RADIO

VOLUME VII DECEMBER, 1925 No. 12

Radiotorial Comment

THE present copyright law, as applied to the radiocasting of music, is much like the bed upon which Procrustes forcibly placed his guests. If they were too long for it, their legs were lopped off, and if too short, they were stretched until they fitted it. The radiocasting of music, likewise, is being fitted to conform to a law passed sixteen years ago, long before radiocasting was started. Yet this law is still the only standard for determining the relative rights of the owners and the users of copyrighted music.

Under its antiquated provisions the owners are demanding their pound of flesh from the users, the radiocast station. This demand varies with the size and the location of the station, but for the average Class B station now amounts to about twenty-five dollars an hour, or an expenditure of about twenty thousand dollars a year. Assuming this amount to be paid by one hundred stations, the annual total would be two million dollars, to say nothing of what might be paid by four hundred smaller stations.

This sum, added to the already heavy costs of operating and maintaining the stations, is almost the last straw which will break the camel's back. In the absence of a Portia to point out that this pound of flesh will drain the very life-blood of the stations, each station is trying to drive the best possible bargain with the Shylock copyright owners. Consequently, the total tax, while less than the figures assumed above, threatens to become more unless early action is taken.

The stations recognize that a composer or author is entitled to a reasonable compensation for his work, especially when it is used during a program paid for by an advertiser. Most of them are willing to pay a just fee. But they feel that the present exactions, not to mention greater demands in the future, are neither just nor reasonable.

Furthermore, several copyright owners have withdrawn the right to use their compositions over the radio. If these are used inadvertently, the station faces a lawsuit for heavy punitive damages. Nor is there anything to prevent a license being granted to one station and withheld from another, thus aiding in the establishment of a radio monopoly.

If this were merely a controversy between the copyright owners and the stations, we would be inclined to let them fight it out among themselves. But in view of the fact that it is of vital concern to twenty million people who own radio receiving sets, due consideration should be given to the interests of the listening public. Such extortionate demands will compel the stations to put on less desirable programs and will tend to break down the American policy of maintaining radio reception free for all. If carried to the possible extreme, they mean the extinction of radio as it is now known.

The logical remedy for all this is a revision of the present copyright law so as to cover the un-anticipated conditions brought about by radio. Such revisions were proposed at the last session of Congress but did not get beyond committee hearings. One, the Perkins bill, was intended to strengthen the strangle-hold of the copyright owners. Another, the Dill bill, was intended to loosen it. Neither was acceptable to the other opposing interest.

New bills will undoubtedly be introduced at the next session of Congress. One will probably propose that the copyright law, as applied to radiocasting, be based upon the same principle as governs phonograph and player piano reproduction of music: a reasonable royalty, fixed by law, and a release to all stations under the same conditions as to any one station.

While this proposal seems eminently fair it will undoubtedly be violently opposed. When it, or some other satisfactory bill is introduced, the fact will be radiocast by many stations, together with a plea that listeners ask their Congressional representatives to vote for the bill. So when you, as a radio listener, hear this plea, it is hoped that you will personally write to your own Congressman. Thus, and thus only, can the Procrustean bed be destroyed and assurance given that the best music may be enjoyed over the radio.

How Much Should a Radio Tube Cost?

Convincing Facts Which Prove That Present Prices Are Reasonable and Relatively Stable

By Volney G. Mathison

"TUBES today, sir?"

"Yes, confound it — five of them. While I was tightening a loose socket with my screw-driver last night, my wife came up behind me and put her arms around me. The screw-driver slipped—instantly there was a flash. Then we—what are tubes selling at, now, anyway?"

"Why, at most any price you wish, sir. We have Little Boy Blue tubes at three-fifty, Big-Voice and De-Trees tubes at three dollars, Radio Gobblers and Orange-Boxes at two-fifty, Super-tinks at two dollars, Leggotrons at one-fifty, and a special sale on Squawking Ducks at fifty-nine cents."

"Fifty-nine cents! Are they any good?"

"Every one guaranteed. But they're not the best. If you want a good tube, better take Leggotrons. A first-class tube can't be sold for less than one-fifty. They cost a dollar apiece to make."

"Bosh! A friend of mine has an office-boy who told him that one of the floor-sweepers in the Radio Gobblers' plant said they are grinding them out back East for less than seven cents apiece."

"Oh, that's impossible. The bakelite bases alone cost twenty-five cents. The grid and plate structure cost at least sixty cents. The marvelous thoriated filament must cost at least another fifty cents. Thorium is worth five hundred dollars an ounce. Then the vacuum-getting chemicals—"

"Humph! I've a little business, myself. I know this much: if tubes cost all that to make, they couldn't be retailed for less than five dollars. Give me five of the Squawking Ducks."

NOTHING in the entire field of radio has ever been more often asked and conjectured about than this:

"How much does it cost to make a good vacuum tube, anyway?" Personally, I have had this query put to me perhaps a thousand times. I have heard divers persons seriously affirm that they knew the manufacturing cost of a tube to be "three dollars," "ninety cents," "forty-nine cents," "ten cents." In the face of some of the prices at which tubes are being offered lately on the retail market, most folks probably are beginning to wonder whether the last-named figure isn't about the most nearly correct one. There are now on the shelves in the radio stores tubes ranging in price from about three dollars down to as low as eighty-nine cents, and occasionally even cheaper. The eighty-nine-cent tubes and lower-priced ones are what are known among men in the tube game as "light-and-play" tubes. The significance of this term may be grasped by the acute reader. I shall explain a good deal more about these tubes, however, in a moment.

It is natural and logical, in conjecturing as to the cost of making a radio tube, to try to estimate the costs of the various things that go into the finished product, and then to take the sum of these costs as the answer. But the wildest misconceptions exist as to the actual cost of the materials and parts that go into a radio tube. Most guesses are very much too high, owing to the high prices at which tubes have long been sold. Even if the correct figures were known, the result would be wide of the mark; because there are too many angles in tube-making entirely unknown to or unthought of by the layman.

During the last two years, I have handled reams of data covering the costs of raw materials, of the manufactured parts, and of the marvelous and elaborate machinery required for manufacturing tubes. I have reconnoitered about the one-man-and-a-blow-torch dumps of the earlier days of tube-making—long since vanished from the face of the earth—and I have just spent a week in an enormous New Jersey factory that is turning out over 10,000 first-class independent tubes a day. The brief discussion that follows on what good radio tubes can be made and sold for is based on these actual data and experiences.

The first thing to be considered, and perhaps the one that the reader is most curious to know, is just what the various parts that go into a radio tube really cost. Here it will be of interest to show by

Schoolboys earning holiday money making bakelite bases. In the winter months, they are replaced by women workers.

illustrations what these parts are. This has been fully done in Fig. 1.

Starting with the upper left-hand corner, the cost of these units, in their raw, unworked state, to the manufacturer—that is, to the manufacturer of 2,000 tubes a day, or more—is about as follows:

Exhaust tubing, each piece	1/8c
Flare tubing, each piece	1/8c
Nickel and copper-clad mountings and lead-wires, complete set of 7	2c
Molybdenum grid-wire, each grid	1/4c
Nickel plates, each pair	1c
Thoriated filament wire, per foot 10 cents, per tube	2c
Glass bulbs	1c
Magnesium vacuum-getter	1/4c
Bakelite bases	9c
Solder (for sleeves or base prongs)	1/100c
Bakelite cement (for cementing on bakelite bases)	1/8c
Carton and wrapper	2½c
Total, approximately	19c

These figures are sufficiently correct, though they will vary widely with the size of the factory. Most manufacturers do not spend as much as 2 cents per tube for filament-wire, except in the case of the platinum-coated wire used in one-volt tubes of the WD-12 type. Platinum-coated wire costs 10 cents for each filament-length, and is mostly rotten stuff at that price. On the other hand, not every manufacturer is able to get his cost of bakelite bases as low as nine cents, though all the larger makers are now doing so. A small concern perhaps could not get its materials together for twenty cents per tube; whereas the producers of millions probably have their costs of materials down to less than sixteen cents per tube.

But now, before the horrified folks who have vivid memories of paying $6.50 and even $9.00 for the common garden variety of radio tubes arise to do summary massacre, I shall hasten to remark that this is not *all* it costs to make a tube. A plant producing 10,000 tubes a day requires a force of at least 250 em-

