Three are shown. Each is a short wave receiver in itself. The modulator and oscillator are combined with the broadcast receiver.

Audio Frequency Amplification

Dealing with the Various Systems in Common Use

By H. G. Cisin, Associate Editor

PART II

WE HAVE said our say regarding the vagaries of audio frequency amplification. We pointed out the many failings of audio systems in the previous article. However, in all fairness to the systems and the host of men who developed them, we pause to advise that the many short-comings referred to cause disturbance only in the minds of theorists. In other words, the fact that an oscillograph test may show a horrifying loss of efficiency at low frequencies in an audio amplifier does not necessarily indicate that the amplifier is not satisfactory for general use.

We might go so far as to say that the saving grace of the amplifier lies in the rather indelicate perception alloted the human ear. It so happens that the ear is unable to discern any change in amplitude of sound, irrespective of the frequency, unless that change exceeds as much as 10 to 25 per cent of the total amplitude. Ergo, some of the frequency characteristic curves of audio amplifiers are not one quarter so bad as they actually appear on paper.

All Systems Good

A man who is well acquainted with the fundamental principles underlying audio frequency amplification and who has his wits about him can take any of the three principal systems commonly employed and make them all operate equally as well and surprisingly well at that.

We have tried to drive home the point that there is no vast improvement to be had in one form of audio frequency amplification, over that of another. The difference in the systems lies not so much in how well they operate but rather their own peculiar limitations.

Suppose we review the three popular systems and attempt to indicate the nature of each and point out why one system is more satisfactory than another under certain conditions.

Transformer Coupled Amplifier

The circuit diagram of a conventional two stage transformer coupled amplifier is shown in Fig. 1. This is the most commonly used amplifier since it is possible to obtain a considerable degree of amplification with the use of but two tubes and a comparatively low plate voltage. This is possible for the reason that there is a step-up in voltage in each stage due to the transformer action. The amount of amplification of course is dependent on the primary to secondary ratio of the transformer in each stage and the mu of the tubes.

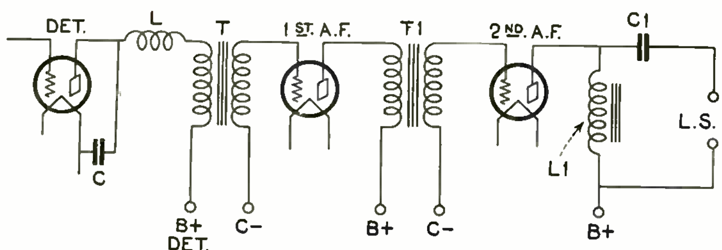


FIG. 1

Schematic diagram of a standard two stage transformer coupled audio frequency amplifier.

The quality of the reproduction from an amplifier of this sort is dependent upon a number of factors but the first and most important one is the characteristics of the transformers. The transformers sold today have excellent frequency characteristics due to intelligent engineering. Large cores are employed and the primary windings have a high impedance which is more acceptable to the output resistance of the tubes commonly employed.

As we shall see, other forms of amplifiers have slightly better frequency characteristics but that this presumed improvement is not all "cream."

"Engineered" Amplifier

A transformer coupled amplifier is capable of producing considerable distortion of its own without any assistance from the detector tube which, unfortunately, usually contributes its own share of distortion due to being overloaded. Harmonic distortion produced in the first transformer can be eliminated by employing a push-pull output stage. We shall have more to say of this in the next article. If considerable volume is being handled further distortion is produced in the transformer due to core saturation. With but a few exceptions, all transformers suffer from this under operating conditions. Core saturation can be obviated by engineering the amplifier. This is accomplished by employing a combination of a choke and a fairly high capacity condenser in the plate circuit of the detector and first audio frequency tube. This idea is practically the same as employing an output filter between the amplifier and the loud speaker to prevent the direct plate current from passing through the magnet windings. Note the output filter L_1-C_1 in Fig. 1. Obviously, in this case the plate current passes through the choke, and the primary winding of the transformer which in this case has its lower leg connected to the filament, is virtually floating. The audio frequency currents can readily pass through the condenser into the primary winding but the direct plate current cannot pass through this winding and saturate the core and thus alter the impedance of the transformer. With a system of this sort true transformer action is provided but it is a question as to whether it is worth the while when the added expense of the chokes and condensers is taken into consideration.

Overloading of Output Tube

Further distortion can be created in this form of amplifier, as well as in the other forms, if the last tube is allowed to become overloaded. An overloaded tube is one of the most common causes of distortion in audio frequency amplifiers and the use of a suitable power tube in the output, with correct plate and grid voltages, is the most logical step to take to improve reproduction. Whether or not a power tube is used it is advisable to employ an output filter, and in some cases an output transformer, and it will be noted that such a filter is indicated in the output of each of the three circuits shown.

Resistance Coupled Amplification

The circuit diagram of a resistance coupled amplifier is shown in Fig. 2. It is seen to have three stages whereas the transformer coupled amplifier has but two stages. The reason for this is quite simple; the only amplification which actually takes place in a resistance coupled amplifier is the voltage step-up or amplification provided by the tube itself. If tubes of the 201-A type are employed one cannot expect an amplification greater than 6 to 8 which is the mu of the tube. Obviously, if high mu tubes are used it is possible to obtain an amplification of 30 or so in each stage. Even thus the total amount of undistorted amplification from the three stages is only a little more than the amplification obtained from a two stage transformer amplifier.

Resistance coupled amplifiers have an excellent reputation because of their practically straight-line frequency characteristics. However, it is one of the easiest things in the world to destroy the excellent properties of a resistance coupled amplifier by employing incorrect values of coupling condensers or resistors. Besides, resistance coupled amplifiers have a rather distressing habit of blocking or choking unless special precautions are taken. This is due directly to the accumulation of a charge on the grid of one of the tubes and the effect usually takes place in the last stage. There are three cures for this ailment. The first is a decrease in the capacity of the last coupling condenser (C_3). However, if the value of the coupling condenser is decreased to any great extent without a proportionate change in the plate resistor R_4 and the grid resistor R_5 the frequency characteristics of the amplifier are somewhat altered and it will be found that this change is more for the worse than for the better. The second cure comes about through lowering the resistance R_5 in the grid circuit of the output tube. This also plays a certain amount of havoc with the frequency characteristics of the amplifier. The third cure, and that which is best, is the use of a grid choke in the grid circuit of the output tube in place of the grid resistor R_5. Such a choke has very low direct current resistance and allows a rapid discharge of any voltage accumulating on the grid of the tube which would tend to block it. At the same time the choke has a very high impedance to the audio frequency currents and therefore practically maintains the same frequency characteristics of the amplifier.

It is not only possible but advisable to tie in the plates of the three amplifier tubes and supply them all with the same "B" voltage as in Fig. 2. If really good results are to be had the "B" potential should be 180 volts. Since the direct current resistance of the choke, which is a part of the output filter L_1-C_4 in Fig. 2, is very low practically the full 180 volts will be impressed on the plate of the last tube which is desirable. The voltage will be considerably lower on the plates of the first two tubes, however, since there is a high resistance in the plate circuit of each.

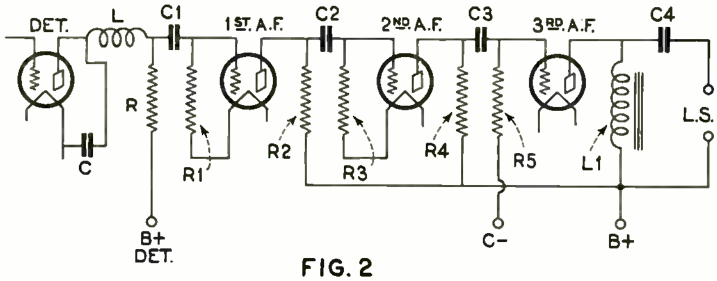


FIG. 2

Schematic diagram of standard three stage resistance coupled A.F. amplifier.

"C" Bias

No other batteries are required in connection with the first two tubes providing the plate resistors R_2 and R_4 are of a high value so that the actual voltage on the plates of these tubes will not be excessive. In this case it is only necessary to run the grid returns from the two tubes to the negative filament connection which provides sufficient bias. If the voltage on the plates is too high, however, sufficient bias is not provided by the "A" battery and the logical relief for the situation is not the addition of "C" batteries in these respective circuits but rather an increase in the values of the two plate resistors in order to decrease the effective "B" voltage on the plates so that both the "B" voltages and the grid bias as provided by the "A" battery will give the correct operating characteristics. It is necessary, however, to use a "C" battery in the grid circuit of the output tube since the full "B" voltage is impressed on the plate. It is safe to select the value of "C" bias advised by the manufacturers of the tubes for the particular "B" voltage employed.

Impedance Coupled Amplifier

A circuit diagram of an impedance coupled amplifier is shown in Fig 3. Again three stages are employed as there is no voltage step-up in the impedance units and it is necessary to rely upon the amplification factor of the tubes to gain volume. However, this amplifier will give more volume than the resistance coupled amplifier for like "B" voltages since the actual voltage on the plates of the first two tubes is higher due to the low direct current resistance of the impedances. The frequency characteristics of this type of amplifier are practically as good as those of the resistance coupled type.

Due to the low D. C. resistance of the impedances I2 and I4, it is not advisable to tie in these two plate circuits with the plate circuit of the output tube. A "B" potential of 90 volts is sufficient as there is no appreciable IR drop. If a higher "B" voltage is employed it will be necessary to increase the grid bias on both tubes, by the addition of "C" batteries, to prevent the grid from going "positive" in value and passing current. Obviously, the output tube should have a sufficient grid bias due to the high "B" voltage.

An impedance coupled amplifier is not inclined to block because the grid impedances I1, I3 and I5 have a low D. C. resistance and readily relieve the grids of negative voltage charges which, if accumulated, would paralyze the tubes. It is practical to use larger coupling condensers for this reason and higher capacity values offer less reactance to the flow of low frequency currents; an obvious advantage.

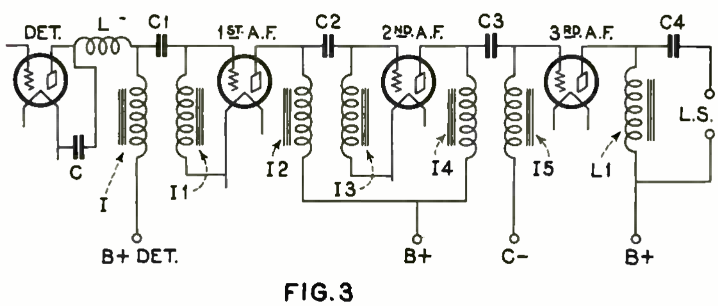


FIG. 3

Schematic diagram of standard three stage Impedance coupled A.F. amplifier.

R. F. Choke

It is always advisable to use an R. F. choke, together with the usual by-pass condenser, in connection with any audio amplifier. They are indicated in the accompanying diagrams as L and C respectively. This arrangement prevents the radio frequency currents, by-passed by the grid to plate capacity of the detector tube, from getting into the audio circuits and being further amplified along with the audio frequency component. This only helps to overload the A. F. tubes and also creates undesirable feedback.

"B" Supply

Many excellent audio amplifiers act terribly because of insufficient "B" supply. It is quite often the case that the "B" supply, whether batteries or an eliminator, is incapable of maintaining the voltage and current requirements when under load. If the batteries are old or the rectifier in the eliminator of insufficient current carrying capacity a heavy current drain will immediately produce a large drop in voltage. This, naturally, upsets the operation of the amplifier, due to a constantly varying voltage with changing current drains, and low frequencies particularly suffer considerable amplitude distortion.

Further distortion, as well as "motorboating" and audio frequency oscillation, can be created by a high impedance filter structure in a "B" power unit and the most satisfactory remedy is to shunt the B— to B+ 90 and the B— to B+ Max. with 4 mfd. condensers. In extreme cases 8 mfd. condensers are required.

Power Output Required

Again we remark that the three basic types of audio amplifiers discussed and any of their modifications will give about the same results. The limitations of each are primarily economic considerations.

Again this leads us to the subject of "best reproduction" which usually implies ample amplification of low frequencies. Best reproduction can only be had by the use of a power tube in the output stage.

Nothing but a power tube, or a power amplifier if you please, can handle the energy required for effectively reproducing low frequencies. An ordinary tube is sadly overloaded. Thus, we might say that the use of a power tube for good reproduction is the most important consideration.

The next article will deal with power equipment.

Radio Engineering Appoints New Mid-Western Representative

ARTHUR G. RUDOLPH has been appointed midwestern representative of RADIO ENGINEERING with offices at 500 North Dearborn Street, Chicago, Ill. Mr. Rudolph hails from the Badger State, the home of cranberries, paper-mills, LaFolettes and the Wild Oats Indians. Before leaving his native town, Fredonia, he was engaged in teaching country or district schools for a number of years. After a brief period in Chicago he soon decided to enter the field of advertising and for about four years was connected with the then Lord and Thomas Advertising Agency. He then joined the advertising staff of the Chicago Inter Ocean for a short period, following which he became associated with the Mitchell Brothers Publishing Company, publishers of the American Miller and the American Grain Trade where he made a most splendid record during his six years' connection with the advertising department of that organization. Following this and for six years he was connected with the advertising staff of the W. D. Boyce Publications making a record covering Chicago and the West and Southwestern territories. During these various connections he covered practically every city and business center in the territory from New York City to Denver and Duluth, to New Orleans, affording him a wide knowledge of business as carried on in different industrial and business sections of the country. Mr. Rudolph recently entered the Special Newspaper Representative Field to cover the midwest advertisers and advertising agencies. For the past year he also represented a Pacific Coast Radio publication fitting himself for proper and satisfactory representation of RADIO ENGINEERING which he is satisfied will be one of the survivors of the numerous radio publications in circulation today. Mr. Rudolph has a host of friends within the various fields he covers.

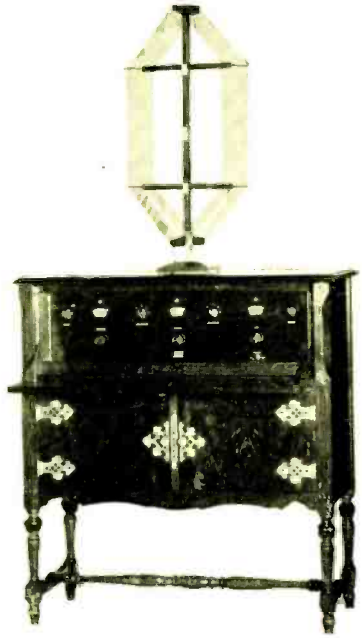
Arthur G. Rudolph

The Dar-Mac Shielded Supernine

THE Dar-Mac Supernine is a receiver designed to operate under the severest of conditions from a selectivity and sensitivity point of view. It was realized at the start of the experimental work on this receiver that the straight superheterodyne had a great deal the matter with it when operating in congested broadcast centers. With this in mind, a receiver was developed that will operate, and has operated, quite satisfactorily under any of the conditions met with in a large city relative to selectivity, tone quality, and volume. This reception is done on a loop, which in turn does away with most of the external noises so familiar when using an antenna operated receiver. The receiver is made so that the band-pass amplifier is interchangeable, thus making possible the suiting of an individual's taste in regard to selectivity and tone quality.