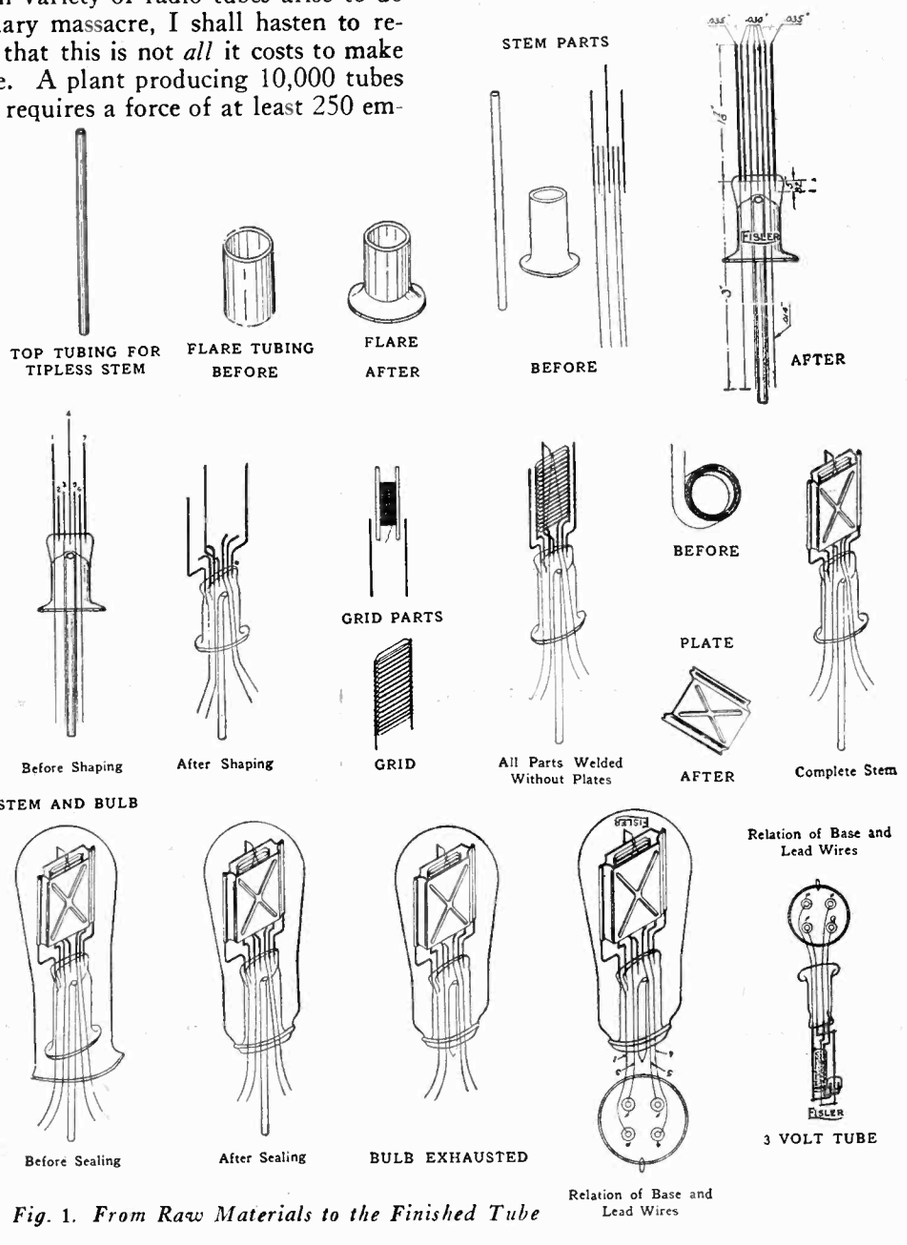
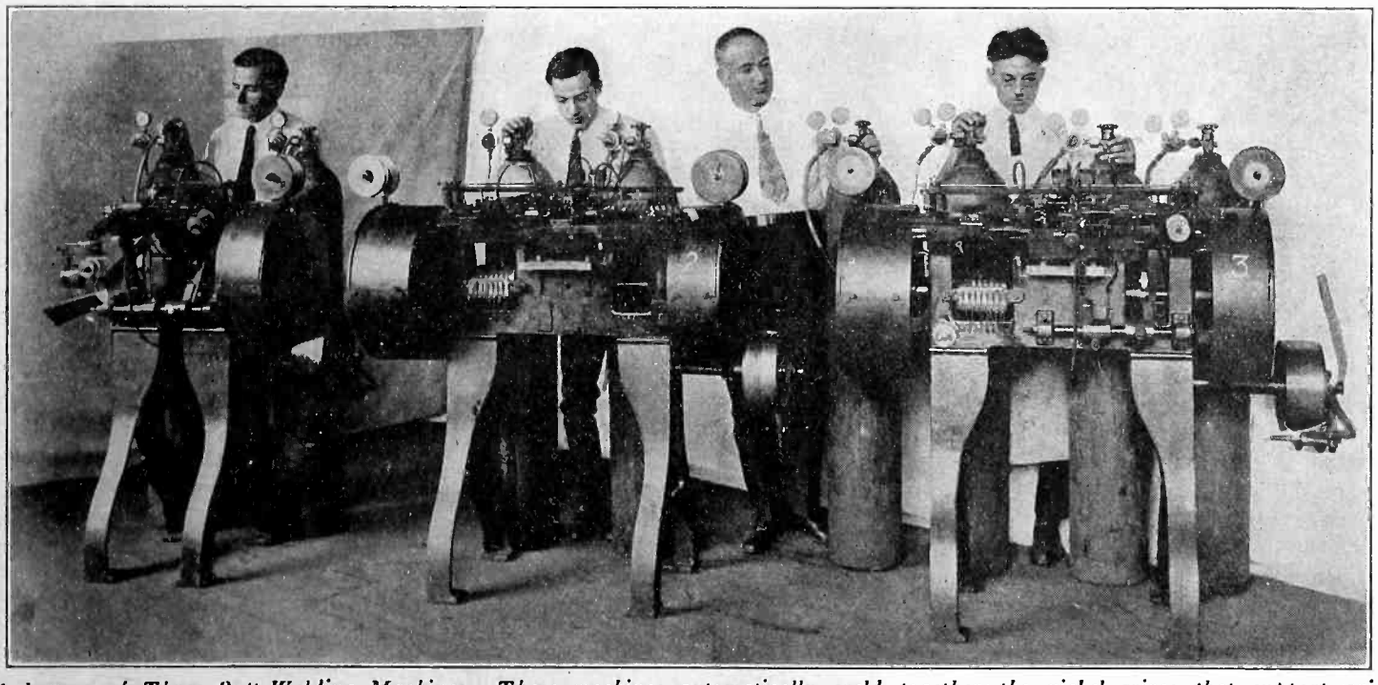


Fig. 1. From Raw Materials to the Finished Tube



A battery of Three Butt-Welding Machines. These machines automatically weld together the nickel wires that support grid, plate, and filament, the copper-clad bits that pass through the glass, and the copper lead-wires to the base. Chas. Eisler, the mechanical wizard who designed these, and countless other tube machines used by Western Electric, DeForest, etc., is in the middle of the picture. The three-piece welder to the right costs $6,000.00 and performs operations amounting to 1/10 of a cent per unit. Scores of equally intricate machines are used today in tube-making.

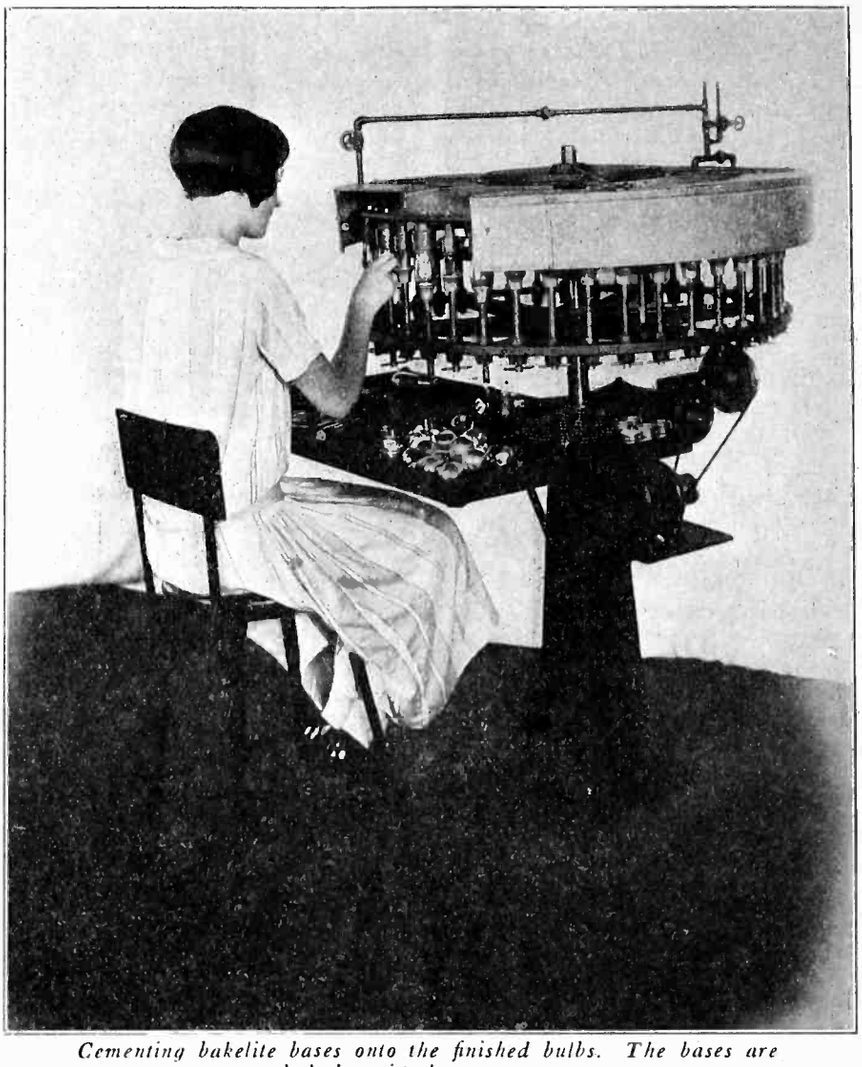
ployees. The manufacturer of 10,000 tubes a day has to be wide-awake and use the very latest methods, in order to turn out his product with this number of workers.

The average daily wage of the tube-factory employees was at one time pretty high, in the cases of the secretly-operated plants, but it has greatly declined. It may now be fixed at about $4.00. One pertinacious belief of many folks is that a force of some kind of super-expert jewellers or goldsmiths is necessary to make a radio tube. As a matter of fact, every popular tube on the market today is assembled practically altogether by girl factory-workers. All possible operations are performed by machines; the girls mostly operate these. Everything, from forming the basic glass parts to the final testing of the finished tubes is done automatically or semi-automatically. Machines mold the stems, shape the mounting wires, wind the grids, punch the plates, seal on the glass bulbs; they do the exhausting, tipping off, high-frequency bombarding, cementing on of bases, and the soldering of the lead-wires into the brass sleeves or prongs in the bases. Of course, a certain number of expert men are necessarily in charge of every plant to adjust the machines and keep them in repair.

It will be seen from the foregoing that the payroll of the 10,000-tube plant runs close to a thousand dollars a day. This makes an additional ten cents to be added to the cost of each tube. It should be borne in mind, too, that perhaps not over half a dozen factories in the country have their labor cost per tube so low as this. Many small concerns claim labor costs as high as twenty-five cents. As most of these smaller companies are without money enough to buy the elaborate machinery required for big low-cost production, they are almost daily going out of business.

Another large item of expense in tube-making is the immense quantity of gas used in purifying the finished metal parts and for heating the glass as it is worked in the various machines. In one large factory, about a cent's worth of gas is consumed per tube. This brings our tube cost up to thirty-one cents.

The next item is the incredibly swift obsoletion of the intricate and costly machinery required for quantity tube-manufacturing. The equipment of the 10,000-tube plant cost $85,000; and it has to be written off the books in two years, at the outside. By that time, as things are going, and perhaps much sooner, the machines are liable to be either worn out or entirely out of date. This means an obsoletion and depreciation item of $40,000 a year. If the 10,000-tube plant produces two million tubes a year, and it will have to hustle some to do that, the obsoletion cost per tube will be nearly two cents. As a matter of fact, when repair and maintenance, and other overhead expenses are included, it probably will run nearer to four or five cents, as the plants cannot count on full-time operation the year around, nor on using all equipment without alteration for a period of two years. Our tubes will now cost us from 35 to 36 cents.



Cementing bakelite bases onto the finished bulbs. The bases are baked on in the rotary oven

The last item, and in certain cases the most serious one of all, is shrinkage. One large manufacturer of 3-volt tubes suffered last year, for a time, a shrinkage of 70%. That is, out of every hundred tubes he made, only 30 were really first-class, and he had to throw out 70. This brought his cost to a dollar a tube, and more. He has since cut his shrinkage, through highly-perfected machinery and the aid of much dearly-bought experience, to less than 20%; and his cost today for first-class tipless three-volt tubes with bakelite bases runs from 45 to 50 cents apiece. In the case of the "A" or six-volt tubes, the shrinkage is not bad in the big plants; hardly as much as 5%, though far higher in all smaller and less efficient establishments.

Allowing for everything, first-class six-volt tubes are produced successfully in a 10,000 tube factory for 40 cents apiece, and three-volt tubes for 45 or 50 cents. Some of the biggest corporations that make absolutely everything they use in their own plants, including filament-wire, and even tube machinery, are believed to have their cost down on "A" tubes to perhaps as low as 30 cents, which is certainly about the least possible amount for which they can be manufactured by anybody.

In the face of the risks and highly unsettled nature of the business, the rapid obsoletion of equipment, and the uncertainty of getting supplies, particularly filament-wire, the manufacturer of the 40-cent tube is exceedingly well entitled to receive 65 or 70 cents for it.

The risks of the tube manufacturer, especially of the independent manufacturer, are excessive. There is the uncertainty of selling the product to an extent sufficient to operate to profitable capacity, the difficulty just mentioned of getting materials, and, worst of all, the patent-suits and spying of competitors. Most folks imagine that "all patents" on tubes expired on February 18th, of this year. Nothing could be farther from the actual facts. Only the basic patent of DeForest specifying the interposition of a grid between the plate and the filament turned up its heels on that memorable date. There remain at least twelve menacing patents, or alleged patents, on high-vacuum, thoriated wire, and tipless stems—though this last one has just been killed in a manner that I hope to

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An Ultra-Selective Crystal Set

The First Unit in a Series of Circuits Involving a Minimum of Discarded Parts As More Elaborate Sets Are Built

By E. M. Sargent

MANY new or so-called new circuits have come on the market, held sway for a short time, and then died a sudden death. Some had been discarded years ago, because of inherent faults, only to be resurrected by some well meaning experimenters who had accidentally stumbled upon them. Others, such as the Cockaday, Harkness, Browning-Drake, and the Roberts, were real contributions to the radio receiving game. However, after playing around with all of these circuits for the past three years, the leading radio fans who like to build their own have about come to the conclusion that, tube for tube, one good circuit is about the equal of any other good circuit, all of which brings us to the newest development, namely,—the series of circuits.

This series of circuits, the writer believes, will fill a long-felt want on the part of the radio set builder. Roughly, the idea is as follows: Let us assume that our set builder has not much ready cash available and is rather doubtful about just how deep he wants to go into the radio game. After looking the field over, he decides to start in with a crystal set. At the same time, he is a believer in quality and therefore wants a crystal set on which he will not have to listen to the nearest and most powerful station all the time but on which he can take his choice of programs as between local stations. A set of this type requires a few dollars more for material than the average, but is well worth it in results gained.

Proceeding along these lines, our radio fan builds his crystal set, puts it on the air and, as is the case nine times out of ten, is immediately inoculated with the radio bug. He wants a larger set and finds that in order to get it he will have to throw away practically everything that he has in his present one. This is where the series of circuits steps in to help out the pocketbook of the newly-made radio fan. Instead of having to discard entirely his crystal set, and buy an entire set of new parts, he finds that Circuit No. 1, which is a very efficient one-tube set, can be easily made in about two hours by slightly redesigning his present set, and finds to his further surprise that this same circuit No. 1 can later be expanded into a two, three, or four tube set, using the same panel and baseboard layout and the same cabinet in which the crystal set was originally built. Not only that, but by redesigning the panel and cabinet when the five tube stage is reached, and using the same parts with a few additions, this same set can be built right up to an efficient eight tube superheterodyne.

LIST OF MATERIAL USED

1 Sargent Input Coil.
1 Battery Clip and Lead.
1 620 Remler Coupler.
2 631 Remler Condensers, .0005 mfd.
1 .001 Micadon.
1 Lincoln Crystal Detector.
1 B. M. S. Open Jack.
1 2-in. Dial.
2 Eby Binding Posts.
1 Bakelite Panel, 3/16 x 7 x 16 in.
1 Baseboard, 3/4 x 7 3/4 x 15 in.
1 Bakelite Strap, 3/16 x 3/4 x 9 in.
5 No. 6 Wood Screws, F.H., 3/4 long.
2 6/32 Machine Screws, 1/2 in. long, with nuts.
2 1/2 in. Angle Brackets.

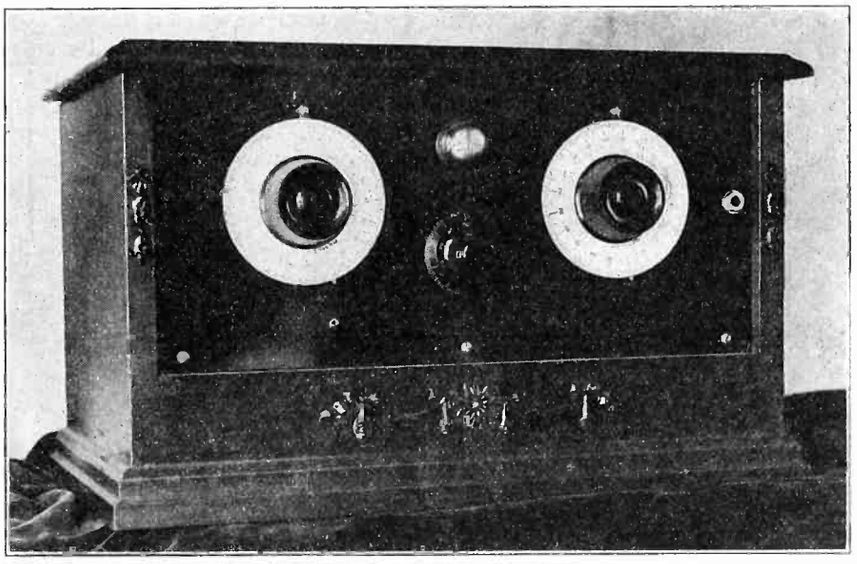

Fig. 1. Panel View of Completed Set.

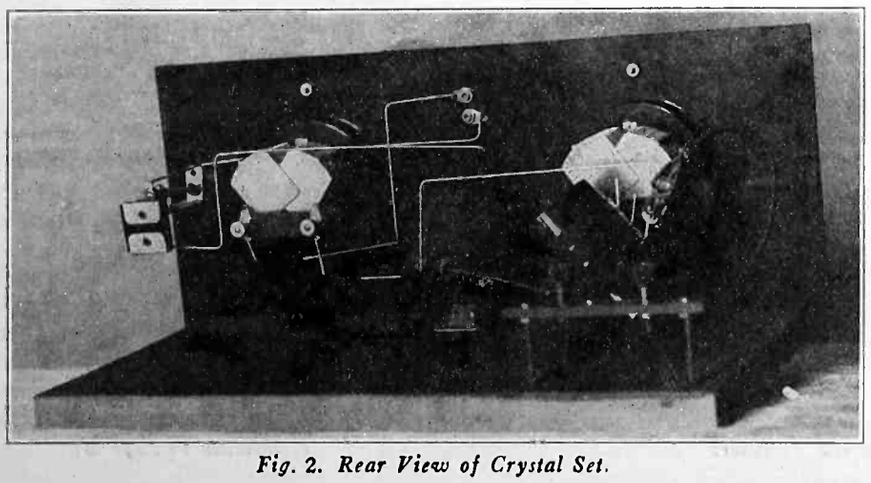

Fig. 2. Rear View of Crystal Set.

Obviously it is necessary that these circuits be at least the equal of any others using the same number of tubes. This, the writer believes, has been accomplished. Incidentally, it should be stated that all of these circuits are not new and that the writer is not laying claim to any originality in a great many of them. They will not put the Browning-Drake, or the Cockaday, or the Haynes, or any other fundamentally good circuits out of date. On the other hand, several excellent ideas have been borrowed from the above named circuits, as well as from a great many other circuits that have appeared in print during the last few years. The one object has been to develop ten highly efficient radio receiving circuits from a crystal up to an eight tube set, having as the most important considerations maximum selectivity, good tone quality, and ability to receive distance. No reflex or trick circuits are included in the series. All of the sets, including the crystal, are selective enough to separate all local stations, one from the other.

Circuit No. 0—A Selective Crystal Set

THE circuit numbers in this series, with the exception of Nos. 9 and 10, correspond to the number of tubes used. It has been unkindly suggested that the numbers are also an indication of the results that may be expected, but this is unfair to the crystal set. The crystal set is selective, sensitive, has good tone, and is not in any way critical to operate. In fact, it will be a distinct surprise to those who have never before operated a good one. There is no reason why a good crystal set is not a perfectly practical proposition, and the writer attributes the poor quality of the present ones to the fact that the engineers who are capable of designing good crystal sets have been concentrating their attention on the multi-tube receivers.

Bearing in mind the fundamental idea that the same parts are going to be used over and over again in the later sets, the radio set builder finds himself in a distinctly new position regarding the cost of his crystal set. He can now afford to immediately buy enough high-grade parts to get the results that he wants. Figs. 1 and 2 show the panel and the back of the crystal set, while Fig. 3 is

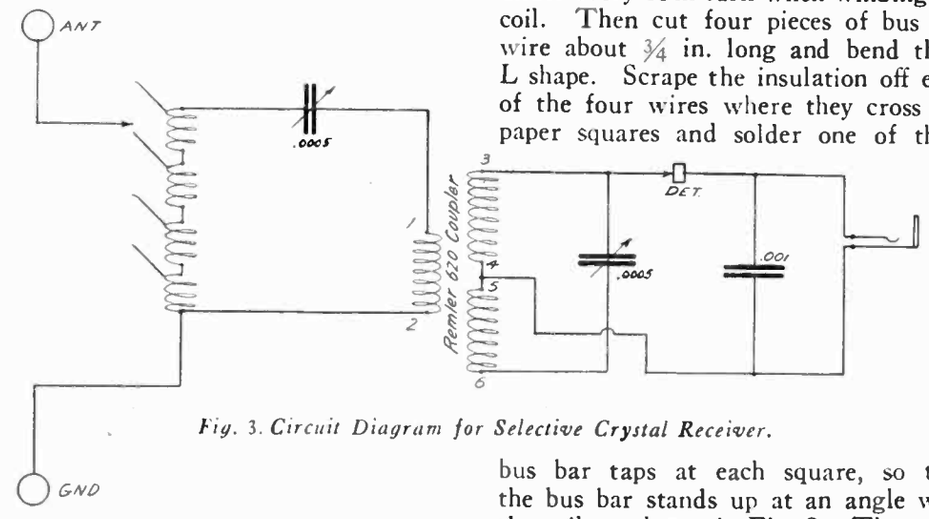

Fig. 3. Circuit Diagram for Selective Crystal Receiver.

a wiring diagram, an inspection of which will show why the set is selective. There are three tuned circuits between the incoming signal and the crystal detector, and these three circuits are plenty to filter out any but the most powerful interference. The perspective sketch in Fig. 4 will help those who have difficulty in following a circuit diagram.

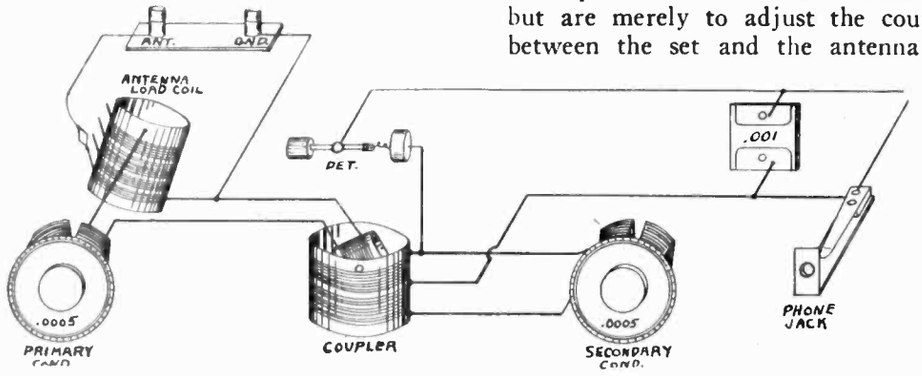

Fig. 4. Perspective Sketch of Completed Receiver.