One of the Dar-Mac units is a 5,000 cycle band-pass arrangement, which, while it does not distort, is extremely critical in operation, and for the average radio fan who desires, along with selectivity, tone quality, is not quite so good as one of the broader units of which two different types are available—a 10 kilocycle band-pass amplifier and a 15 kilocycle band-pass amplifier. These units, while they are much broader, at the same time afford ten kilocycle separation between local and out of town stations when used with the receiver recommended in this article, which, coupled with their tone quality, makes a very efficient and all around satisfactory radio receiver.

There are several things necessary for a proper amplifier system. To begin with, the ideal receiver requires selectivity. This selectivity, unless a band-pass filter principle is used, will cause the receiver to distort and give very poor musical reproduction. It is possible to build an ordinary amplifier system which will afford ten kilocycle selectivity, but in building this system you are quite likely to experience a result as shown in Curve 1 of Fig. 1. In other words, the amplifier has a peaked amplification about two kilocycles wide and it is an impossibility to get good musical reproduction out of the amplifier.



A view of the Dar-Mac Supernine in its attractive Console Cabinet on top of which is the loop aerial.

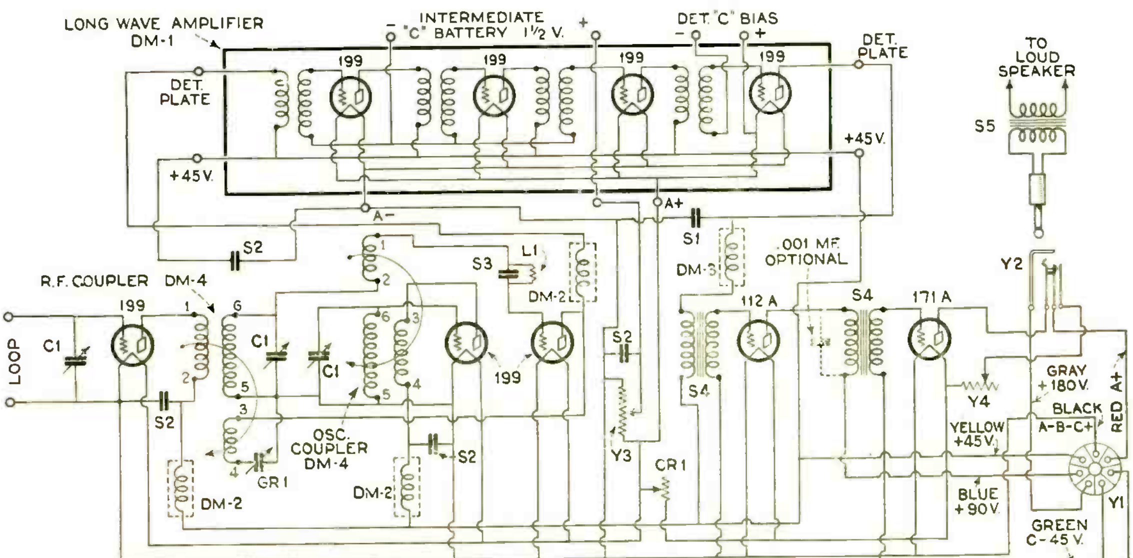
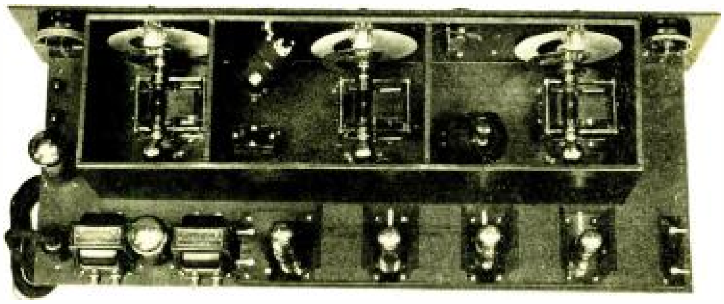


FIG. 6

The schematic diagram of the Dar-Mac Supernine. Note that the 199 type tubes are used throughout, with the exception of the A. F. amplifier which uses a semi-power tube and a power tube with one-quarter ampere filaments.

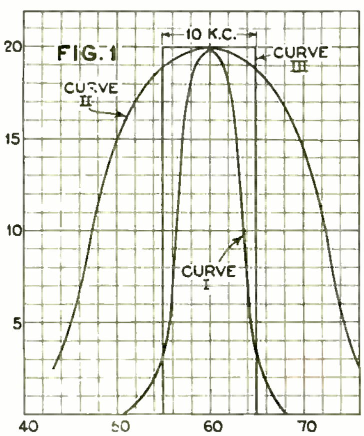


Interior view of the Dar-Mac Supernine. The intermediate frequency amplifier and the audio amplifier extend along the rear of the sub-base.

If we design an amplifier that gives very good tone quality without using a band-pass filter system, we find that it is very broad in its operation, somewhat like Curve II in Fig. 1.

If a band-pass amplifier is developed that is thoroughly efficient, it will give an amplification curve as shown in Curve III in Fig. 1, which, of course, is the ideal but is very hard to obtain. There are several ways to obtain this band-pass amplifier action.

There are two prominent types of band-pass filters. There is the pure band-pass filter circuit as shown in Fig. 2, and a radio frequency amplifier band-pass filter as shown in Fig. 3. This amplifier circuit, when analyzed, as in Fig. 4, is almost identical to the circuit shown in Fig. 2. Due to the fact that in designing this amplifier it is designed for one frequency alone, which means that none of the constants, after they are once determined, are changeable. The first type of band-pass filter is a very good filter,



Comparative resonance curves of intermediate frequency amplifiers.

but it has the disadvantage of possessing no appreciable gain, which means that it is a loser as compared to the type shown in Fig. 3. It is very difficult to design a real band-pass amplifier around the circuit shown in Fig. 3, and there really is only one way to accomplish this, that is, by interposing transformers of unlike characteristics. This principle is clearly shown in Fig. 5.

While there are a lot of objectionable features about air core transformers, yet we find that they are much more satisfactory than the iron core ones. The unit is made with four transformers, the three R. F. tubes and the detector all mounted on the one unit. This facilitates wiring and at the same time eliminates any possibility of parasitic capacity between different parts of the circuit.

In the Dar-Mac unit all of the metal work is cast aluminum. The wiring is shielded and the transformer cases are mounted on a cast aluminum base plate, the wiring receding into the casting. If no metal could be used and the same effect produced, it would, undoubtedly, be more efficient, but the Dar-Mac Laboratories have found that without shielding a stable operating amplifier is a difficult thing to make efficiently. For this reason and also the added reason of mechanical strength, all of the equipment is thoroughly shielded and made very rigid.

The Dar-Mac units have all the transformers thoroughly impregnated in a sealing compound which, while it does not add appreciably to the distributed capacity of the windings, prevents any atmospheric changes from effecting the electrical characteristics of the windings. The condensers used in the unit are moulded bakelite, which are assembled under pressure, and do not change capacity with age.

In congested broadcast communities where a large number of broadcasting stations are operating simultaneously, it is very essential that no energy be picked up save through the pick-up system used. With a superheterodyne having the circuit characteristics of the Dar-Mac Super, if no shielding were used, on account of the super-efficiency of the intermediate am-

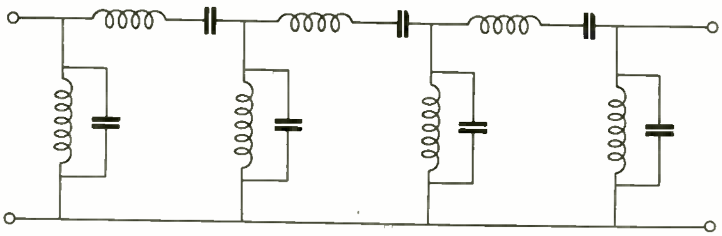


FIG. 2

A pure band-pass filter circuit.

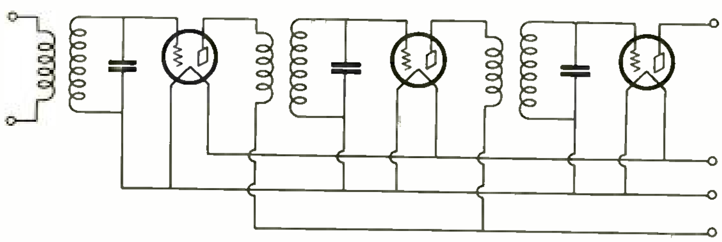


FIG. 3

A radio frequency amplifier band-pass filter.

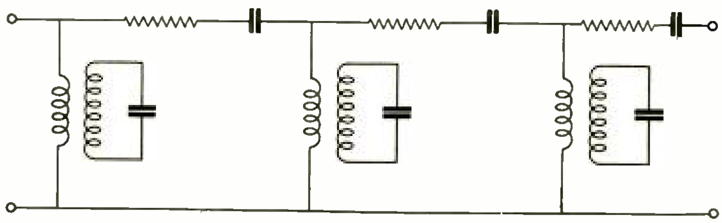


FIG. 4

An analyzation of the pure band-pass filter circuit shown in Fig. 2.

plifier, very good reception could be had from both local and out of town stations without using the loop. This, while it sounds as if the set were operating efficiently, is not the case. In dealing with a receiver of this character, from the time the signal is picked up in the loop and passed on to the receiver proper, it is a pure repeater action, which means that full advantage can not be taken of the selectivity of each tuned circuit unless they are shielded from each other.

The shielding is divided into three compartments, the first compartment containing the variable condenser which tunes the loop, and a socket. The second compartment contains the Radio Frequency Coupler, another variable condenser, and another socket. The Coupler used is so arranged that regeneration can be obtained in the detector circuit at the same time placing both the tuning condenser rotary plates and the regeneration rotary plates at a ground potential. The third compartment contains the Oscillator Coupler. This is also a tuned grid type, which allows the rotary plates of the variable condenser to be placed at a ground potential. The 50 m-mfd. Rengeration Condenser is located in this compartment.

The Dar-Mac Supernine also makes use of a new audio transformer. This transformer has an "A" Metal core which gives it several times the permeability of an ordinary silicon steel

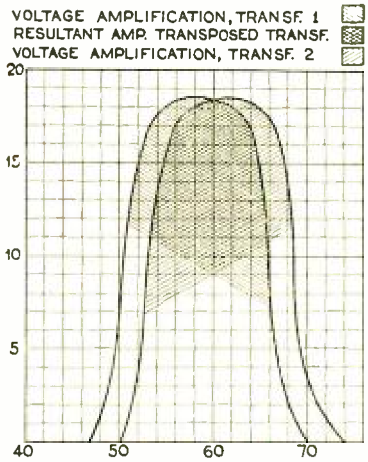


FIG. 5

The effect of interposing intermediate frequency transformers of unlike characteristics in the I. F. amplifier circuit.

transformer. This gives it practically a flat frequency response curve and possesses a very high primary impedance. The core also allows a much higher turns ratio to be used in the transformer, which results in a much more powerful amplifier. The "A" Metal core used in the transformer does away with a great amount of distortion caused by overloading the transformer.

A different system of volume control is used in the Dar-Mac. The primary of the first radio frequency transformer has its coupling varied from the front of the panel, this allowing for the regulation of voltage to the detector with a consequent deduction of distortion due to overloading the detector tube.

The complete schematic diagram of the Supernine is shown in Fig. 6.

LIST OF PARTS REQUIRED

GR—1	1	General Radio 50 Mmfd. Midget Condenser
Y—1	1	Yaxley No. 660 Cable Connector Plug
Y—2	1	Yaxley Single Circuit Fil. Control Jack
Y—3	1	Yaxley 400 Ohm Potentiometer
Y—4	1	Yaxley 3 Ohm Rheostat
S—1	1	Sangamo .002 Mfd. Fixed Condenser
S—2	4	Sangamo 1. Mfd. Fixed Condensers
S—3	1	Sangamo .00025 Mfd. Condenser with Grid Leak Clips
S—4	2	Sangamo 3 to 1 ratio A. F. Transformers
S—5	1	Sangamo Output Transformer
L—1	1	Dubilier 2 Megohm Grid Leak
C—1	3	Camfield .0005 Mfd. Variable Condensers
CR—1	1	Carter 10 Ohm "Imp" Rheostat
DM—1	1	Dar-Mac Long Wave Amplifier (complete unit)
DM—2	3	Dar-Mac Short Wave Chokes
DM—3	1	Dar-Mac Long Wave Choke
DM—4	2	Dar-Mac Couplers
	2	Benjmain U. X. Sockets
	2	Eby Binding Posts
	3	General Radio Type 349 Sockets
	1	Formica Panel, Drilled, 8"x30"x3/16"
	3	Type 220 Marco Dials
	1	Set of Dar-Mac Shielding
	18	Lengths of Acme Celatsite Wire
	2	Kurz Kasch 1½" Knobs
	7	Type 199 Tubes
	1	Type 112-A Tube
	1	Type 171-A Tube
	1	Excello Type R-31 Radio Cabinet
	1	Matheison Loop
	1	B. B. L. Speaker
		Miscellaneous Hardware

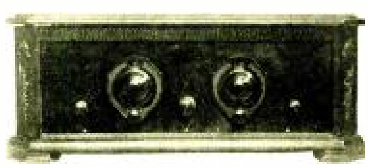
The "Alpha Six" Receiver

THE SET we are about to describe was built for the one who requires, beauty of appearance, good tonal quality, sensitivity and will operate without much preliminary labor.

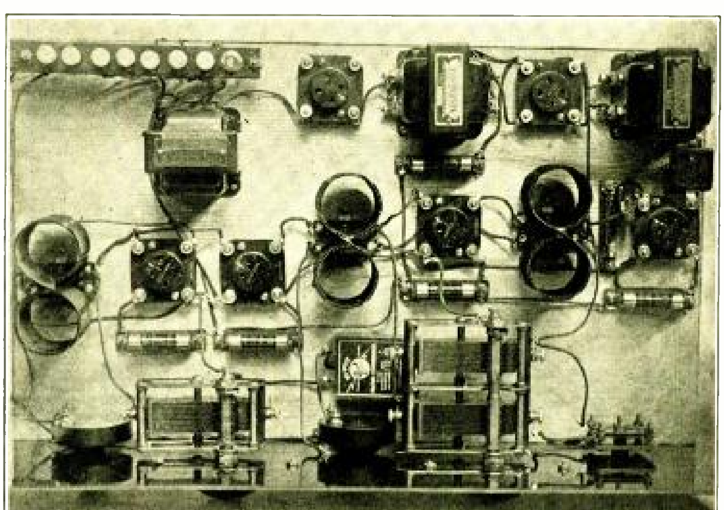
The whole set is built into two portions, the receiver being a six-tube affair, built into a beautiful cabinet, while the power supply portion is built on a board and is to be stored in some sort of a compartment near the receiver. This can be one of the numerous radio tables on the market, that have this battery compartment. Buying one that will match the finish of the cabinet will make up a very pleasing and satisfactory ensemble.

The receiver is composed of two stages of tuned radio frequency amplification, the first stage employing a method of feeding back some of the R. F. energy by the use of an additional tube as a coupling medium. This adds to the sensitivity of the R. F. stages. The detector stage is tuned and immediately proceeding this is the audio frequency amplifier. This is of the ordinary two stage transformer coupled type.

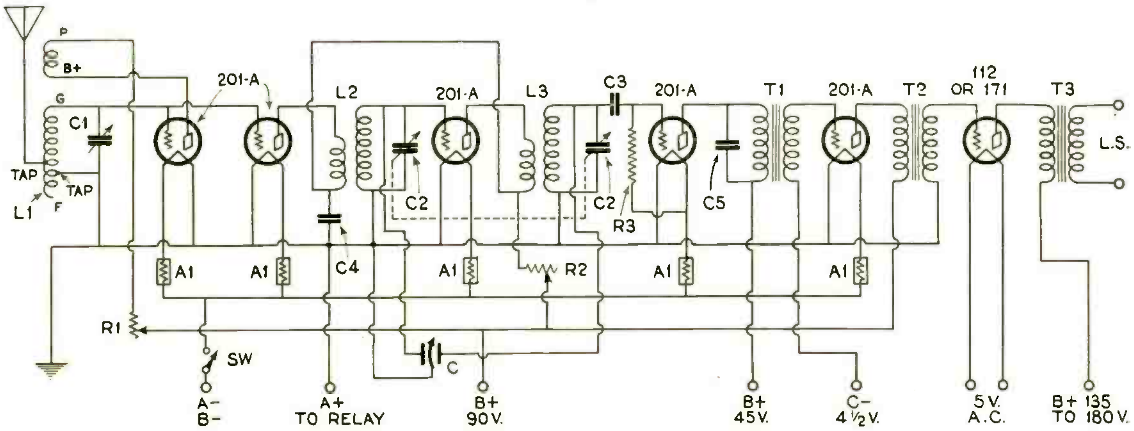
The first or antenna stage is tuned with a single .00035 mfd. variable condenser while the second and detector stages are tuned with a double tandem variable condenser. When a condenser of this type is to be used, it must be of a very rigid and efficient construction. However, even with a perfectly balanced condenser, some means of



Panel View of the "Alpha Six" Receiver.



The interior view of the Alpha Six which clearly shows the positions of the parts.



Schematic diagram of the "Alpha Six." Note that two tubes are employed in the first radio frequency stage. Also observe the unique compensating condenser C.

compensating must be provided, for an uneven or unbalanced condition that will exist between the two stages, which may be due to internal capacity of the vacuum tubes, capacity between leads, length of leads and capacity between parts. Glancing at the diagram you will notice that we used a compensator condenser to bring the circuits in resonance should either of them be unbalanced. This is shown as C in the diagram and you will note that the rotor of the condenser connects to the common rotor of the large condenser (C 2) and each of the stators of C connects to one of the stators of C 2. Then if either of the stages happens to be off, the compensator is turned either to the right or left depending on the stages that requires more or less capacity. If both stages are at resonance, the compensator is kept at a neutral point.

The coils used in the R. F. portion are the well known binocular type. This type of coil we find to be of very efficient design and due to low distributed capacity, low radio frequency resistance, constricted or small external field, have a high gain and selectivity factor.

The first stage of audio employs the regular 201-A type tube while the second or last stages makes use of either the 112 or 171 type of power tube. The filament current for the power tube is obtained direct from the 5 volt A. C. winding on the power transformer in the supply portion.

The audio transformers used are of very efficient design and reproduce the impressed signal quite faithfully. This is due to the mechanical, as well as electrical, construction of this unit. The primary inductance is high in compliance with correct engineering specifications which also includes a core of ample cross section made of a good grade of steel and low distributed capacity. Other factors that contribute to the good reproduction qualities of an amplifier are correct biasing voltages on the grid of each amplifier tube and an output transformer which prevents overload of the speaker windings from the D. C. plate current which is also a cause of speaker distortion. A glance at the schematic diagram will show the protective transformer as T 3.

(The Power Supply Unit will be described in the next issue of RADIO ENGINEERING)

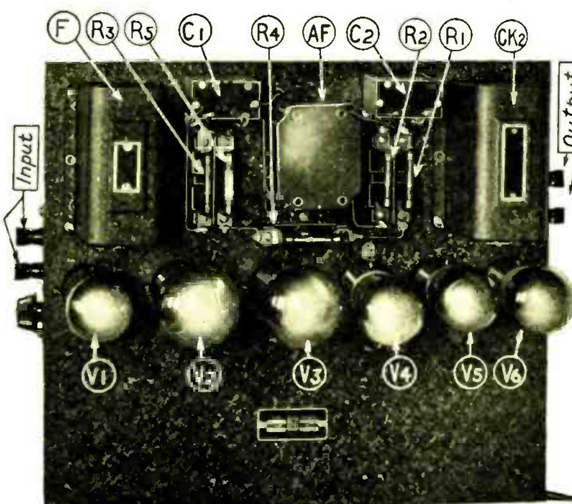
LIST OF PARTS REQUIRED

C 2—1 De Jur Double Variable Condenser, .00035 Mfd.
C 1—1 De Jur Single Variable Condenser, .00035 Mfd.
1 De Jur 7 Wire Flexaton Battery Cable.
L 1, 2, 3—3 Benjamin Lekeless Transformers.
6 Benjamin Cle-Ra-Tone Sockets.
T 1, 2—2 Thordarson R-200 Audio Transformers.
T 3—1 Thordarson R-76 Output Transformer.
C 4—1 Polymet 1. Mfd. Condenser, Type A.
C 3—1 Polymet .00025 Mfd. Grid Condenser, Bakelite.
C 5—1 Polymet .001 Mfd. Grid Condenser, Bakelite.
A 1—5 Amperites, Type 1-A.
R 2—1 Centralab, 0-200,000 Ohm Radiohm, RS-200.
R 1—1 Centralab, 0-50,000 Ohm Radiohm.
C—1 Daven Compensator Condenser.
R 3—1 Daven 2 Meg. Glastor Leak.
2 Kurz Kasch Vernier Dials.
2 Kurz Kasch ¾" Bakelite Knobs.
1 Micarta Panel, 7" x 21".
1 Corbett 7" x 21" Cabinet, Model C, 12" depth.
5 Armor CF-501A Tubes.
1 Armor CF-571 Tube.
2 Rolls Corwico "Braidite" Wire.
8 Eby Binding Posts (2 Ant. A +, A —, C —, B 45, B 90, B Amp.)
1 Carter Midget Jack.

An A.C. Phonograph Amplifier

THIS special amplifier, designed by *James Millen* and described in the January issue of *Radio News*, has a number of very interesting features.

Amplifiers of many different types are suited for electrical phonograph use; the audio end of almost any high grade radio set is capable of quite excellent results. The author has, however designed primarily for phonograph use the amplifier hereinafter described, and has incorporate in the design several features which particularly fit it for such use.



Top view of the A. C. Phonograph Amplifier. This employs a tandem full wave rectifier system and a voltage regulator. The output amplifier is a push-pull arrangement.

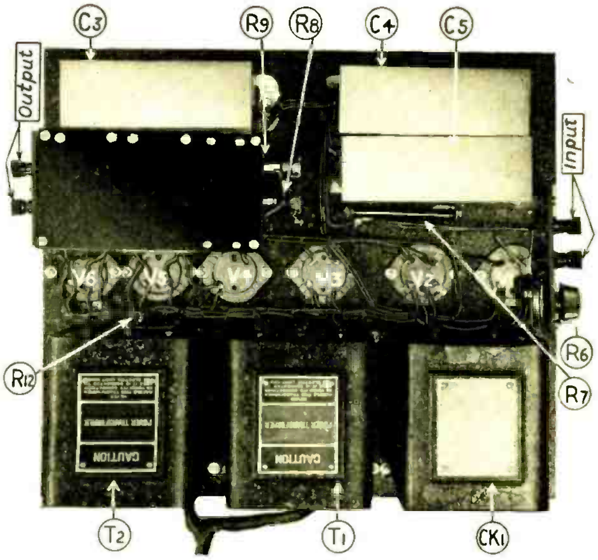
First, it is all A. C. operated, no batteries of any kind being necessary. Second, by the use of two of the 210-type power-amplifier tubes in a push-pull amplification circuit, an unusually high undistorted watt-output is obtainable. This is essential for natural reproduction of the lower tones and musical notes at full volume. Furthermore, the use of a push-pull circuit reduces to an entirely negligible value the slight A. C. hum that would otherwise result from the heating of the power-tube filament by means of raw alternating current.

A standard high quality audio transformer (AC) has been adapted to the push-pull circuit by the use of two 500,000 ohm resistors (R1 and R2) across the transformer secondary to establish the electrical equivalent of a center-tap.

In the input stage is employed an A.C. tube (V1), which overcomes much of the trouble experienced with former amplifiers employing the fragile and highly-microphonic 199-type tube for such a purpose.

The power supply section of the amplifier also boasts of several innovations. One is the use of two full-wave 300-volt gaseous-conduction rectifier tubes (V5 and V6) connected with their outputs in series: the necessary 600 volts is thus supplied by the full-wave filamentless rectification method, with but two inexpensive and long-lived tubes. Another innovation is the use of the 3-element voltage regulator (V4). Aside from stabilizing the operation of the amplifier and maintaining the "B" and "C" voltages at their proper values regardless of line voltage fluctuations, the regulator tube also contributes largely to the lack of hum and to the good tone quality, due largely to its action as the equivalent of a 50 to 60 microfarad condenser across the high voltage plate supply.

Aside from tone quality, one of the outstanding achievements in the new



Under view of the A. C. Phonograph amplifier showing the power transformers, the filter choke and the condenser banks.

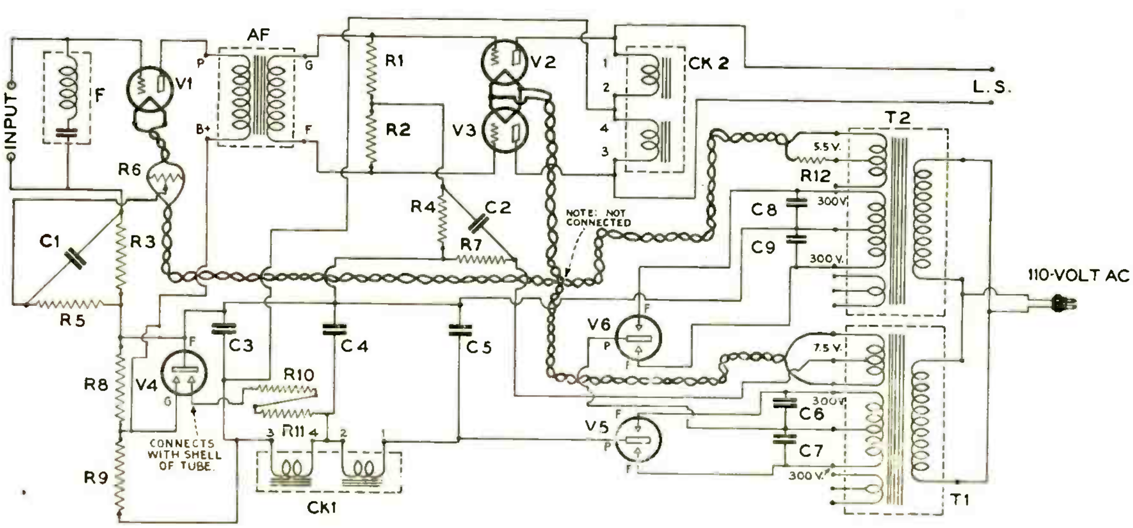
phonographs is the elimination of surface noises and needle "scratch." The use of a new material for the manufacture of records has done much to mitigate this annoyance of the past; but its final and complete elimination is accomplished by means of an electrical filter circuit, so tuned as to suppress scratch frequency. Such an electrical filter is connected between the pick-up and the amplifier. The filter is so located before, rather than after the amplifier in order to prevent unnecessary overloading of the latter.

The difficulty in completely eliminating the scratch lies in the fact that it is not of any one frequency, but covers quite a wide band. If, however, the filter circuit is tuned to approximately 4,500 cycles, the greater part of the scratch noise is removed without sacrifice of tone quality. The residual hiss is practically unnoticeable when a scratch filter is employed, and cannot be detected except for the first few seconds or so before the music starts.

While an electrical filter circuit of the type indicated in the diagram will remove objectionable scratch from the music issuing from the loudspeaker, it will not prevent one from hearing the unamplified scratch noise directly from the record. For this reason the lid of the turntable compartment should be kept closed while records are playing.

LIST OF PARTS REQUIRED

T1, T2 — 2 National Power Transformers (300 volt secondary with center tap)
CK1 — 1 National Filter Choke
CK2 — 1 National Plate Choke
F — 1 National Needle Scratch Filter
AF — 1 AmerTran 2nd Stage Audio Transformer
C1, C2 — 2 Tobe 1. Mfd. Filter Condenser (450 volt rating)
C3 — 1 Tobe 4. Mfd. Filter Condenser (1,000 volt rating)
C4, C5 — 2 Tobe 2 Mfd. Filter Condensers (1,000 volt rating)
C6, C9 — 2 Tobe 0.1 Mfd. Buffer Condenser Units
R1, R2 — 2 Lynch .5 Megohm Fixed Resistors



Schematic diagram of the A. C. Phonograph Amplifier. The resistance R12 is a section of wire from a rheostat. Its value must be determined by experiment. F is an especially designed needle scratch filter.