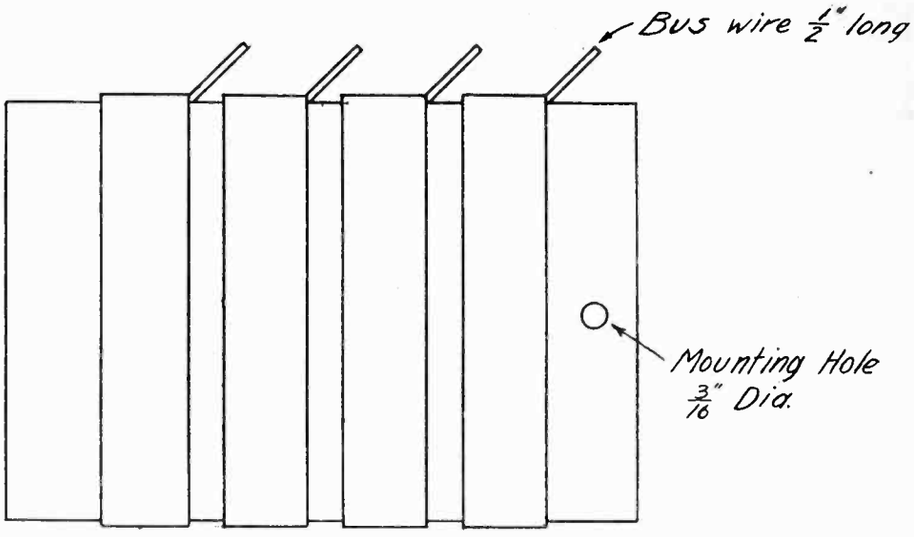

Fig. 5. Constructional Details of Sargent Input Coil.

The Sargent input coil, Fig. 5, consists of 60 turns of No. 24 double silk-covered wire wound on a piece of 2-in. Formica tubing 2¾ in. long. This coil is tapped every 15 turns and each tapped section is separated from the next by a spacing of about ⅛ in. The best way to take off these taps is to slip a small square of heavy paper or empire cloth under every 15th turn when winding the coil. Then cut four pieces of bus bar wire about ¾ in. long and bend them L shape. Scrape the insulation off each of the four wires where they cross the paper squares and solder one of these bus bar taps at each square, so that the bus bar stands up at an angle with the coil, as shown in Fig. 2. The small square of paper will protect the windings of the coil from any injury while soldering. The paper squares may be removed if desired after the taps have been attached.

It will be noticed that no provision has been made for a tap switch on the panel. This is done purposely, because the taps are not intended to tune with but are merely to adjust the coupling between the set and the antenna and ground in use. Once this coupling has been set for the antenna and ground in question, it need not be changed. Adjustment is made with a small No. 48 *B* battery clip and a flexible lead wire about 6 or 8 in. long.

The radio frequency transformer used in the set must have an adjustable coupling coil, and can be bought almost as cheaply as it can be made. The writer has selected the Remler No. 620 Coupler as being the best for this use. However, for those who wish to make their own, the specifications are as follows: The primary is wound on a piece of formica tubing 2 in. in diameter and 2½ in. long and consists of 70 turns of No. 28 D.S.C. wire. The secondary is wound on a piece of 1½-in. tubing, ¾ in. long and consists of 25 turns of No. 28 D. S. C. wire. The secondary must rotate inside of the primary and be adjustable by a dial from the panel. The panel layout and drilling instructions are shown in Fig. 6, the numbers on the panel template referring to the drill sizes to be used. All No. 18 holes are to be countersunk. Plenty of clearance has been allowed in every place where a condenser shaft comes through the panel so that if a slight mistake is made in drilling the holes for the screws, the shaft will not bind. The panel is laid out for two .0005 Remler Condensers. If any other condenser is used, the condenser drilling will have to be changed correspondingly. This same panel layout is used, with a few additions, up to and including the four tube set.

A word about variable condensers. There are so many good ones available on the market that it is not possible to select any one make and say that is the best. The standard of variable condensers has been raised so much in the last eighteen months that most of the better known makes are almost perfect, both electrically and mechanically. However, in certain of this series of circuits it is absolutely necessary to have a condenser with a neutral shaft; that is, a shaft that

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The ABC Battery Eliminator

Directions for Constructing the Device and Rewiring A Set So That 110 Volt A.C. Replaces All Batteries

By G. M. Best

IT IS possible to construct a d. c. power plant, operated from the a. c. mains, to supply a quiet source of current for lighting the filaments of a radio receiving set having as many as eight tubes, as well as to provide *B* and *C* voltages for all tubes. A few changes in the wiring of the set will be necessary, and consequently the new type of eliminator should appeal to those who have built their own sets, as it will be easier to rewire a homemade set than one which has been factory built.

Such a d. c. source, made from standard parts which are easily obtainable, is shown in the picture. It can be used to operate any radio set having from one to eight tubes, and consumes approximately 30 watts from the power line. The total cost of all parts is less that $50.00.

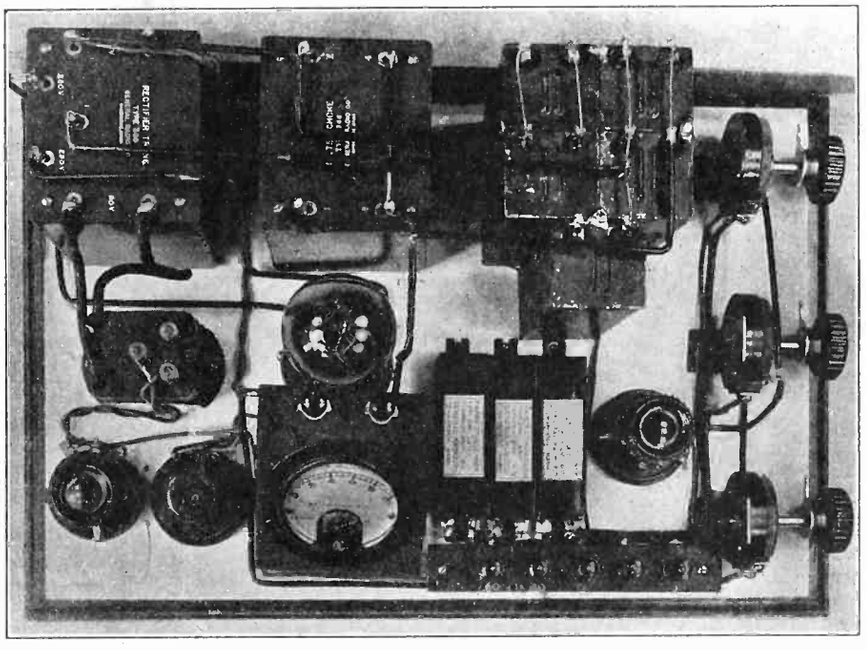
The theory of the new device is simple and can be easily understood by reference to Fig. 1, which is a schematic wiring diagram of the *ABC* eliminator connected to the filament circuit of a 5-tube Browning-Drake receiver having 3 stages of resistance coupled audio amplification. This particular circuit was selected because it represents the average circuit arrangement of a 5 tube receiver, and from the information shown, other circuits having 5 tubes or less can be rewired to enable operation from the eliminator.

The power apparatus consists of a transformer with 110 volt primary; two 250 volt secondaries, and a 7.5 volt rectifier filament secondary; a UX-213 or CX-313 full wave rectifier tube; a filter consisting of a two-section inductance and a number of filter condensers; a set of variable resistances with shunt by-pass condensers; and a 5-watt bell ringing transformer having a 6 volt secondary. The new rectifier tube has two filaments and two plates contained within the one glass bulb, and when connected to the transformer secondary as shown, will deliver both halves of the alternating current wave in the form of pulsating d. c., which is then passed through the filter and appears at the output as pure d. c. with a voltage of 250 under normal load. If the General Radio power transformer is used, a 1.25 ohm resistance must be placed in series with the rectifier filament lead, as the CX-313 tube draws 2 amperes at 5 volts A 1½ ohm filament rheostat will be best to use for reducing the secondary voltage. The Raytheon tube, which does not have a filament, may also be used as the rectifier.

The filtered 250 volts d. c. is used to provide plate and filament potential for the various tubes in the receiver, by means of a set of resistances, which are so designed that the load across the rectifier circuit draws exactly 70 milliamperes constantly. In series with these resistances are placed the filaments of the vacuum tubes, which are wired so that they are in series instead of in parallel, as is the usual custom. Bias voltages for the various grid circuits are obtained through wiring the series filament circuit in such a manner that the voltage

LIST OF PARTS USED

1 Power Transformer 110 v Pri., 250-250-7.5 v Sec., General Radio, Dongan.
1 Filter Choke—General Radio, Amertran.
1 Rectifier Tube Socket.
4 1500 ohm Potentiometers—Federal No. 25.
5 2 mfd. Filter Condensers—Dubilier, Tobe-Deutschmann, Western Electric.
3 .5 to 2 mfd. By-pass Condensers—General Radio, Dubilier, Tobe-Deutschmann.
1 Binding Post Strip—5 posts.
1 200 ohm Potentiometer or Black's Polarizer.
1 5 Watt Bell-Ringing Transformer.
1 0-100 Milliammeter (optional).
1 1½ ohm Filament Rheostat—Amsco.
1 UX-213 or CX-313 Rectifier Tube. (Raytheon helium tube may also be used.)
1 Baseboard, 12 x 18 in.



Assembly of Complete Rectifier.

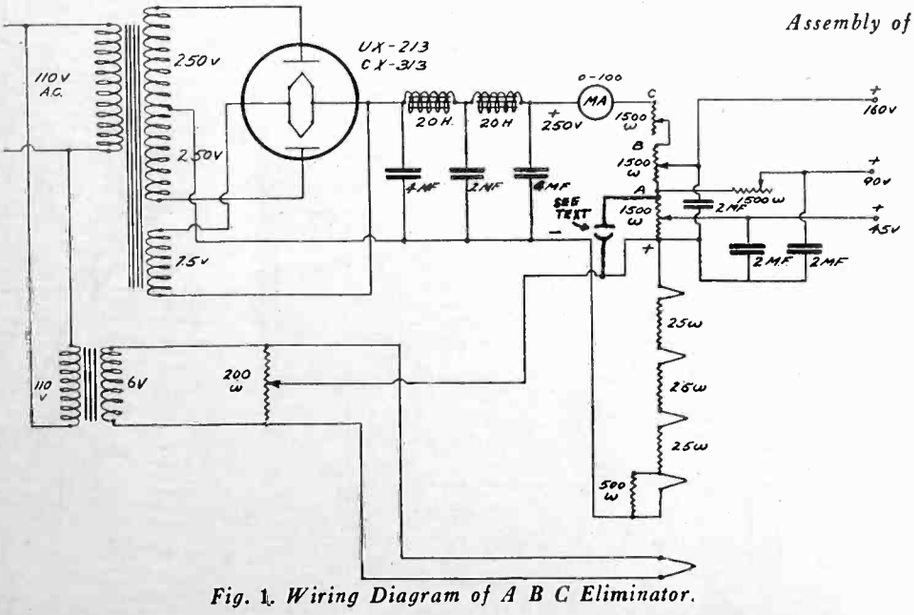


Fig. 1. Wiring Diagram of A B C Eliminator.

drop across the filament of each tube can be used to furnish *C* voltage for some other tube in the same circuit. This method of obtaining *C* voltage through the drop across the filament of the tube is used in many commercial receiving sets, notably the Victor-Northern Electric Type R-41, and the new line of Radiolas.