R3, R4 — 2 Lynch .1 Megohm Fixed Resistors
R5 — 1 Lynch 1,000 Ohm Fixed Cartridge Type Resistor
R6 — 1 Carter 30 Ohm Potentiometer
R7 — 1 Lynch 10 Watt, 750 Ohm Wire Wound Resistor
R8 — 1 Lynch 20 Watt, 10,000 Ohm Wire Wound Resistor
R9 — 1 Lynch 20 Watt, 12,000 Ohm Wire Wound Resistor
R10, R11 — 2 Lynch 20 Watt, 40,000 Ohm Wire Wound Resistors
V1 — 1 Ceco M-26 A.C. Amplifier Tube
V2, V3 — 2 Ceco L-10 Power Amplifier Tubes
V4 — 1 Raytheon 3-Element Voltage Regulator Tube
V5, V6 — 2 Raytheon Full Wave Rectifier Tubes (BH type)
6 Eby UX Tube Sockets
4 Eby Binding Posts
2 Lynch Double Resistor Mounts
1 Lynch Single Resistor Mount
1 Roll Cornish Insulated Hookup Wire
EP — 1 Bosch Phonograph Pickup
R12 — Resistor Wire (see text for description)
VC — 1 Bosch Potentiometer Type Volume Control
SW — 1 Standard 110 volt Snap Switch
A — 1 Steel Chassis 13¾" x 12" x ⅛"
B — 1 Westinghouse Micarta Panel 1¼" x 1"
C — 1 Westinghouse Micarta Panel 1¼" x 3"
D — 1 Westinghouse Micarta Panel 3" x 5½"
WXYZ — 1 Brass Posts (2¼" x ½" tubing)

of "C" batteries is employed as the source of "C" potential. This bank is inexpensive, functions excellently and supplies grid bias voltages to all the the tubes in the unit.

Nothing has been sacrificed in the control of the intermediate frequency amplifiers. The conventional potentiometer control is used, but with an improved modification. The gain in amplification is controlled with the potentiometer, but the wiring arrangement is such that only negative biasing voltage is applied. No position of the potentiometer control affords a positive bias. The movement of the lever varies the negative biasing voltage from 0 to 6 volts negative.

The A. C. tubes used obtain their filament potential from a 25 volt Lionel train transformer, rated at 100 watts. This transformer supplies a variable voltage, as desired, from 7 to 25 volts. The design of the tubes is such that a center tapped filament circuit is unnecessary. The filament system in the tube is of the heater type and the cathode in each tube functions as the common terminal. The tubes consume .35 of an ampere at 15 volts.

The superhet. unit utilizes a loop

An A-C Superheterodyne

A SUPERHETERODYNE receiver utilizing A. C. tubes and a "B" battery eliminator as a source of "B" potential is certainly of interest to superhet. fans.

John F. Rider has designed a superheterodyne receiver unit suitable for use with any and all audio amplifiers, and which utilizes A. C. tubes and a "B" battery eliminator. The unit contains six tubes, apportioned as follows: One tube as the first detector or modulator tube, one tube as the oscillator, two tubes as intermediate frequency amplifiers, one tube as the second detector and one tube as a stage of audio frequency amplification. The reason for omitting a complete two or three stage audio amplifier, is founded upon the fact that so many fans are now utilizing power amplifiers, and by incorporating one stage of audio amplification, the complete unit is adaptable to any power amplifier.

This superhet. unit is complete as far as electrical design is concerned. The introduction of A. C. tubes does not impose any limitations whatsoever. The unit, in a long series of tests has been found to possess an excellent degree of stability and sensitivity and addition to very satisfactory amplification. Despite the use of A. C. tubes throughout, the unit is very silent in operation. And despite the use of the A. C. tubes, the construction of the unit does not entail any difficult problems. The problem of grid bias voltages is solved in a neat and efficient manner. Grid bias voltages usually cause a great deal of trouble in superhets, due to the critical adjustment encountered in the majority of these receivers. This is particularly true when an attempt is made to obtain the various grid biasing voltages from a "B" battery eliminator. To avoid the possibility of trouble, which would cause a great deal of annoyance, a small bank

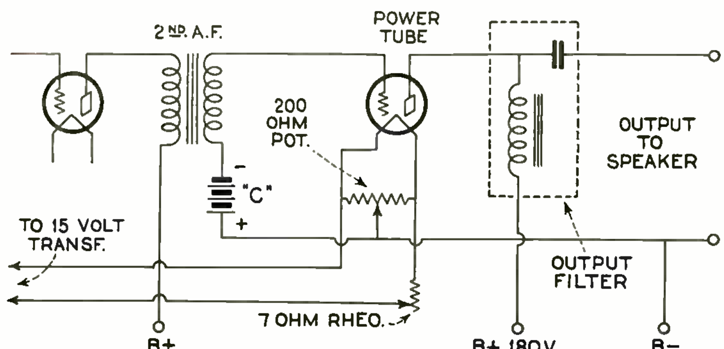
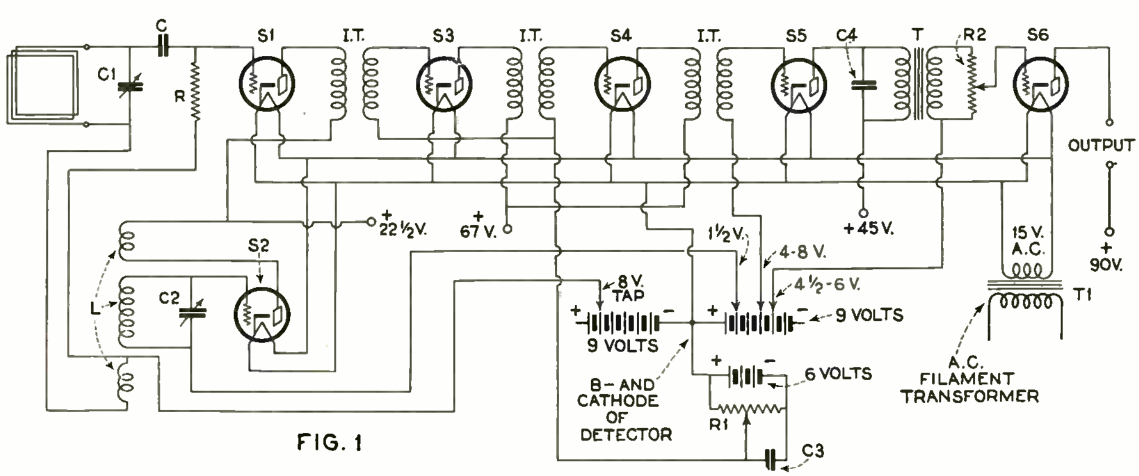


FIG. 3

Diagram of connections for a stage of power amplification, operating the filament of the power tube from raw A. C.



Schematic diagram of the A. C. Superheterodyne. Note the special arrangement of "C" batteries for biasing the A. C. tube grids.

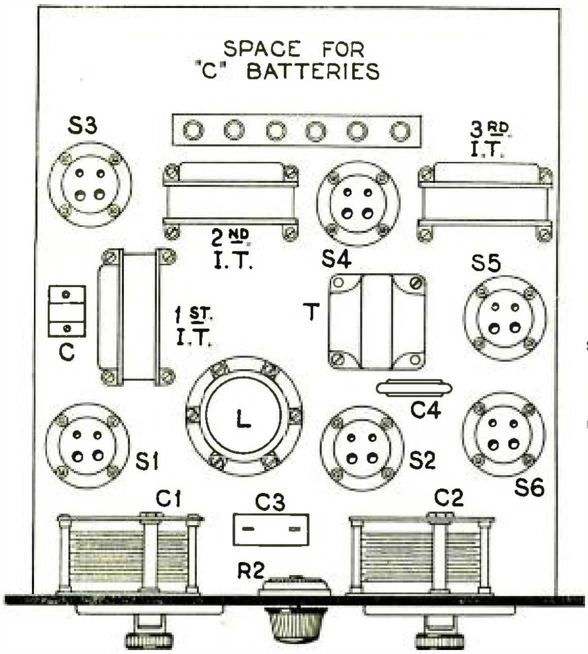


FIG. 2

Constructional layout of the A. C. Superheterodyne. L is the plug-in type oscillator coupler and its six prong contact base.

pickup, and affords excellent selectivity without any need for stages of tuned radio frequency amplification. 1000 and 1500 mile reception has been regularly accomplished with loud speaker volume and excellent quality of reproduction. The fact that A. C. tubes are used does not interfere in any way with the quality. The amount of hum due to the raw A. C. on the tube filaments is so little as to be completely negligible.

The unit is comparatively small, and therefore readily adaptable to all installations.

Mention must be made of the connection of the "B" minus and the common "C" battery returns. The design of the tubes is such that the common battery terminals must be carried to the cathode tube terminals. These are the filament plus terminals on the socket. Do not connect the common battery terminals to the transformer cathode lead.

The baseboard layout is shown in Fig. 2. Provision is made to house the "C" batteries in the cabinet. The wiring diagram is shown in Fig. 1. The wiring diagram in Fig. 3 shows the method of connecting an additional stage of audio frequency amplification using a 171 type tube fed from the same source of filament potential.

LIST OF PARTS REQUIRED

S1-6 — 6	Eby UX Sockets
C — 1	Aerovox No. 1450 .00025 Grid Condenser with Leak Clips
R — 1	Aerovox 5 Meg. Grid Leak
C1, C2 — 2	Dejur No. 180B .00035 Mfd. Variable Condensers
R1 — 1	Dejur No. 210P 400 Ohm Potentiometer
C3 — 1	Aerovox No. 250 1. mfd. Bypass Condenser
T — 1	Samson Symphonic Audio Frequency Transformer
2	Arcturus A.C. Detector Tubes
4	Arcturus A.C. Amplifier Tubes
IT — 3	Magnaformer Intermediate Frequency Transformers
1	Silver Marshall No. 515 Socket
L — 1	Silver Marshall No. 115A Coil
C4 — 1	Aerovox No. 1450 .001 Mfd. Fixed Condenser
R2 — 1	Electrad Type E. 0 to 500,000 Ohm Royalty Resistance
2	Dials
TI — 1	Lionel Type T 25 Volt 100 Watt Toy Transformer
1	7" x 14" x 3/16" Black Westinghouse Micarta Panel
1	14" x 12 ½" x ½" Wood Baseboard
2	Eby Binding Posts marked Loop
2	Eby Binding Posts marked Output
1	Eby Binding Post parked 22½
1	Eby Binding Post marked 45
1	Eby Binding Post marked 67½
1	Eby Binding Post marked 90
2	Rolls of Acme Celatsite Connecting Wire

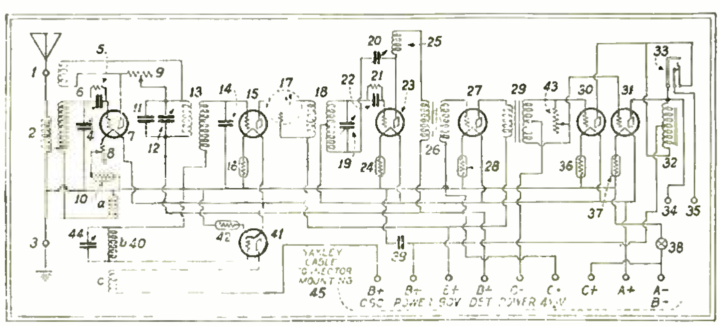
The "Duo-Sonic" Super-Heterodyne

IN DESIGNING the "Duo-Sonic" receiver, it has been the purpose to simplify the superheterodyne, without detracting from its value as a powerful and sensitive circuit. In other words, if simplification is going to result in loss of sensitivity, it would be preferable to build some other type of receiver. Here then, was an ideal problem for the set designer—and it was solved by Mr. Cisin in the construction of the "Duo-Sonic" Super-Het.

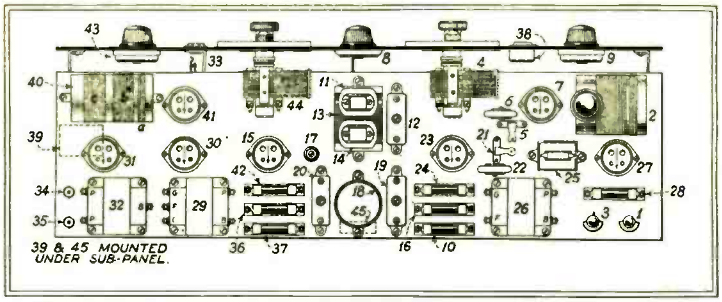
In the "Duo-Sonic" receiver, both the first and the second detectors are regenerative. This means that regeneration is attained at incoming radio frequencies and also at the beat frequency of 1000 meters. Since each regenerative stage is very nearly equal to two stages of tuned radio frequency, the "Duo-Sonic" with seven tubes, is equivalent in power and superior in performance to a nine or ten tube standard superheterodyne. In all superheterodyne circuits, regardless of the number of intermediate stages, the sensitiveness is limited by the energy picked up by the first detector. Making this detector regenerative greatly increases the sensitivity, and avoids the complications inherent in the addition of more stages of tuned radio frequency ahead of the first detector. Regeneration control of the first detector is obtained by means of a variable resistance shunted across the tickler coil of the three circuit tuner.

With the particular constants used in this circuit, regeneration at shorter wave lengths is minimum, while it is maximum at longer wave lengths. This is due to the interaction between the two regenerative detectors.

In the second detector, regeneration is obtained by means of a center tap on the secondary of the "Duo-Sonic" coil (18). One end of the secondary is connected to the grid of the detector tube (23) through the metallized resistor grid leak and the grid condenser. The other end of the secondary goes to the plate of the same tube through a Variodenser.



Schematic diagram of the "Duo-Sonic" superheterodyne which employs regeneration in both the first and second detector tubes.



Layout of the "Duo-Sonic" Superheterodyne. The variable resistance 9, on the panel, controls the regeneration in the circuit of the first detector tube.

In the "Duo-Sonic" receiver, only a single stage of tuned intermediate frequency is used, together with the regenerative second detector. Nevertheless, the results are superior to those obtained with three stages of transformer coupled intermediate frequency. In the latter system, the three circuits must be balanced by a potentiometer and this is generally inefficient and hard to control. The "Duo-Sonic" utilizes a phasatrol to balance the tuned stage.

On the audio side, the first stage uses a standard transformer. This is followed by a stage of push-pull amplification, using a power push-pull input transformer and an output choke. The push-pull transformer and choke should be used with power amplifier tubes only, any of the present types being suitable.

LIST OF PARTS REQUIRED

2—Mar-Co Vernier Dials, type 192
1—Three Circuit Tuner, Precision, type 3 B (2)
2—"Duo-Sonic" Long Wave Coils. (13,18)
1—Oscillator Tuner, Precision Resisto Coupler (40)
2—.0005 Mfd. Hammarlund "Mid-Line" Variable Condensers (4, 44)
5—Amperites, No. 1-A, with Mountings (10, 16, 24, 28, 42)
2—Amperites, No. 112, with Mountings (36, 37)
1—Electrad Phasatrol (17)
1—Royalty Variable Resistance, Electrad type "F" (9)
1—Electrad Tonatrol (43)
1—Thordarson Transformer, type R-200 (26)
1—Thordarson Push-Pull Input Transformer type T-2408 (29)
1—Thordarson Push-Pull Output Transformer type T-2420 (32)
3—.00025 Mfd. Sangamo By-Pass Condensers (6, 14, 22)
1—.0001 Mfd. Sangamo By-Pass Condenser (11)
2—2 Meg. Durham Metallized Resistor Grid Leaks (5, 21)
1—Acme "Parvolt" ½ Mfd. series "A" cubical Condenser (39)
1—10-ohm Yaxley Air-Cooled Rheostat, type 110 K (8)
1—Yaxley 7-Strand Cable, complete with Connector Plug & M'ting Plate (45)
2—X-L Variodensers, type G-5 (12,19)
1—X-L Variodenser, type G-1 (20)
2—X-L Push-Posts (1, 3)
1—Carter "Imp" Lock Switch (38)
2—Carter Tip Jacks (34, 35)
1—Carter Closed Circuit "Hold-Tite" Jack, type 102-A (33)
1—Samson R. F. Choke, No. 85 (25)
2—Rolls Acme Celatsite Wire
1—Can Kester Radio Solder (Rosin Core) By the Chicago Solder Co.
1—Panel, 7"x26"x3/16" Westinghouse Micarta
1—Sub-Panel, 7"x25½"x3/16", Westinghouse Micarta
3—Brackets (low type)
1—"Iveyline" Cabinet, 7"x26"x10" By the Southern Toy Co. Hickory, N. C.
5—"Speed" Super Emission Tubes, type 201-A (7, 15, 23, 27, 41)
2—"Speed" Super Emission Tubes, either X 112 or X 171 (30,31)
7—Eby Sockets, new style (7, 15, 23, 27, 30, 31, 41)

Harkness Counterfonic Six

THE Counterfonic Six, designed by *Kenneth Harkness*, uses the Hiler system of audio amplification on which patents have been granted. This "double impedance" audio amplifier is *tuned* to give increased amplification of low tones below 200 cycles.

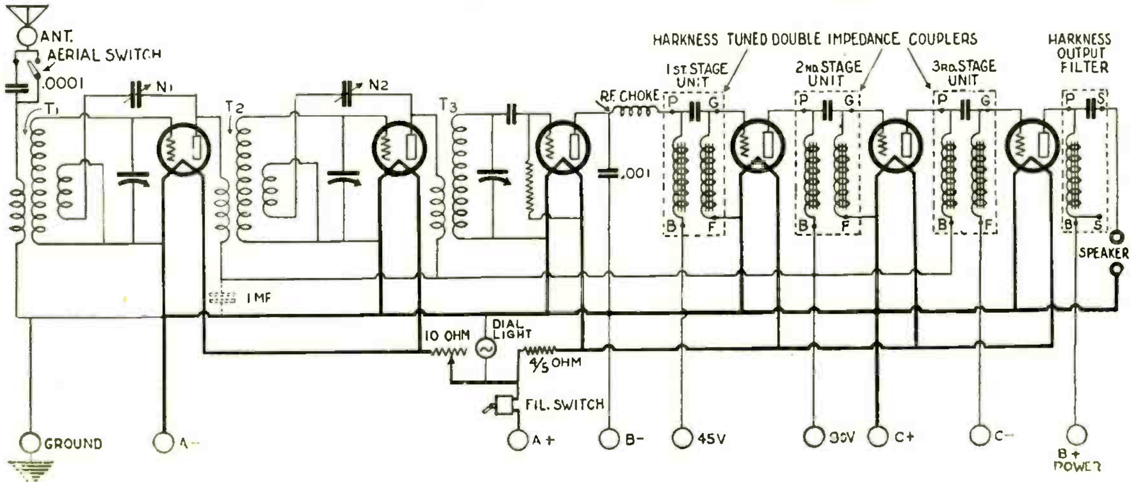
Stations are tuned in by turning a single knob. The radio frequency transformers and tuning condensers are accurately matched and tuning is reduced to a single control without loss of efficiency. Volume is controlled by a separate knob.

The Counterfonic is very selective. Any station can be tuned in without interference from other stations on adjoining waves. Distant stations can usually be tuned in while locals are on the air.

The overall amplification of the Counterfonic is unusually high. Each stage of the radio frequency amplifier is shielded and neutralized. The r.f. gain per stage is large. Under normal conditions distant stations can be received regularly, on the loudspeaker.

LIST OF PARTS REQUIRED

3 Harkness Counterfonic R.F. Transformers
3 Harkness Tuned Double Impedence Audio Couplers (1st, 2nd and 3rd stage types)
1 Harkness Audio Output Filter
1 Harkness Radio Frequency Choke
1 U.S.L. 3-Gang Condenser, .00035 Mfd.
1 Carter 10 ohm, Midget Rheostat
2 Carter or Saturn Battery Switches
1 Carter Fixed Filament Resistance, 4/5 ohm.
3 Aerovox Fixed Condensers, .0001, .00025 and .001 Mfd.
1 Aerovox 2 Meg. Grid Leak
1 Aerovox Grid Leak Mounting
2 X-L or Wizard Neutralizers, .0001 Mfd.
2 Hammarlund Equalizer Condensers (optional)
1 Aerovox 1. Mfd. Condenser (optional)
12 Eby or X-L Binding Posts
3 Copper Shields
1 Silver-Marshall Drum Dial
1 Pair Sub-Panel Brackets 9½" long
Westinghouse Micarta Front and Sub-Panels, drilled, with 6 sockets attached.



Schematic diagram of the Harkness Counterfonic Six which employs the Hiler system of tuned double impedance audio frequency amplification.

Second R. M. A. Trade Show Announced

Director Herbert H. Frost, Chairman of the Association Show Committee has announced the date of the second R. M. A. Trade Show as June 11-15, 1928, to be held at the Stevens Hotel, Chicago, Ill.

Last year it was impossible to properly take care of all members because of the lack of space, but this year Mr. Frost states that in addition to the Exhibition Hall, he has also arranged with the Stevens Hotel for use of the Grand Ballroom which will make available over 30,000 sq. ft. of exhibition space.

Admittance this year will be the same as last, that is by invitation only to jobbers and dealers, and such others as the Show Committee might determine.

No applications for space at this Trade Show will be accepted from new members after February 15, 1928.

Bulletins will be issued from time to time by the Show Management.

During the Trade Show week the Fourth Annual Convention of the Association will be held and reports received from all standing and special committees. The annual election of officers will also be held for the year 1928-29.

The R. M. A. Annual Banquet will also be held during the week of the Show.

Large Radio and Phonograph Merger

One of the most far-reaching and important mergers in the radio and phonograph business to be announced this year was the formation of a $10,000,000 corporation, which includes the Sonora Phonograph Co., makers of radio sets and phonographs, the Bidhamson Co., a patent holding corporation and the Premier Laboratories, headed by Dr. Miller Reece Hutchinson, which have patents covering loud speakers, electric recording apparatus and electrical phonographs.

The new corporation will be known as the Acoustics Products Company and will be headed by P. L. Deutsch of Chicago as president. Mr. Deutsch was associated for two decades with the Brunswick organization and is as well known in Europe as in this country in the phonograph business.

Headquarters of the Acoustical Laboratories Company will be maintained in New York, this concern being the manufacturing division, while the headquarters of the Sonora Phonograph Company, which hereafter will be the selling division, will be located at Chicago. All products will be sold under the Sonora trade name, through the Sonora selling organization.

Mr. Deutsch will also be president of the Sonora Phonograph Company and Harris Hammond will be chairman of the board of the parent company. The board of directors will consist of the two foregoing named officers and Richard Hoyt and Arthur Sherwood of Hayden Stone & Co.,: Anthony J. Drexel Biddle, Jr., and Dr. Miller Reece Hutchinson. A. J. Kendricks, for many years general sales manager of the music division of the Brunswick Company has been appointed general sales manager of the Sonora Phonograph Company.

Daven Announces New Appointments

C. B. L. Townley, Sales Manager of the Daven Radio Corporation, announces the following new appointments in their sales organization: Walter H. Dyer, 1521 Arcade Bldg., St. Louis, Mo., covering Southern Illinois and Eastern Missouri: William S. Reid, 308 East 17 St., Kansas City, Mo., covering Kansas, Oklahoma and Western Missouri.

Temple, Inc., Moves

Temple, Inc., announce the removal of their office and factory from 213 South Peoria Street, Chicago, Ill., to their new and larger home at 1925 So. Western Avenue, Chicago, Ill.

C. J. Brown Moves Into New Quarters

Mr. C. J. Brown, representative for the Samson Electric Company in the New York and New Jersey districts, has moved his offices to the Lexington Tower Building, 369 Lexington Avenue, at 41st Street, New York City.

Booklet on Wiring Buildings for Radio

The Carter Radio Company, 300 South Racine Avenue, Chicago, Ill., have put out a very interesting 10-page pamphlet covering detailed specifications for wiring homes, apartments, hotels, hospitals, and office buildings for radio. Complete working diagrams are included in the booklet which show how to install outlets for aerial and ground, batteries, loud speakers, etc. Numerous different arrangements are shown for providing outlets in rooms for loud speakers and also an outlet arrangement whereby all of the power equipment can be placed in the cellar.

This booklet should be very valuable to any radio contractor-dealer who is interested in taking advantage of this profitable end of the radio business.

The booklets may be had upon request.

Flechtheim Appoints New Sales Manager

Mr. Arthur M. Flechtheim, president of the A. M. Flechtheim Condenser Company, Inc., announces the appointment of Leon L. Adelman as head of the sales department, and consulting engineer.

Mr. Adelman, who is well known in radio circles, has had an interesting and varied experience in all phases of the industry.

Beginning with a humble start as a salesman behind the counter of one of the pioneer radio stores, Mr. Adelman was successively Service Engineer for the F. A. D. A. Co., Radio Editor of Science & Invention Magazine, Associate Editor of Radio News, Assistant Advertising Manager and Publicity Director for the Chas. Freshman Co., Inc., and Assistant Sales Manager for the Hammarlund Manufacturing Co.

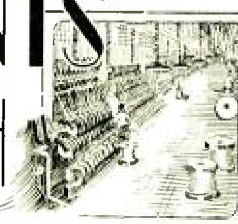
F. R. T. A. to Publish Trade Journal

The Federated Radio Trade Association have opened their executive offices at 32 W. Randolph Street, Chicago, with H. G. Erstrom as Executive Secretary in charge.

The Federated Radio Trade Association announces the starting of their official publication the Federated Radio Trade Journal which will be published monthly from their executive offices in Chicago starting with a December issue.

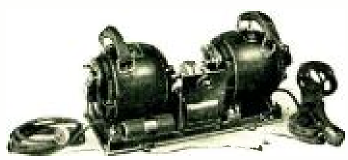
A Legislative Committee composed of Harold J. Wrape, St. Louis: Fred Yahr, Wisconsin, and Thomas White, Buffalo, was appointed with instructions to represent the Federated Radio Trade Association in matters of legislative import in Washington, D. C.

NEW DEVELOPMENTS OF THE MONTH



Bodine Radio Motor Generator Set

A special motor generator outfit designed to supply an alternating current for operation of radio receivers from a direct current lighting line has been



Bodine D. C. to A. C. Motor generator.

introduced by the Bodine Electric Company, 2254 West Ohio Street, Chicago, Ill. This motor generator is designed to operate from a 110-volt D. C. line and supplies 110-volts, 60-cycle alternating current at the output.

A very efficient filter system is built into the machine itself which, it is stated, eliminates the disagreeable noises and furnishes a pure 60-cycle alternating current.

The motor generator is practically noiseless in operation and free from undue vibration.

Special models have been designed for operation on voltages other than 110-volts D. C.

New Browning-Drake Unit

The Browning-Drake Company, of Cambridge, Mass., announce a new unit for the improved Browning-Drake receiver.

This unit consists of two variable condensers, the antenna coupler, the radio frequency transformer with variable tickler coil and a new type of drum dial, all combined into a single unit.

The Browning-Drake receiver has been resolved into a single control set and the drum dial in the unit operates both of the variable condensers. The two Browning-Drake coils have been redesigned and are much smaller in diameter and length which makes the unit more compact. The drum dial is operated by an ingenious type of chain drive rather than the usual gear arrangement, and is exceedingly smooth in operation as well as being accurate. The dial is turned by the small knob mounted directly below it.

Automatic "A" Battery Charger

The Johnson Motor Products Company, 1401 Carroll Avenue, Chicago, Ill., have announced a new automatic "A" battery charger known as the Charg-A-Matic which employs a dry type rectifier.

The Charg-A-Matic will deliver a 1 to 1¼ ampere charge to the battery until it reaches full charge at which

The Charg-A-Matic Unit.

time the charging rate is automatically reduced to a trickle charge of approximately .3 ampere. At any time the "A" battery drops below normal voltage, the Charg-A-Matic automatically resumes its full charging rate.

This unit is equipped with a plug for attaching the "B" eliminator and an automatic switch shuts off the charger and turns on the "B" eliminator when the set is in use, and vice versa, when it is off.

Flechtheim High-Voltage Filter Condensers

The A. M. Flechtheim Condenser Company of New York City, are now manufacturing a group of high-voltage

Flechtheim high voltage filter condenser.

filter condensers of new design. These new condensers are made to withstand testing voltages up to 3,000 volts D. C., and are within 5% of their rated value, according to the manufacturer. These condensers are manufactured with capacity values ranging from 1 mfd. upwards to 8 mfd. within a single unit or block.

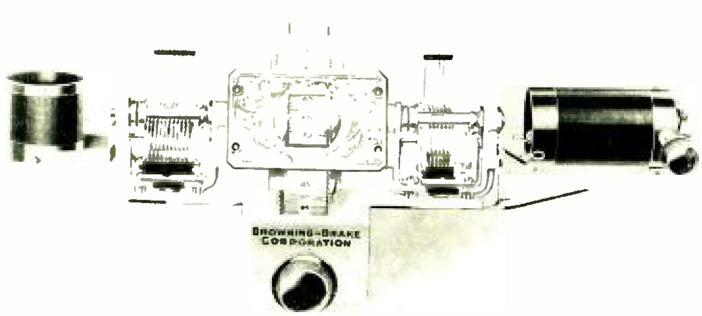
Flechtheim low voltage filter condenser.

Low voltage filter condensers are also manufactured and can be obtained in all of the low capacity values commonly employed.

Volume Control Clarostat

Differentiating between the heavy-current requirements of the usual radio power unit and the relatively light-current requirements of the usual radio receiver, there has been added a smaller and moderately priced type to the Clarostat line of micrometric variable resistors.