The actual load circuit for the rectifier system consists of a number of resistances having variable taps, and the filaments of the vacuum tubes in the radio receiver. The maximum safe output of the rectifier is 70 milliamperes at 250 volts, and consequently the use of vacuum tubes requiring over 70 milliamperes filament current is prohibited, except in the last audio stage, where either a UX-CX-112 or 210 tube may be used, as its filament is lighted from alternating current through a separate step-down transformer. The 70 miliampere maximum limits the tubes available to either the '99 type, or the DeForest DV-3, both of which operate at 3 volts, 60 milliamperes.

In Fig. 1, the filaments of four '99 tubes are shown in series, each filament having a resistance of 50 ohms. In series with the filaments, between each tube, is a 25 ohm Cutler-Hammer fixed resistance unit, making the total resistance of the filament circuit 275 ohms. This produces a voltage drop in the 250 volt d. c. line of 16½ volts, leaving a total of 243½ volts available for *B* potential.

The three 1500 ohm resistances shown in the diagram are Federal No. 25 potentiometers, and when placed in series they will pass at least 70 miliamperes and take care of the various *B* potentials required. The drop across each potentiometer, with an average of 60 milliamperes current flowing, is 90 volts, so that the 90 volt tap for the radio set can be taken off at point *A* in Fig. 1. An additional 1500 ohm potentiometer is placed in series between point *A* and the radio set, in order that the voltage may be reduced slightly if it is found to be over 90. The slider of the first potentiometer may be used to take out the 22 or 45 volt tap, the adjustment for 45 volts being approximately in the center of the swing of the slider. If the line voltage fluctuates badly, a Neon tube, such as the new UX-274, CX-374 glow tube, can be used as shown in Fig. 1 to maintain the voltage across the first potentiometer at exactly 90, but as the glow tube is of relatively low resistance, the potentiometer should be 5000 ohms to permit proper operation of the tube. Ordinarily, in residential districts, this tube is not needed.

The power tube requires 160 volts plate, with 10 volts negative grid, if it is of the UX-CX-112 type, so that the slider of the potentiometer connected between *A* and *B* in the diagram will enable the voltage to be adjusted to the correct value. The remaining 1500 ohm potentiometer takes care of the additional voltage above that required for the *B* voltages of the set, and enables adjustment of the current flowing through the circuit to exactly 70 milliamperes. A milliammeter having a scale of 0-100 milliamperes is convenient to have permanently connected in the circuit, as is shown in the picture.

The actual wiring diagram of the 5 tube Browning-Drake receiver is shown in Fig. 2. The radio frequency tube, and two of the resistance coupled audio stages, each require 4½ volts *C* potential, and the power tube in the last stage requires 9 volts negative grid. The r. f. tube obtains its *C* voltage through a 3 volt drop in the filament of the detector tube, plus the 1½ volt drop across a 25 ohm resistance, making a total of 4½ volts. The detector tube, not requiring *C* voltage, has its grid return connected to the positive end of its filament. The first a. f. tube grid is connected to its filament through voltage drop across the r. f tube filament and a 25 ohm resistance, and the second a. f. tube obtains its grid voltage through drop across the 1st a. f. tube and resistance. The power tube uses the filaments of both preceding a. f. tubes in series with 50 ohms resistance, to obtain a total of 9 volts negative grid. If *C* voltages greater or less than those specified are desired, for the power tube, the grid return can be connected to some other part of the filament circuit.

On account of the fact that the *B* voltages are supplied through resistances, a set of condensers are required, either mounted in the radio set, or on the rectifier board, as shown in the picture. The slider of each potentiometer is connected to the junction with the filament circuit through a 2 mfd. paper condenser, which should be of high grade manufacture. Filter condensers having low internal resistance are preferable to the ordinary grade of by-pass condenser, for if the *B* circuit of the receiver has any appreciable resistance, the set will howl at some audio frequency continuously.

The plate current flow for the various tubes in the circuit must pass through the series filament circuit, and hence precautions must be taken to prevent excessive filament current in the tube filaments nearest to the negative rectifier terminal. The tube nearest this terminal is the second a.f. amplifier, and assuming normal plate current for the other three tubes in the circuit, which will total 6½ milliamperes, there will theoretically be 66½ milliamperes passing through the filament of the second a.f. tube, and the filament will appear somewhat brighter than the others. The first a. f. tube will have only 4 milliamperes in excess of its normal current, which is not sufficiently large to be serious, but the second a. f. tube filament should be shunted with a 500 ohm resistance to by-pass at least 6 milliamperes. Such a resistance is put up in convenient form by the General Radio Co., and is called a Type 283 Tube Protecting Resistance Unit. It should be connected as shown in the diagrams.

The plate return for the power tube is through a 200 ohm potentiometer

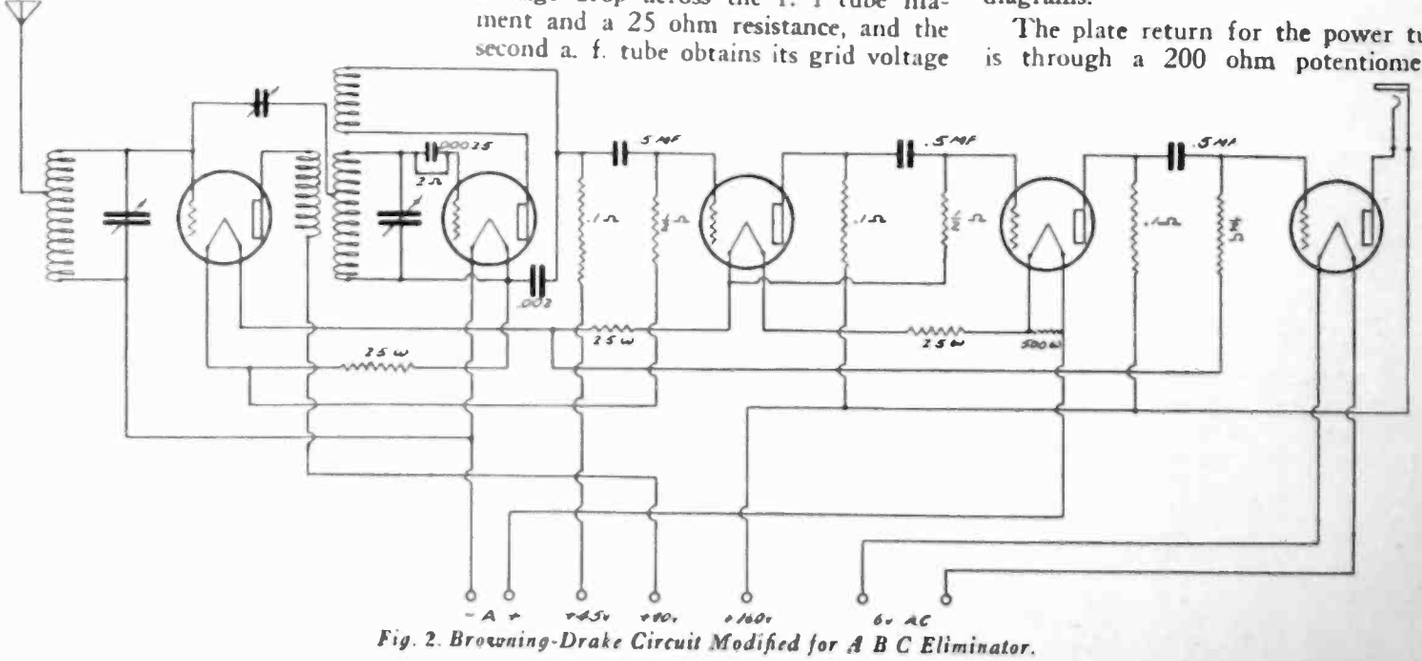


Fig. 2. Browning-Drake Circuit Modified for A B C Eliminator.

bridged across its filament circuit, the slider being connected to the junction of the potentiometer group with the series filament circuit.

For those who wish to use the device with a superheterodyne, the circuit of an 8 tube Best Superheterodyne such as that described in September RADIO is shown in Fig. 3, modified for series filament hookup.

At first glance, the circuit appears very complicated, but most of the wiring shown is the arrangement of the filament and grid return circuits so that each tube will provide negative grid voltage for some other tube in the circuit. As the intermediate frequency tubes ordinarily require 45 volts plate and 1½ volts negative grid, the use of 90 volts plate is undesirable, and with 3 volts available for *C* potential, obtained from the drop across any one tube filament, the plate voltage to correspond to 3 volts *C* potential, for the '99 type tube, should be 70 volts, and no more. As the 1500 ohm potentiometer connected in the 90 volt tap, as shown in Fig. 1, is not sufficient resistance to cut the voltage to 70, two General Radio 500 ohm resistances must be added in series, making a total of 2500 ohms.

The volume control is preferably a 1500 ohm potentiometer shunted across the filaments of the three intermediate frequency tubes, as the potentiometer will thus prevent the plate current coming from preceding tubes in the circuit, from burning the i. f. tubes at excessive brilliance, and will obviate the necessity of extra shunt resistances. The second detector and oscillator tubes should be equipped with shunt resistances across the filament, the oscillator tube requiring 500 ohms, and the detector tube 250 ohms, the latter being obtained by placing two 500 ohm resistances in parallel.

If there is any doubt about the correct resistance values for the last two tubes, it would be advisable to measure the voltage across the tube filament with a high resistance voltmeter, such as the Weston Model 506, and shunt the filament with a variable resistance, such as a 1500 ohm potentiometer, varying the resistance until the desired voltage of 3 is obtained. Either measure the resistance of the potentiometer at that setting and obtain a fixed resistance of equivalent value, or leave the potentiometer permanently connected across the filament.

Fixed mica condensers of at least .0025 mfd. each are necessary between the grid return connection of each i. f. transformer and the filament of the tube, in order to by-pass the high frequency currents around the C biasing resistances. As in the Browning-Drake circuit shown in Fig. 2, the last audio frequency tube is a power tube with 5-volt filament operated from a. c. through a bell transformer.

THE actual construction of the *ABC* eliminator is not difficult, and most constructors will prefer to mount the apparatus on a suitable board, as is shown in the picture. The power transformer, filter coil, filter condensers and rectifier tube socket are mounted in a group, and the connections made with heavily insulated wire. As the total voltage across the transformer secondary is 500 volts a. c., an unpleasant shock could be had if these terminals were touched.