The new type is known as the Volume Control Clarostat. It is of about the same diameter as the Standard



The new Browning-Drake Kit Unit.

type, but only a third as deep. The current-handling capacity is approximately one-third that of the Standard type employed in radio power units and for the heavier receiver requirements. In several turns of its knob, the Volume Control Clarostat covers a resistance range of approximately zero to 500,000 ohms, which is more than ample for the usual requirements. Furthermore, this range is covered in several turns of the knob, which means a finer degree of adjustment than is usually available.

The Volume Control Clarostat.

The Volume Control Clarostat is a one-hole mounting job. It is provided with screw terminals for ready wiring. Its bright nickel finish and polished bakelite knob of new design, make it an attractive and worthy addition to any radio assembly.

Many applications will suggest themselves for the Volume Control Clarostat. However, it is essentially intended for volume control, plate voltage control, regeneration control, tone control and other forms of control required in modern reception.

Belden Flat Extension Cord

The Belden Manufacturing Company, 2300 South Western Avenue, Chicago, has recently developed a flat, rubber insulated extension cord for running under the rug, to provide convenient and safe outlets in any part of the room. The Belden Flat Floor Cord, as it is called, provides an ideal connection for floor and reading lamps, fans, heaters, electric phonographs, irons and radio power units. This unique cord is not noticed under the rug. The soft rubber gives and does not cause the rug to wear. A four-foot cord connects the flat cord to the house outlet. A most unusual feature is the Belden soft rubber plug which will not break and cannot be crushed. The other end of the flat cord is fitted with receptacle for a standard plug.

Belden Flat Extension Cord.

New Majestic "A" Unit

The Grigsby, Grunow, Hinds Co., manufacturers of the Majestic line, announce a new "A" unit. The Majestic "A" Unit is almost identical in size, shape and appearance to the Majestic "B" Eliminator except for a small rectangular metal box at the front which houses the "A" rectifier used. In operation it equals a storage battery in every respect on any radio set and will supply humless power at six volts even up to current loads of two and one-half amperes which in effect means the largest commercial radio sets.

Majestic "A" Unit.

Regulation or voltage control is extremely simple. Variation in line voltages and current drains can be compensated for by adjusting the knob on the front of the unit until the proper voltage is obtained. Although it is not necessary to use a voltmeter, means have been provided by two phone tip jacks into which a standard 0 to 8 voltmeter of the pin type may be inserted and extremely accurate adjustment obtained.

An examination of the makeup and hookup reveals a conventional rectifier and filter circuit but it also reveals a new type of condenser which, it is stated, has a maximum capacity of over eighteen thousand microfarads although its physical dimensions would seem to make such a large capacity prohibitive. The condenser contains no liquids and is scientifically known as a dry polarized type. It is stated that the current consumed by this "A" unit when used with a seven-tube radio set is less than that used by a medium-sized lamp bulb. A current tap is provided in the front of the "A" eliminator into which the plug from the "B" eliminator is plugged. The connector cord from the "A" unit has a switch in series with it which is used to turn on and off both the "A" and "B" unit at the same time.

Carter Hi-Watt Rheostat

The Carter Radio Company, of 300 South Racine Avenue, Chicago, Ill., have introduced a new series of rheostats for use in connection with A. C. tubes, etc. These Hi-Watt rheostats are capable of carrying 20 watts and

Carter Hi-Watt Rheostat.

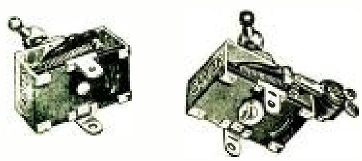
can be obtained in the following resistance values: ½, 1, 2, 3, 6, 100, 150 and 250 ohms.

Unlike the usual form of rheostat, these new units are wound with heavy resistance ribbon on a heat resisting insulation strip. Practically the entire resistance element is exposed and is therefore air-cooled.

Carter Power Switches

The Carter Radio Company, of 300 South Racine Avenue, Chicago, Ill., have introduced two new types of Power Switches for 110-volt circuits. Both of these are of the snap-switch type, with double contact and a quarter-turn movement.

The Automatic Power Switch is also designed for operation in a 110-volt circuit and replaces the usual automatic relays employed for switching from "B" eliminator to charger. This switch will control any type of "A" or



Carter Power Switches.

"B" supply unit and when turned to the "off" position, automatically connects the charger to the "A" battery and disconnects the "B" supply. On closing the filament circuit, the charger is turned off and the "B" supply connected to the receiver.

Both of these switches are provided with "on" and "off" nameplates and are of the single mounting type fitting a hole ⅜" in diameter.

The PXY-1 Powerizer

The Radio Receptor Company, Inc., of 106 Seventh Avenue, New York City, have announced an addition to their line of Powerizers known as the PXY-1, the Universal Model, which can be adapted to any set for the purpose of supplying power amplification and the complete "A," "B" and "C" power to sets of five, six or seven tubes.

New Receptrad Powerizer.

The PXY-1 Powerizer includes a power amplifier, employing a 210 type tube, along with the power unit. A 280 type rectifier tube is used in the power unit and is capable of supplying sufficient current for all purposes.

New Sonochorde Speakers

The new Sonochorde Speakers for 1927-8 include four models—two table designs, a wall type and a floor standard type. All are of the perfected cone type. The supporting frame of each model is finished in rich semi-gloss mahogany with base to match

The Sonochorde Junior Speaker.

and is practically unbreakable. The cone itself is covered with a warm wine-colored silk front neatly festooned from the center. Each oversized base is provided with heavy felt pads so as not to mar the finest surfaces. The back of each cone is protected with metal arms integral with the frame, thus insuring the reproducing mechanism from possible injury.

All models incorporate the balanced armature actuation unit developed and perfected by Sonochorde. This unit is ruggedly constructed and according to the manufacturer utilizes four super-powered magnets capable of lifting 10 lbs. These magnets are angularly spaced and scientifically balanced with a minimum air gap.

The Sonochorde Junior stands approximately 15 in. high and is 13 in. in diameter, and like all Sonochordes is provided with an adjustment control. The Senior Model stands 18 in. high with a diameter of 16 in. The Wall Model is equipped with heavy cord and decorative tassel and is designed to meet the vogue for wall hanging, but otherwise is identical with the Senior Model. The Floor Standard design is mounted on an upright base, similar to a piano or floor lamp.

The B. B. L. Speaker

The B. B. L. Speaker, manufactured by B. B. L. Speaker, Inc., of 101 West 131st Street, New York City, has very fine tonal qualities and is a good reproducer of low frequencies.

It is of the double cone type, 24" in diameter and employs a balanced armature type unit. The sloping pole pieces are made of laminated silicon steel.

The B. B. L. Cone Speaker.

The speaker is supported by a tri-foot base with provisions for hanging on the wall with the base removed.

The cone is made of a rich, dark colored material suggesting old Spanish leather.

Shieldplate Tube

The Shieldplate Tube Corporation, 206 South LaSalle Street, Chicago, Ill., announce a new four-element tube known as the type SP-122. This tube employs a screen grid which entirely surrounds the plate of the tube, both inside and outside. This grid acts as a shield between the plate and the control grid, thereby reducing the capacity between these two elements to a negligible quantity.

Due to this arrangement the tube has an amplification constant of approximately 175, it is stated.

The tube is designed primarily for use as a radio frequency amplifier but can also be used as a detector or an audio frequency amplifier with a few changes in circuit connections.

The SP-122 Shieldplate Tube.

The filament voltage of this tube is 3.3 volts and the filament current consumption is .133 ampere. Due to the low filament consumption it can be operated from dry cells or, if desirable, from the six-volt storage battery, by using a 15 ohm fixed resistance in series with the negative filament lead.

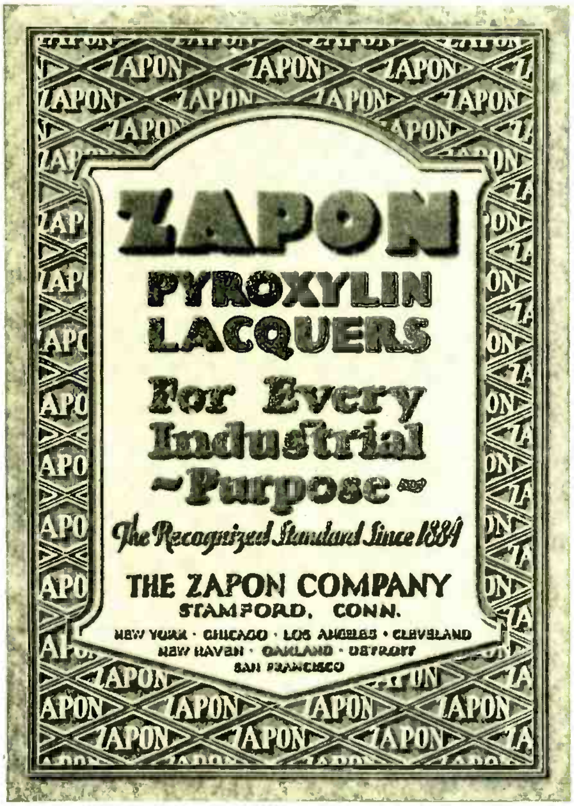
Much greater amplification can be obtained from this tube in both radio and audio frequency circuits.

Electro-Chemical Dry Condenser

A high capacity dry condenser for use in "A" eliminators, "B" eliminators and power packs, is announced by the Electro-Chemical Company of America, Indianapolis, Ind. The special construction of this condenser permits the use of a paste electrolite that cannot spill, or leak out of the container. It is stated by the manufacturer that the condenser is self-healing and that the break-down voltage is approximately 500 volts.

The condenser is tapped so as to provide capacities of 40, 80, and 120 microfarads.

The entire condenser is contained in a seamless pressed steel can 3" long, 3" wide, and 4" high.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For Every
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The Recognized Standard Since 1884
THE ZAPON COMPANY
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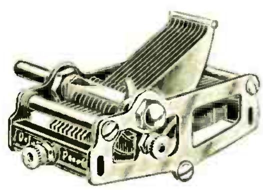
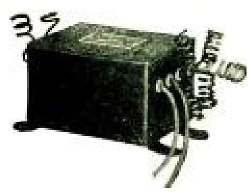


New Dongan A. C. Power Transformers

The Dongan Electric Manufacturing Co. of Detroit announce 14 types of new low-voltage transformers and units.

Together with No. 4568 are eleven other transformers for use with various types of the new A C tubes. Then there are two "A-B-C" Power Units which, together with UX 226



Dongan A. C. Power Transformer.

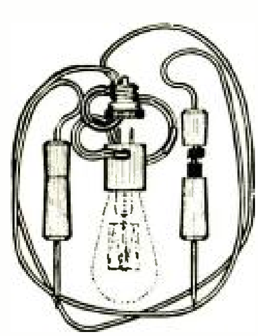
and UX 227 tubes and either the Raytheon B H Rectifier Tube or the UX 280 Rectifier Tube serve as power units to operate radio receivers. Furthermore, these units provide for the sets equipped with the UX 171 power amplifier tube. Of these 14 types, several are built in unmounted style for the requirements of the set manufacturer.

Meco Test Handles

The Metropolitan Electric and Manufacturing Company, of 1163 Sedgewick Street, Chicago, Ill., are marketing two types of Test Handles for regular circuit testing work.

Meco Test Handles.

Test Handle No. 115 comes complete with two heavy leads and large terminals so that they can be connected to a storage battery or a regular light circuit for testing work.



Meco Trouble-Shooter.

The points on the test rods are noncorrosive and rust-proof.

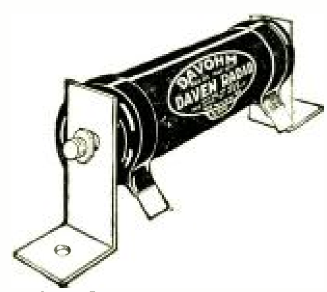
The "Meco" Trouble-Shooter consists of two Test Handles, similar to the ones described, together with a special plug and socket arrangement which can be screwed into any 110-volt A. C. or D. C. line for testing work. Any incandescent lamp can be screwed into the special socket and will immediately indicate any short or open circuits.

New Daven Power Resistors

The Daven Radio Corporation of Newark, N. J., announce two new complete lines of heavy-current resistors.

One is a power resistor, wound on porcelain and thoroughly insulated, for use in power packs delivering up to 450-500 volts. This series ranges in values from 500 to 15,000 ohms, with actual heat dissipation in excess of five watts.

It is stated that these voltage regulators pass, according to their size,



New Daven Power Resistor.

from 27 to 150 milliamperes, which is ample for all standard units employing 171 to 210 power tubes.

A desirable innovation in this model is the inclusion of mounting rods and supporting brackets, "Resistoprops," which prevent sagging of the resistors under heat and which provide for rigid, easy assembly.

A smaller series of resistors, wound on glass and comparable in size to the Daven Glastor, or the ordinary grid leak, are made in sizes from 100 to 5,000 ohms, in 100-ohm graduations up to 1,000 ohms, in 500 ohm graduations up to the maximum of 5,000 ohms.

These Glastor-type resistors are intended for power-packs delivering up to 180 volts, and for all purposes where a unit is not required to dissipate more than two watts. Because of their diminutive size this model of Daven Resistor may be mounted in the conventional gridleak clips.

Westerland Loop-Tuner

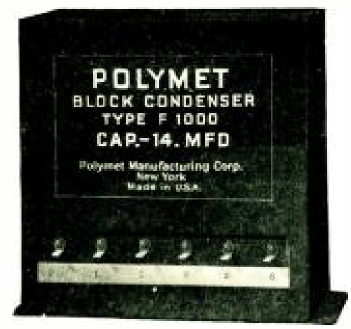
The Westerland Corporation, Dobbs Ferry, New York, have placed on the market a new and very excellent arrangement for direction control of loop aerials.

It consists of a small cabinet with a knob and dial marked with the points of the compass. This is placed on top of the radio set. The loop aerial fits into a rotatable jack in the top of the small cabinet which is geared to the knob and dial. This mechanism adjusts the loop to exactly the proper direction for any station, as indicated on the dial.

The Loop-Turner is easily attached to any ordinary loop.

Polymet Block Condensers

In order to satisfy the popular demand for condensers in block form



Polymet Block Condenser.

to be used in connection with the various types of "B" Eliminators and Power Amplifiers, the Polymet Mfg. Corp., 599 Broadway, New York City, have placed on the market a number of condenser blocks containing the correct total capacity tapped in the proper places for the most popular of these circuits.

The working voltage under which these condensers are to operate has been studied and only the proper condenser sections incorporated in these blocks.

The Mayolian 615 "B" Power Supply

The new Mayolian 615 "B" Power Supply, delivers 150 volts at 40 mils, has six output voltage terminals varying from 22½ to 150 volts. Line voltage variations are compensated for by a wire-wound variable resistance.

New Mayolian 615 "B" Power Supply.

A novel method is incorporated for servicing, enabling anyone to service this unit in a few minutes time.

Centralab Radiohm RX 100

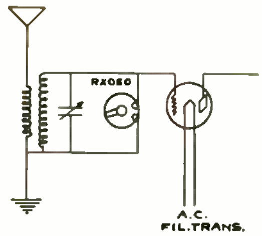
Radiohm
RX 100

A STANDARD unit with a new taper of resistance built for one specific purpose — controlling volume of sets equipped with the new AC tubes.

The popular method of volume control for battery type tube circuits, that is, a variable resistance in the R. F. plate circuit or in the R. F. filament circuit, cannot be used with AC tubes, since a variable resistance in either of these positions will disturb the delicate balance and introduce an AC hum. This makes a new type of volume control essential and the Centralab RX 100 Radiohm is ideal because of its minimum capacity and its smooth, noiseless action.

Inserted in the grid circuit of the R. F. stages, it has the distinct advantage of a smooth, accurate volume control without affecting the filament or plate potentials, insuring balance and eliminating a source of AC hum. In "super" circuits, this Radiohm gives the most satisfactory volume control when placed in the grid of the intermediate frequency that is not sharply tuned.

Another helpful method of keeping an AC circuit in balance is a Centralab Power Rheostat of 50 ohms inserted in the primary of the transformer. It will compensate for any line fluctuation — increasing the life of the tubes and holding the entire circuit to the point of best operating efficiency.

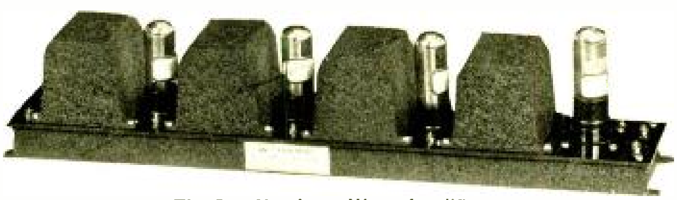


The Application

Other products of Centralab are *Radiohms, Modulators, Potentiometers, Power Rheostats* and *Heavy Duty Potentiometers*—Folder 328 describes them all. Write for it.

CENTRAL RADIO LABORATORIES
25 Keefe Ave., Milwaukee, Wisconsin

Ten Kilo-Cycle Selectivity



The Dar-Mac Long Wave Amplifier.

without Distortion

made possible by using a

DAR-MAC Long Wave Amplifier

The DAR-MAC Amplifier is a real laboratory article designed and constructed for custom set builders specializing in building receivers for the most critical radio buyer.

Every DAR-MAC Amplifier by reason of the severe tests to which it is subjected assures the uniform excellence of performance so much desired in all super-heterodyne receivers.

This DAR-MAC Amplifier unit consists of four transformers completely encased in aluminum and mounted on a cast aluminum base. The sockets and all of the wiring are completed in the unit when it is made.

These DAR-MAC Units are made to have band pass acceptances of 5, 10 and 15 kilo-cycles respectively thus enabling the user to decide for himself the degree of selectivity required by him in his particular locality.

This DAR-MAC Amplifier can very easily be installed in existing out-of-date superheterodynes with a great improvement in selectivity, tone-quality and sensitivity.

NOW—the DAR-MAC scores another triumph by incorporating in their units the new S P 122 Shielded Grid Amplifier Tube which makes possible hitherto unknown Sensitivity, Tone Quality and Selectivity with an amplification gain of approximately three times that of any other amplifier.

Custom Builders write for full details regarding the DAR-MAC Amplifier and also the DAR-MAC Super Nine Kit as described in the article appearing in another part of this issue. This amplifier and kit will assure satisfied customers as no difficulty will be experienced in proving in actual tests the superiority of DAR-MAC precision equipment.

Dar-Mac Laboratories, Inc.
19 So. Wells St., Chicago, Ill.

USE THIS COUPON

DAR-MAC LABORATORIES, Inc., 19 So. Wells St., Chicago, Ill.
Gentlemen: Please send full information on your DAR-MAC Long Wave Amplifier and DAR-MAC Kit to the following:

Name..

Street..

City.............................State......................

Engineer...... Jobber...... Dealer...... Set Builder......

New France "A" Eliminator

The France Mfg. Co., Cleveland, Ohio, have just recently released their "A" Eliminator models for replacing both four- and six-volt radio "A" storage batteries.

A dry disc rectifier and electrolytic filter are employed. The filter used is licensed under patents of the Andrews-Hammond Corp.

New France "A" Eliminator.

Operates only while set is in use and consumes no more current than the average house lighting bulb—forty to fifty watts.

Size 6¼" x 6¼" x 9¼" high. Takes less cabinet space than the trickler-battery combination which it replaces. Furnished complete with both A. C. and D. C. leads.

The "Power" A, B and C Socket Power Unit

Harold Power, Inc., of Medford, Mass., have placed upon the market a very compact "A," "B" and "C" Socket Power Unit for use with the new A. C. tubes. The "B" portion of the unit will supply a maximum of 50 mills at 180 volts. A flexible lead plugging into tip jacks provides adjustment for high, low, or intermediate line voltages. "B" voltage taps are included which provide voltages ranging from 33 to 180 volts. The "A" portion of the unit supplies three distinct raw A. C. voltages, namely, 1½ volts A. C., with a capacity for seven 226 type A. C. tubes, 2½ volts A. C., with a capacity for supplying four 227 type A. C. tubes and a five-volt tap for lighting the filament of a 171 type power tube.

"C" voltages are obtained by the proper biasing of the A. C. tubes in the receiver. No separate "C" voltage terminals are incorporated in the power unit. The unit is provided with a resistance so that either a type 213 or a type 280 rectifier tube may be used.

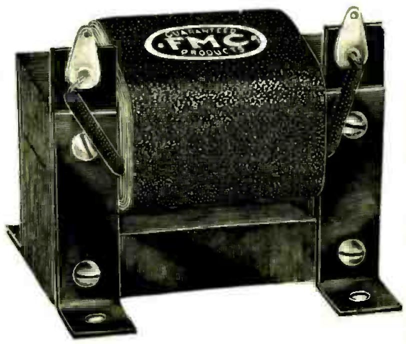
This socket power unit is 6¾" wide, 6½" high, and 9" long. Its weight is 15 pounds.

The new "Power" "A, B and C" Socket Power Unit which supplies 50 milliamperes at 180 volts, and "A" supply for A. C. tubes and power amplifier tubes.

The F. M. C. 30 Henry Choke

This is an impedance designed for use in connection with a "B" Eliminator or an output choke for use with a power tube in the last stage of the receiving set. The stated current capacity of 90 milli-amperes is ample for use in any "B" Eliminator. The resistance is low, thus keeping losses at a minimum.

In using the choke for a "B" Eliminator it is preferable to use two chokes as recommended for the Raytheon tubes although in some cases, where the output is low, one choke will be sufficient. When used with the UX 213 or 216 B tube one F. M. C. Choke and condensers of about 10 microfarads capacity are usually satisfactory for smoothing out the current and eliminating the hum although it is better to use two chokes.



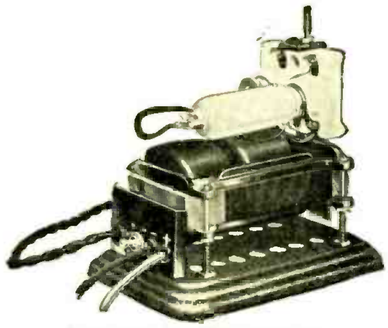
Ford Mica 30 Henry Choke.

When used as an output impedance with a 1 to 3 microfarad condenser, a power tube and a good speaker, the F. M. C. Choke makes an ideal device for obtaining both high and low notes in their proper proportions, at the same time keeping the plate current from passing through the speaker winding.

Manufactured by Ford Radio & Mica Corporation, 111-113 Bleecker St., New York City.

The MetAnode Rectifier Cartridge

The Electro-Chemical Company of America, Indianapolis, Ind., announce a new type of full-wave cartridge rectifier which was developed in their laboratories. The MetAnode Rectifier



MetAnode Rectifier Cartridge

Cartridge is made of metals sealed in a metallic cartridge and all rectification occurs in the ionic displacement of the metals themselves. This unit will deliver a steady rectified current of five amperes. The permissible potential per unit is 200 volts. The manufacturer states that this new rectifier cartridge has a life of 1,200 hours.

The unit is made in two types, one to fit the standard Fahnestock connector and the other with a special three contact base which fits into a moulded three-contact socket.

The MetAnode Cartridge is 3" long and ¾" in diameter. The shell is made of pressed steel plated with polished silver.

Quam Cone Speaker

The Quam Radio Corporation, of 9705 Cottage Grove Avenue, Chicago, Ill., announce a cone type speaker with a new principle. Instead of a floating reed secured at only one end, this new

The New Quam Cone Speaker.

speaker has a stretched reed—like the human vocal chords—and it is stated that this arrangement considerably improves the tonal quality of the speaker.

NO OPEN CIRCUITS with the New all duty DAVOHM

After months of research, Daven, the Resistor Specialists, are giving to the Radio Fans of America what they honestly believe to be the most perfect wire wound resistor . . Davohm.

Will Not Open Circuit

Davohms are built to the most exacting specifications. The enamel is a special composition which resists the highest temperatures. *Davohms will not open circuit.* Davohms will carry their full rated current capacity plus an overload, *safely* without excessive heat.

Constant Efficiency

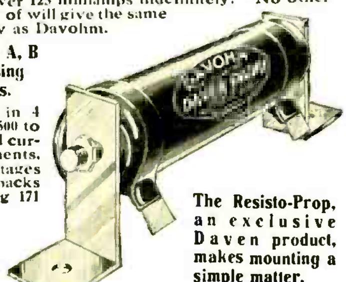
Davohms are accurately rated when you buy them and they remain accurate. If you draw 125 milliamps from a Davohm, it will continue to deliver 125 milliamps indefinitely. No other resistor that we know of will give the same unchanging efficiency as Davohm.

For All Power Packs, A, B and C Eliminators using 171 or 210 Tubes.

Davohms are made in 4 sizes in values from 500 to 25,000 ohms and for all current carrying requirements, dissipating all wattages specified in power packs and eliminators using 171 or 210 tubes.

At your dealer

Daven Radio Corporation
161 Summit Street
Newark, N. J.



The Resisto-Prop, an exclusive Daven product, makes mounting a simple matter.

Shieldplate Type S.P. 122 Shielded Grid Tube

Exclusively Specified
for use in the
Darmac Super 9
(described in this issue)

Also specified and recommended for the

Tyrman "70"

and all leading circuits employing the use of Shielded Grid Tubes.

Shieldplate Shielded Grid Tubes, type SP 122, are guaranteed mechanically perfect.

Price $7.50

Insist on the Original

Sold by all reliable Jobbers and Dealers.

Write us for FREE Literature.

Shieldplate Tube Corp.
Dept. E.
208 S. LaSalle Street
CHICAGO, ILL.

KELVIN FULLWAVE NO FILAMENT RECTIFYING TUBES ARE DIFFERENT

Tipless Construction

Longer life
Larger output
Quieter operation
Quicker pickup

125 M. A. Price $4.00

Uniform quality

Sole Distributors

Eureka T & M Co.,
42 Walnut St., Newark, N. J.
Guaranteed for one year

PHOTO-ELECTRIC CELLS
THE BURT CELL

Without Fatigue—Highly Sensitive
Absolutely Reproducable—Instantaneous in Response

The BURT-CELL is made by a new method and should not be confused with any other photo-electric cell. By a special process of electrolysis, the photo-electric metal is introduced into a highly evacuated bulb directly through the glass wall of the bulb, giving photo-electric material of absolute purity. The superiority of the BURT-CELL is due to these features, making possible results never before obtainable.

We also manufacture the STABILIZED OSCILLOSCOPE—the only VISUAL OSCILLOGRAPH having a lineal time axis and no inertia—giving an accurate picture of high frequency wave forms.
Write for Bulletin 273

DR. ROBERT C. BURT
Manufacturing and Consulting Physicist
327 S. Michigan Ave., Pasadena, Calif.

Independent Laboratories
Newark, N. J.

Oxide Coated Filament
for
All Tubes

Special Getter
for
Detectors — A.C. Tubes — Amplifiers
Power Tubes — Gas Rectifiers

Cerium Alloys

Exclusive Sales Representative

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

Vacuum Tube Directory

Name	Type	Use	"A" voltage Bat.	"A" voltage Fil.	Fil. current (Amps.)	Voltages (minimum) "B"	Voltages (minimum) "C"	Voltages (maximum) "B"	Voltages (maximum) "C"	Voltage "B" Det.	Grid return (Det.)	Plate current (milliamps) Min.	Plate current (milliamps) Max.	Output resistance (Ohms)	Mutual conductance (Micromhos)	Voltage amplification factor	Remarks
Arcturus Radio Co.	26	A. C. Detector		15	0.35	22	4.5	45	9	45				9500	1100	10.5	Positive "C" voltage
	28	A. C. Amplifier		15	0.35	45		90	1.5					9500	1100	10.5	R. F. and A. F. amplifier
	30	A. C. Power Tube		15	0.35	135		180	22.5					2700	1650	4.5	
C. E. Manufacturing Co.	K	R. F. Amplifier	6	5	0.25	45	0.0	135	3.0	45–90	F+	3.0	4.8	11000–12800	975–1130	12.5	May be used as detector
	G.	Hi-Mu	6	5	0.25	90	0.5	180	5.0	67–90	F+	0.8		25000–	800–	20	Det., Res. Impedance Amplifier
	H	Special Det.	6	5	0.25	67	3.0	90	4.5	67–90	F+	1.2	3.0	14000–15900	910–1030	14.4	Detector only
	F	Power Amplifier	6	5	0.5	90	6	180	15	45	F+		5	5300	1500	8	
	J–71	Power Amplifier	6	5	0.5	90	16.0	180	45.0			9.0		2500–	1200–	3.0	Use output device above 135 v. "B"
	L–10	Power Amplifier	8	7.5	1.25	250		425	20					4500			Use output device
	AX	General Purpose	6	5	0.25	90	4.5	135	7.5	45	F+		3	10500	810	8.5	
	M–26	A. C. Amplifier		1.5	1.05	90	4.5	135	9								R. F. and A. F. Amplifier
	N–27	A. C. Detector		2.5	1.75	90	4.5	135	9	45							
	D–G	Full-wave Rectifier	85 milliamperes at 300 volts														Gaseous conduction type
	R–80	Full-wave Rectifier	6	5	2.0												125 M. A. at 300 V.
	R–81	Full-wave Rectifier		7.5	1.25												110 M. A. at 750 v.
Daven Radio Corp.	Mu–6	Power Amplifier	6	6	0.5	90	4.5	180	20				14.2	3200	1800	5 to 6	
	Mu–20	High Mu	6	6	0.25	90	1.5	180	3				1.1	40000	500	20	
	201–A	General purpose	6	5	0.25	45	4.5	135	12				2.0	12000	700	8	
	A.C.–1	R. F. Amplifier		1.5	1.05	45	3	150					5.0	9000	900	8	A. C. Tube
	A.C.–1–D.1	Special Detector		1.0	1.0	45								8500		7	A. C. Tube
	A.C.–15	Special A. F. Amp.		1.5	1.05	45	3	150					1.5	30000	500	15	A. C. Tube
	A.C.–10	Power Tube		7.5	1.25	400		500	60				03.	6000	1100	7	A. C. Tube
	A.C.–R.–1	Rectifier		7.5	1.25	Half-wave. 65 M.A. at 200 volts											A. C. Tube
Q. R. S. Music Co.	201–A	General purpose	6	5	0.25	20		180						8000	1000	8	
	200–A	Special Detector	6	5	0.25			45		45				5000		7.5	
	112	Power Amplifier	6	5	.5	135		180								3	
	171	Power Amplifier	6	5	.5	135		180						2500			Use output device above 135 v. "B"
		Full-wave Rectifier	60 milliamperes at 150 volts														Gaseous conduction type
		Full-wave Rectifier	85 milliamperes at 200 volts														Gaseous conduction type
		Full-wave Rectifier	100 milliamperes at 350 volts														Gaseous conduction type
		Full-wave Rectifier	100 milliamperes at 500 volts														Gaseous conduction type
		Full-wave Rectifier	400 milliamperes — for "B" and "C" elimination														Gaseous conduction type
		Glow tube	Voltage regulator tube														
Shieldplate Tube Corp.	SP–122	Screen grid tube	4.5 or 6.0	3.3	.133	90	1.5	135	(Screen grid = postive 45 to 69.5 volts)								R. F. or A. F. Amplifier