The group of potentiometers are mounted at one end of the board. As considerable heat is produced when the plate connections to the radio set are disconnected, they are mounted on end by means of small brass brackets, so that there will be a good circulation of air around the bakelite supports of the potentiometers. As soon as the *B* voltage taps are connected to the radio set, from 10 to 20 milliamperes, depending upon the set, will be by-passed around the potentiometers and through the plate circuits of the tubes, so that in regular operation the potentiometers will be only slightly warm. Even with the *B* battery taps removed, the rectifier operated continuously for 24 hours without any of the potentiometers becoming too hot for safety. As the resistance wire on the potentiometers is held in place with shellac, there will be a slight odor of heated shellac for a few moments when the outfit is first turned on, but will quickly disappear with use.

The by-pass condensers are mounted on the board adjacent to the potentiometers, together with the bell transformer for the last audio tube. A snap switch for turning the rectifier system on or off may be mounted on the board, or inside the radio receiver, on the panel. In testing out the rectifier, place the tube in the socket, and operate the tube without load, other than the filter. If the plates of the rectifier tube do not become red, and the tube appears to be normal in all respects, connect the load circuit to the rectifier, including the filament series circuit, but not the *B* potential taps.

Adjust the current in the circuit to 70 milliamperes by means of the potentiometer nearest the positive 250 volt terminal of the rectifier, and then connect the 160 volt terminal to the radio set. It may be impossible to obtain as much as 70 milliamperes with the outfit, due to the high d.c. resistance of the particular filter coil used, in which case cut all the resistance out of the voltage regulating potentiometer and obtain as high a current as is possible. With either a high resistance voltmeter or a milliammeter, adjust this tap to the proper value. With 10 volts negative grid, and 160 volts plate, the plate current of a CX-112 tube will be about 10 milliamperes. If a voltmeter is used, adjust the tap to 160 volts or with only a milliammeter available, adjust the current in this tap to 10 milliamperes. A slight change will be noted in the rectifier milliammeter, and the total current should again be adjusted to 70 milliamperes.

Now adjust the 90 volt tap either with the voltmeter or milliammeter. The normal plate current of a CX-299 tube with 90 volts plate and 4½ volts negative grid is 2½ milliamperes, so that the number of tubes requiring 90 volts can be multiplied by 2½ and the total current which should be drawn from this tap will be had. This will again make a change in the total current

(*Continued on Page* 52)

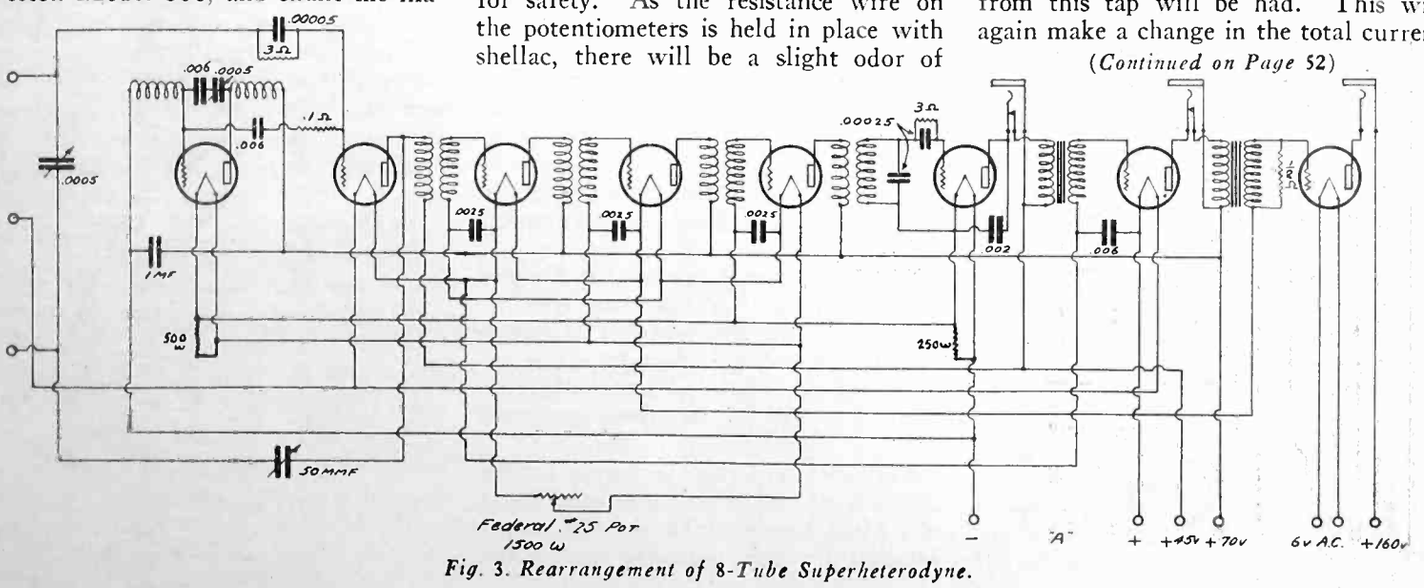


Fig. 3. Rearrangement of 8-Tube Superheterodyne.

Radio For Train Signals

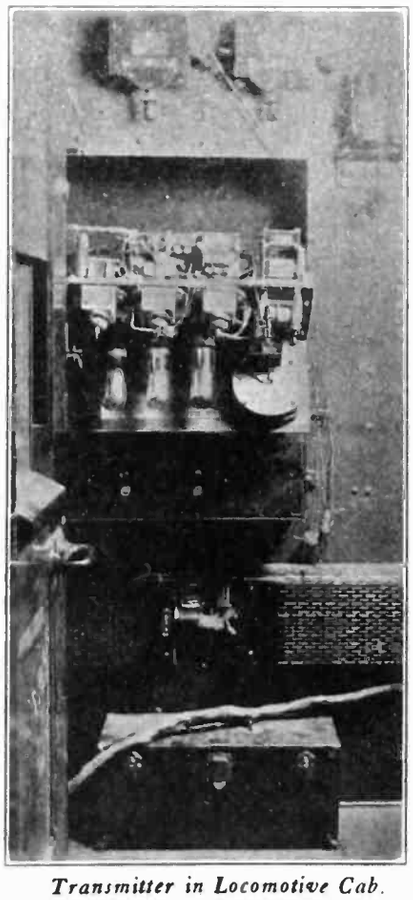
How the Crews of Two of the World's Largest Electric Locomotives Keep In Touch With Each Other Though Separated By a Mile-Long Coal Train

By Austin C. Lescarboura

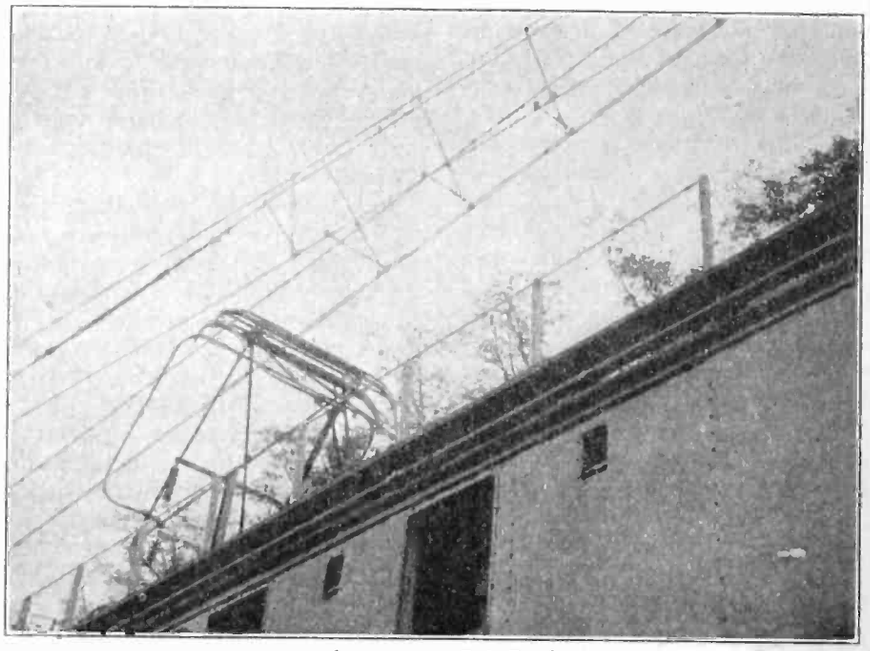
RADIO is now employed in train signalling. This application of radio telegraphy and radio telephony comes about as the result of the mile-long coal trains on the Virginian Railway, which are hauled and pushed up the steep mountain grades of the Appalachians on their way from the West Virginia coal fields to tidewater at Norfolk in Virginia, by means of the world's largest electric locomotives. In order to synchronize the operation of the front and the rear electric locomotives, separated by a mile of coal cars winding in and out of tunnels, across tall trestles, around valleys and through mountains, radio communication is summoned to serve the railroaders of today in realizing the full meaning of mass transportation.

With the steam locomotives heretofore employed, it has been the practice in starting, to open the throttles of the two rear or pusher locomotives just sufficiently to exert a steady push, taking up the slack in the long string of cars. Then, when the front locomotive got under way, it had the help of the pushers from the very start.

But with the new electric locomotives, however, the situation is different. It is uneconomical to exert the pushing action with the rear electric locomotive unless the train is ready to move. And since the front locomotive cannot haul the entire train without danger of pulling it apart, some system of signalling must be employed between front and rear locomotives. The compressed air whistles of electric locomotives cannot be relied upon for everyday signaling of a distance of a mile. Visual signals are out of the question since it is rare that the two locomotives, separated by a mile of train, are in sight of one another.



Transmitter in Locomotive Cab.



Antenna on Cab Roof

So it has come about that radio telegraphy is employed as a means of signaling on these giant Virginian locomotives, with radio telephony as an adjunct. In the center cab of the three sections comprising one of the giant Virginian locomotives, is placed the radio transmitter and receiver equipment. The apparatus is mounted in stout steel cases and amply protected against the intense vibration and shocks.

The transmitter consists of a 50-watt master oscillator tube operating two 50-watt power amplifying tubes in parallel. The signaling is done by a remotely controlled relay. Plate voltage is supplied by a 1/4 k. w. motor-generator set.

The antenna, which is employed for transmitting and receiving alike, consists of a 24-ft. length of 1/2 in. brass pipe, mounted on uprights on the roof of the center cab of the electric locomotive. The ground is the frame of the locomotive.

The only operation necessary, when the engineer desires to signal, is that he pull a signaling cord hanging out of the signaling box, half way down. The signaling box is placed in the engineer's compartment, within convenient reach, alongside the "howler" or modified loud speaker. Pulling the signaling cord halfway down starts the motor-generator set, lights the transmitting tube filaments, and sends high-frequency current out over the system. On pulling the cord all the way down, the output is modulated by a 500-cycle modulator, producing a note in the "howler" at the other end of the train. By using a code of signals similar to that used for whistling, any message can be transmitted. Furthermore, the signal can be acknowledged and communication carried on in the opposite direction.

In the event that the radio telephone is to be used, the engine crew must go to the center cab where the radio equipment is located. A head set is plugged into the receiving set, and a switch is thrown on the transmitter to bring the radio telephone feature into action. The engineer or fireman then talks into the transmitter microphone, mounted on the transmitter panel, and hears the party at the other end by means of the head

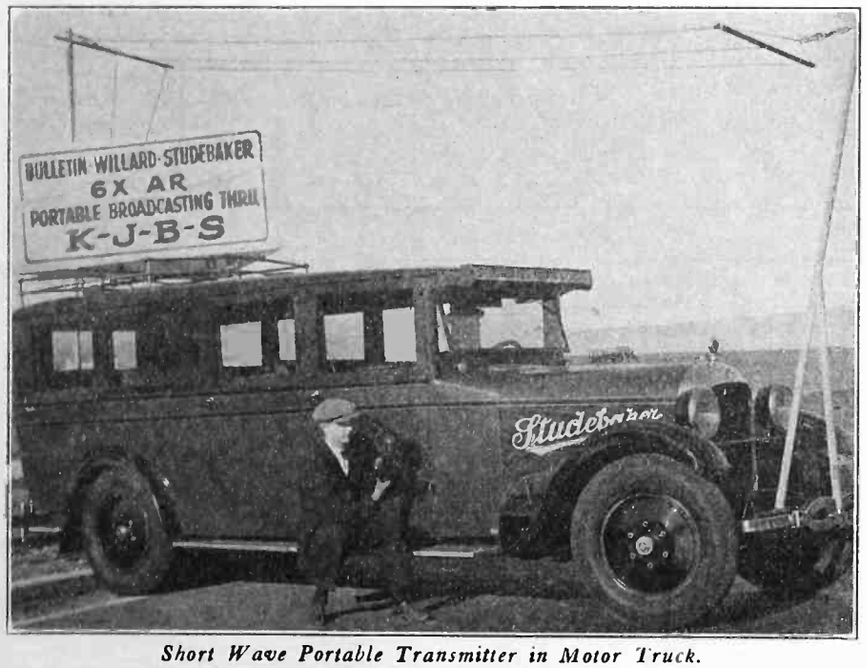
(*Continued on Page* 58)

Motorized Short Wave Phone Transmission

An Interesting Account of Successful Experiments in Radiocasting From a Motor Truck

By Earle Ennis

AMONG the many new fields into which radio is slowly but surely penetrating, is that of flexible or motorized radiocasting, viz., the possibility of transmitting under either emergency conditions or for pickup flexibility from a motor-truck to some central point, from which it is given either specialized or general re-transmission. The advantages to be gained from a small compact unit which might be sent rapidly from point to point was recognized many years ago during the infantile phase of the science, but the unstandardized equipment and meager knowledge of transmission data made such attempts, in the main, abortive.



Short Wave Portable Transmitter in Motor Truck.

Recent work, however, has not been so unsuccessful as accomplished by the motor wing of KJBS, at San Francisco. This station has also invaded the more recently developed field of short wave work where some interesting discoveries have been made in motorized radiocasting.

The transmitter used by 6XAR is rated at 50 watts and is installed in a Studebaker twelve passenger motor coach. The set uses Heising modulation system with a tuned plate circuit with 1000 volts of Willard B batteries actuating it. With 130 milliamperes on the oscillator, the average antenna reading is 3.5 amperes, with UV-203 tubes for oscillator and modulator and 216-A tubes in the three-tube resistance coupled amplifier.

In building the antenna certain new factors had to be worked out. Experiment finally settled on a three-wire flat-top antenna of the inverted "L" type, 18 ft. long, 10 ft. high at the front end, and 13 ft. high at the rear. The lead-in was taken at the rear and brought into the car through the ventilator going directly to the set. The frame of the car itself was used as a counterpoise, with no connection whatever to the primary circuit with respect to grounding it.

Several surprising phenomena were noticed when the set was put into preliminary test. When the series condenser was used in the counterpoise and the negative *A* was grounded on the car the set would not radiate to any degree. When it was connected to the set side, the radiation was slightly better but not sufficient to warrant the connection.

If the door of the machine was opened, it changed the wavelength of the set, in some instances stopping radiation altogether. The set would, however return to normal, as soon as the door was closed again. In transmission, signals from the set were clear up to three miles while the machine was in motion even on streets where the overhead trolley wires were not more than 3 ft. from the antenna.

Without a series condenser the fundamental of the set was 69 meters but due to harmonics from other stations this was decreased to 63 meters by means of a counterpoise condenser. When steel buildings intervened between the set and the receiving station, at KJBS from two to three miles away, a certain amount of fading was noticed, not sufficient however, to put the signals entirely "out," of reception.

One of the most interesting attempts was undertaken by the set on the closing night of the Diamond Jubilee Celebration in San Francisco when the coach participated in the night electrical parade, sending on short waves everything that could be picked up along the line. The pickup was re-broadcasted by KJBS, and the band music of the parade and scraps of conversation from the crowd was heard by listeners, through the parent station, for several hundred miles.

The microphone was of the portable type and was simply held through an open window of the moving coach. Arguments between the driver and traffic policemen, the blare of horns, the clang of Chinese gongs carried by one parade division, and the music of passing bands were all successfully transmitted. Thousands, who tuned to KJBS, were able to obtain some adequate idea of what was transpiring through this means.

There was a slight whistle in the re-broadcast noticed by many listeners. This was due to trouble in the super-het used at KJBS to couple the incoming signals from the coach to the main set and could have been obviated by the use of another set which could not be obtained at that hour of the night. In general the idea was a success and marks a big step forward in portable work.

The coach installation was entirely temporary and could not therefore carry the proper insulation. It is now planned to make a permanent installation on a Studebaker chassis for future experimentation. In time of emergency, such as a big fire, or a disaster similar to the Santa Barbara earthquake, the machine could be rushed to the spot and be in instant communication over long distances with a central parent station. For such work it is planned to use straight c. w., telegraph for news or bulletin purposes.

The Brunton interests have also conducted a series of experiments with fire boats in action from San Francisco bay, linking them with the parent station as an emergency measure and the tests were highly successful. It is planned in constructing the 6XAR portable to so arrange the units that they may be lifted off and converted into either a stationary land station or an emergency ship set for specialized work, giving great flexibility for re-broadcast purposes.

Adding Two R. F. Stages to a Grebe CR. 8

By H. F. Manchester

OWING to the former popularity and excellent construction of variometer types of regenerative receivers, they afford an excellent foundation upon which to start the construction of a more up-to-date set. The modified Grebe CR-8, illustrated herewith, shows how two stages of radio frequency amplification may be introduced without too greatly disturbing the original appearance or wiring of the set.

The coupler and all associated wiring were carefully removed, the antenna coil taps being clipped off at the contacts. The two variometers were left in place, but all bus-wiring was disconnected from them. The wavelength change condenser was also disconnected but left in place so as not to disfigure the panel.

Two sockets for radio frequency amplifier tubes were then wired rigidly with bus-bar in the space formerly occupied by the coupler. As the original rheostat was designed to handle 1 ampere it had sufficient resistance to control three 0.25 ampere tubes, the wiring being extended to include the two r. f. tubes.

One of the antenna switches was used to cut in the fixed condensers required, in combination with the average antenna, to determine the wavelength range of the first variometer. This is clearly shown in the circuit diagram which indicates the rest of the winding.

The dial of the first variometer can be logged for tuning and the second can be used as a regenerator by gradually increasing from zero until just before oscillations start so as to permit radiation.

The aperiodic coupling used in the plate of the second r. f. tube proved to be the missing link for smooth operation. While it does not make the fullest use of the tubes' amplifying abilities, it certainly provides a decided boost to the received signal and, what is equally important, the arrangement acts as a shock absorber between the regenerative first tube and the grid of the detector.

The aperiodic coil may be a honeycomb or other inductance of about 300 turns, although the exact number of turns is not critical so long as it does become resonant at some frequency which is to be received. It may occupy a position back of the r. f. tubes and preferably at right angles to the two variometers so as to obviate any inductive action with regard to them.

The grid and phone condensers for the detector are below the sub-panel and may be used as they are.

The results were surprising, for readable signals from stations 2000 miles distant were received during the summer months.

Nothing new or remarkable is claimed for the circuit except its application to an excellent piece of existing apparatus.

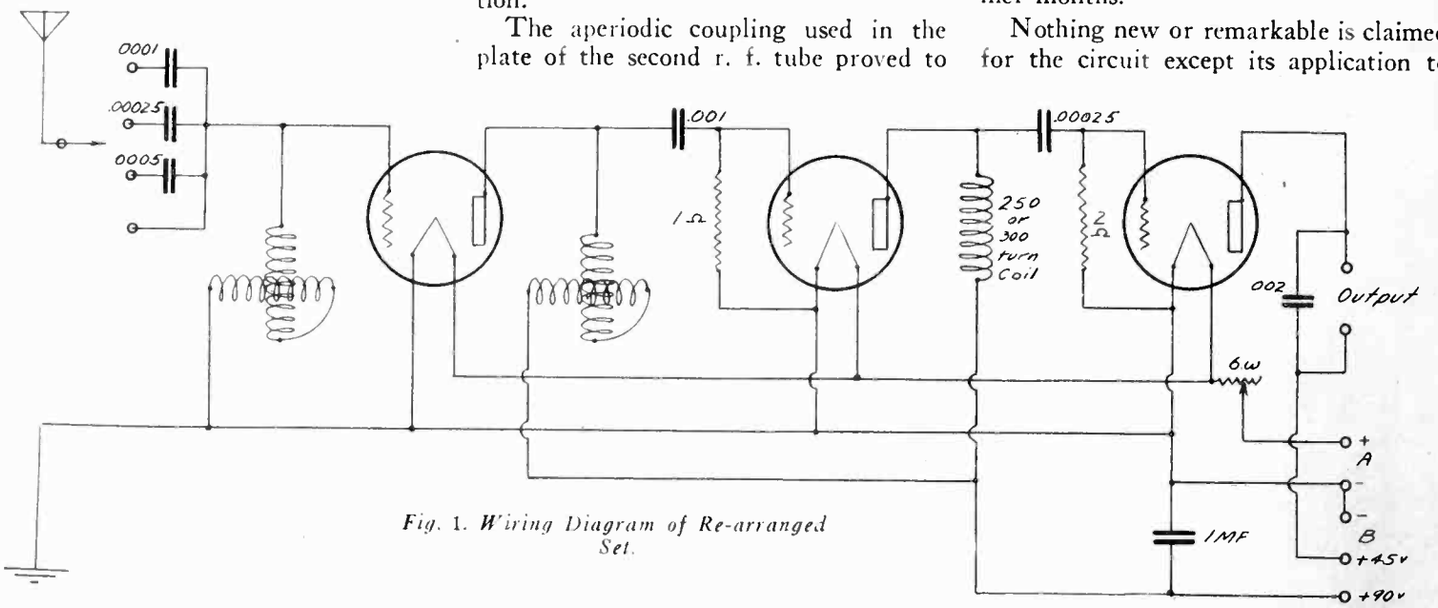
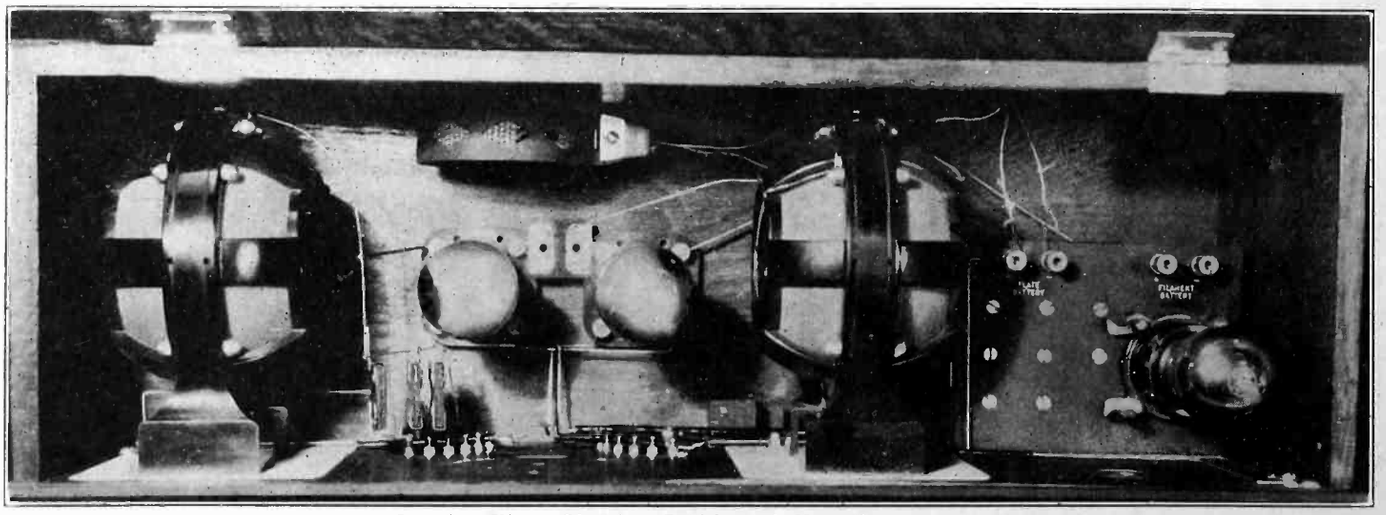