For RIDER'S A-C Super

Arcturus A-C Tubes

Specified for this circuit, Arcturus A-C Tubes insure perfect operation under normal line voltage variation, exceptional tone quality, volume and sensitivity, freedom from hum, and unusually long life.

Unique features of construction give Arcturus A-C Tubes unique operating characteristics. Heater type —four prong base—filament voltage the same (15 volts) for all types, detector amplifier and power, operate with common toy transformer.

The use of a heavy carbon filament enables Arcturus A-C Tubes to withstand even an unusual overload. Enormous electron supply resulting from low operating temperature of heater gives to Arcturus A-C Tubes their exceptionally long life.

To Get Your Tubes

Your distributor should be able to supply you, but unusual demand has depleted many stocks. To avoid delay readers of RADIO ENGINEERING may write direct to the factory and their orders will be filled promptly.

ARCTURUS RADIO COMPANY
255 Sherman Ave., Newark, N. J.

RADIO FREQUENCY MEASUREMENTS

by

E. B. MOULLIN
M.A., A. M. I. E. E.

A worthwhile investment for every radio engineer

The latest treatise on the practical applications of R. F. measments. Contains invaluable formulae which save hours of calculation.

Every measurement is illustrated by examples.

$10.00 Postpaid

See Page 1094 for Radio Engineering's Special Offer

Your "B" Battery Eliminator will give you better service

with

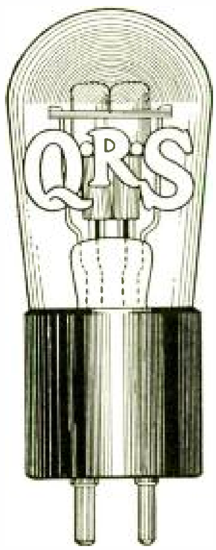
Q·R·S
Trade Mark Registered

Gaseous

Rectifier Tubes

ARE BETTER

60	Milliamperes -	$4.50
85	Milliamperes -	4.50
400	Milliamperes -	7.00



Ask for Catalog of full line of Standard Tubes.

Guaranteed

The standing of the Q. R. S. Company, manufacturers of quality merchandise for over a quarter of a century, establishes your safety.

Orders placed by the leading Eliminator Manufacturers for this season's delivery, approximating Four Million Dollars' worth of Q.R.S. Rectifier Tubes, establishes the approval of Radio Engineers.

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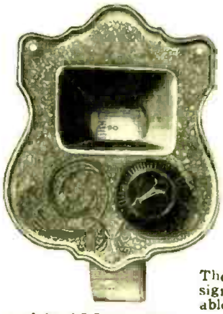
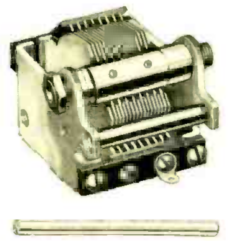
Established 1900
References—Dun, Bradstreet, or any bank anywhere

SCIENTIFIC

Type UXB DRUM CONTROL





The new SCIENTIFIC has been designed to meet the need for a dependable, fine appearing drum control to be used in ALL circuits.

Beautiful escutcheon shield will enhance the appearance of any set. Dial is calibrated 0 to 100 with figures and markings that stand out clearly. Friction drive drum made of finest pressed steel, improves with use. Action is smooth and powerful and develops no backlash. This unit is supplied with any combination of condensers. List price of drum dial with escutcheon plate, $3.50; condensers, .00035MF, $2.00 per unit. Write or wire for information TODAY!

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RADIO INDUSTRY

The Egyptian Lacquer Manufacturing Co.

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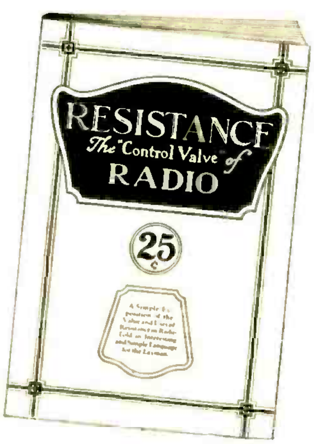
LYNCH Resistance in Radio



What it Is

This compact handbook, "Resistance the 'Control Valve' of Radio," tells you all about the uses and importance of resistance in radio. Contains a wealth of interesting, dependable information on resistors, equalizors, grid leaks, and other important radio devices. An indispensable manual for the fan, set-builder, and engineer.

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Addresses of companies listed below, can be found in their advertisements—see index on page 1142.

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EBY U.Y. Sockets with 3 big Features

A guide for the prongs. A simple turn of the tube in the grooved top of the socket insures a quiet, smooth insertion.

New Bi-metallic Prongs. Phosphor-bronze for perfect spring action and tinned copper for perfect contact and conductivity.

Easy mounting above or below Bakelite, wood or metal. Small, compact and completely self-contained.

Another step in the transition from cushion to rigid sockets. Nobody uses cushion sockets with the A C tubes.

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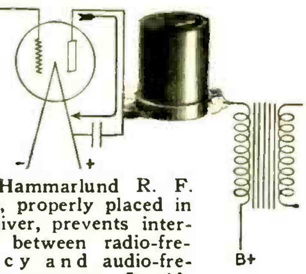
Improve Your Radio With this R. F. Choke



The Hammarlund R. F. Choke, properly placed in a receiver, prevents interaction between radio-frequency and audio-frequency currents. It aids stability and improves tone quality.

A specially developed method of winding and impregnating gives minimum distributed capacity, thereby providing an extremely high impedance to all frequencies in the broadcast range.

Two sizes—85 and 250 millihenries.

Diagram shows Hammarlund R.F. Choke in the Detector plate circuit of a radio receiver to prevent R.F. Currents entering the audio - transformer This is only one of its many important uses every radio engineer knows about.

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They are but a few of the more prominent corporations who have turned to Harfield Resistors during the past year.

Tell us about the resistor you want and let us make up a sample for you with prices. Write to

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RESISTORS

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B. A. 1. Balanced Armature Unit 3 11/16" x 3 5/16".

Balanced Armature Units—for air-column or Cone

They embody many impressive new features to insure quality in any set.

1. Diaphragm with point of application off center to reproduce successfully, high and low frequencies.
2. Straight bar magnets of finest English tungsten steel — the most efficient type of construction.
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Our Engineering Staff is always at the disposal of Set Manufacturers.

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AMPLION

JEWELL

Two Hundred Thousand Ohms

A Quality Product

Pattern No. 116 High Resistance Voltmeter

Two hundred thousand ohms is quite a lot of resistance. It is quite a lot of resistance in wire wound form and of a type unaffected by temperature changes, to build into a voltmeter. Still, that is the actual amount required to establish a high resistance of 800 ohms per volt in the Jewell high resistance, portable voltmeter Pattern No. 116. A current draw of only one and one-fourth milliampere at full scale reading, or one-tenth millampere at the 22½-volt scale reading gives an idea of the small amount of current required to deflect the pointer of this instrument.

The movement of the Pattern 116 is a high grade, D'Arsonval moving coil type having silvered movement parts. The scale is silver etched with black characters and the movement is provided with a zero adjuster.

Besides its adaptability for making B-eliminator adjustments, the Pattern 116 may be used for general test purposes as well.

Write for descriptive circular No. 1103.

"27 Years Making Good Instruments"

Jewell Electrical Instrument Co.
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The right flux for radio can *make* a manufacturer The wrong flux can quickly *break* him

After costly experiments scores of radio manufacturers have found there is but *one* safe flux for radio soldering—rosin.

Rosin, an organic mixture, is a *non-conductor* and *non-corrosive.* The glass-like surface of this material does not readily lend itself to the collection of dust (carbon particles) as will the sticky organic greases of paste. Nor will rosin attract moisture from the atmosphere; the chlorides of pastes and fluids will. *Moisture plus carbon particles defeat the best insulations produced. Moisture plus chlorides direct a slow but determined corrosive attack upon supporting metals.* Such slow corrosion in wiring causes a steadily increasing resistance to the flow of electrical energy.

Kester Rosin-Core Radio Solder scientifically combines radio's premier flux, rosin, with a solder alloy of unvarying quality. The use of Kester Radio Solder furnishes the user with a means of accomplishing *safer, faster and cleaner* set wiring.

Manufacturers using Kester Rosin-Core Solder are assured that no part of their production will ever be returned or fall into discard through the corrosive and conductive action of a chloride flux.

Our experimental and research laboratory has assisted many manufacturers in the solving of their soldering problems. A post card will bring you further information without obligation.

KESTER SOLDER
Rosin-Core

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4224 Wrightwood Avenue, Chicago, U. S. A.

Originators and World's Largest Manufacturers of Self-fluxing Solder

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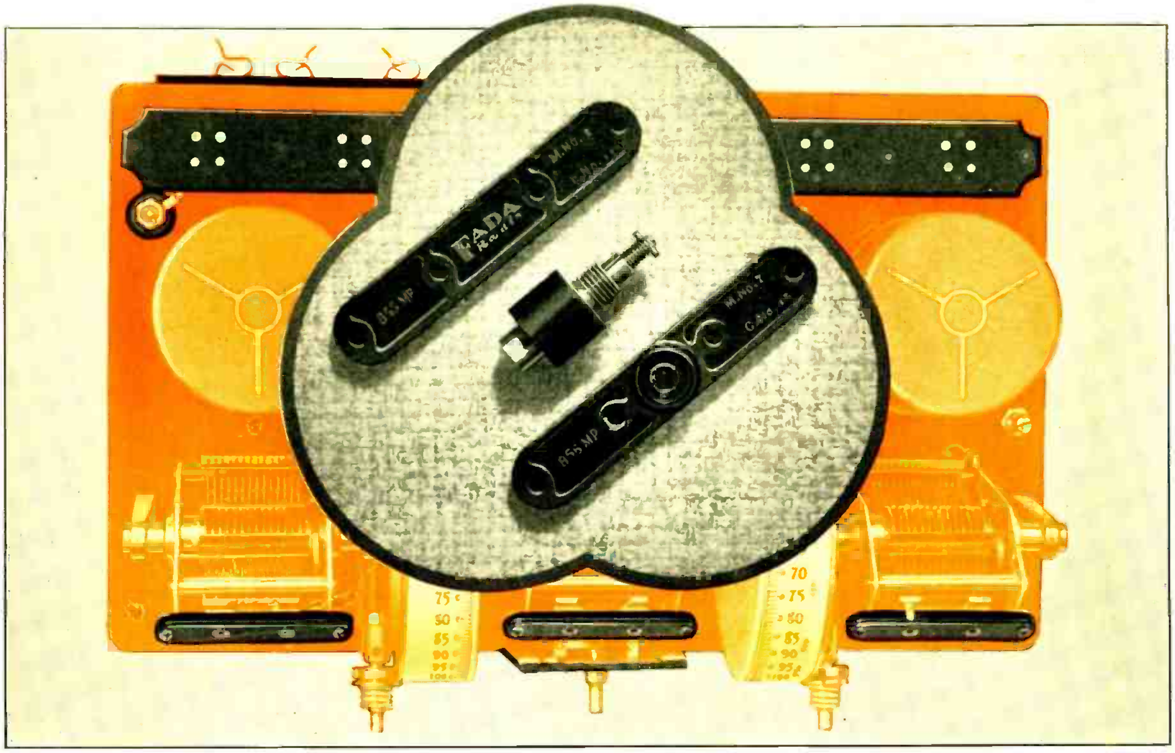

Chassis of Fada Special Receiver, with Bakelite insulation shown in black. In addition to the parts illustrated, Bakelite Materials are also used for socket lower plate, R. F. transformer, condenser and leak mounting strips and minimum adjustor base. This Receiver is made by F. A. D. Andrea, Inc., Long Island City, N. Y.

In the *Fada Special* vital parts are insulated with Bakelite Materials

RECOGNIZING that sustained excellence of performance may only be assured through the use of an insulation whose properties are unimpaired by time, exposure or use, F. A. D. Andrea, Inc., have adopted Bakelite Materials for many parts of the Fada Special Receiver.

The use of Bakelite Materials not only provides excellent insulation, but economical production as well. For example, twenty of the upper and lower condenser strips are molded at one time with holes, recesses and relief lettering accurately formed. In the case of the neutrodon cylinder part a nine cavity mold is used, the Bakelite Molded cylinders being formed around the terminal posts.

Since the earliest days of Radio, the Bakelite Corporation has kept pace with the development of Broadcast Receivers, and its engineers and research laboratories have cooperated with manufacturers in adapting Bakelite Materials to each exacting need. The wealth of knowledge acquired during these years of experience is offered to the radio industry through our Service Engineers located in important industrial centers. *Write for Booklet No. 38.*

BAKELITE CORPORATION

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