Fig. 1. Wiring Diagram of Re-arranged Set.

Should the holes left by the removal of the vario-coupler appear unsightly it would be a good idea to place a filament voltmeter in the vacant space left on the panel and connect it across the filaments of all three tubes.

The regular Grebe RORK audio amplifier may be used for speaker volume.



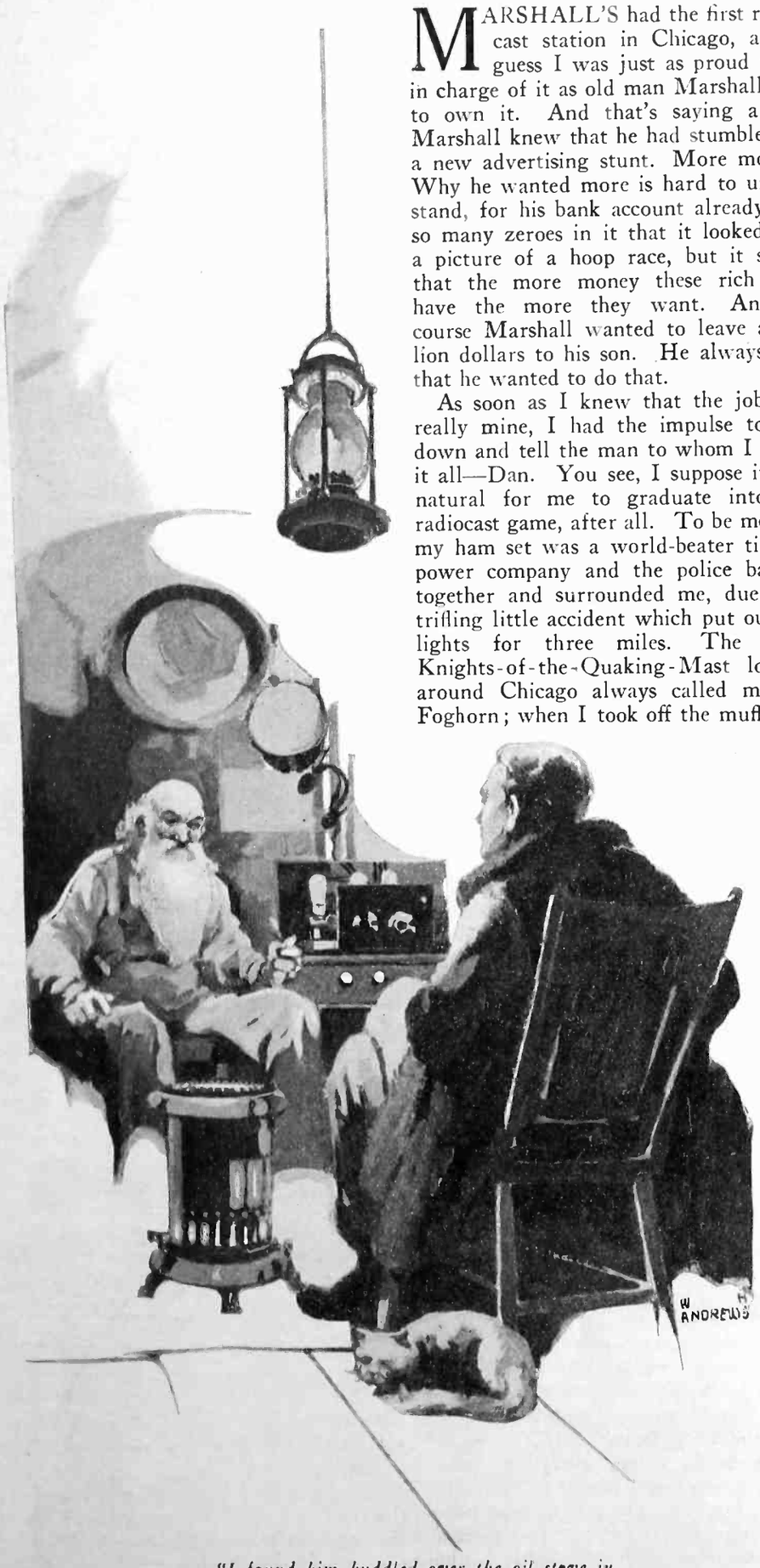
Interior View, Showing Position of New Apparatus

Two Christmas Eves

By Jan Dirk

MARSHALL'S had the first radiocast station in Chicago, and I guess I was just as proud to be in charge of it as old man Marshall was to own it. And that's saying a lot: Marshall knew that he had stumbled on a new advertising stunt. More money! Why he wanted more is hard to understand, for his bank account already had so many zeroes in it that it looked like a picture of a hoop race, but it seems that the more money these rich men have the more they want. And of course Marshall wanted to leave a billion dollars to his son. He always said that he wanted to do that.

As soon as I knew that the job was really mine, I had the impulse to run down and tell the man to whom I owed it all—Dan. You see, I suppose it was natural for me to graduate into the radiocast game, after all. To be modest, my ham set was a world-beater till the power company and the police banded together and surrounded me, due to a trifling little accident which put out the lights for three miles. The other Knights-of-the-Quaking-Mast located around Chicago always called me the Foghorn; when I took off the muffler of my two-foot rotary the boats on the Lake used to steer by the noise.



"I found him huddled over the oil stove in the 'S. S. Moper's' dilapidated radio cabin."

In other words, I knew something about running a station, so that when Marshall's installed a set I was about the only man in town who knew enough to build and operate it, thanks to having studied C.W. on Dan's advice. I had the knowledge of construction, a line of "bull," and some C.W. theory; although no practice. Lucky? If I was, I owe the luck to Dan.

I wanted to tell Dan I was grateful, so I put on everything I could find that would help to keep out the icy wind that was blowing, and climbed on a car for the docks, where old Dan was sure to be. I found him just as I expected to find him, huddled over the oil stove in the *S. S. Moper's* dilapidated radio cabin, reading a magazine with the phones tight over his ears.

In his rough shirt and jeans he looked like a gardener. The only thing that marked his profession was his battered old uniform cap, that hung on a peg, its tarnished lettering spelling the name of this little lake steamer which was now used to bring goods down to Marshall's from some of the manufacturing towns farther north on the Lake—sash and door products from the mills at Oshkosh, where lumber is lumber, for example. As I busted in, Dan looked up and smiled.

"Hello, Son. Still blowing outside?"

I told him it was. If you were in Chicago that week before the Christmas of 1921 you will recall what the winds were like on the Lake, and how bitterly cold it was. "Well, Dan," I told him, "I've got a surprise for you."

"What?"

"I'm in charge of Marshall's new station. Your boss is my boss."

Dan jumped so high that he nearly knocked over the oil stove. "That's great." He grabbed at my hand as if he were a young man. His grip didn't have the strength of youth, though—every year his hands were getting more and more like fine old waxwork, with veins showing, the color of faded purple ink. Faded . . .

"How've you been getting me down here, Dan?"

"Fine. I've been hearing your voice, I guess, Jimmy, but my ears must not be as good as they used to be; I didn't recognize you." He chuckled. "I guess I ought to make a good testing station—you know how near I stay to the set, all the time!"

"Still sleep with the 'phones on?" I asked laughingly.

(*Continued on Page 66*)

Passing Your Next Radio Examination

Complete Information on How To Pass Your Next Bout With the Department of Commerce, Be It Amateur or Commercial Examination

By C. William Rados

IT SURE is a grand and glorious feeling to be the envied possessor of an impressive U. S. wireless operator's license. You rush down to the 5 and 10 to get a frame and some glass, while your friends congratulate you and stare at the "ticket" with awe and wonder. Even if it is only a deep sky-blue amateur ticket, your hat becomes too small and your chest—?? well that doesn't tell anyone how to get the precious document.

The radio operator's license examinations conducted by the Department of Commerce, are hard for the inexperienced person to pass. But the exams are fair and not difficult to pass if the training for them has been adequate.

Whether the examination is for an amateur or commercial license, the code part is given first. If the applicant fails to pass this test, he will have to wait three months (theoretically) before being allowed to try again. Statistics show that half of the amateur applicants and two-thirds of the commercial applicants fail to pass their first test. As practically all fail on the code we see how important it is to be able to pass your first five-minute test.

Good knowledge of the international Morse code is perhaps the most important thing, since the potential operator will never be allowed to operate unless he knows the Morse well. Therefore learn the code, and learn it well.

If you do not already recognize in dots and dashes, the different letters and numerals of the English language, memorize them from the code sheet. Notice that this sheet is called the International Morse Code and Conventional Signals. Therefore when you take your examination for a commercial license you are expected to know all of the characters on that sheet.

However, for the amateur license, the alphabet, the numerals, and a few of the punctuation marks are all that is necessary. For the commercial examination, the fraction bar end of transmission (*sk*), and end of message (*ar*) are frequently given. In fact it is well to be familiar with all the characters on the sheet. For instance, a fraction bar is - - - - - -, German *ch* is - - - -. However, if you know nothing about the code, spend a few weeks on the alphabet alone. Then when you can copy about ten words per minute (w.p.m.), learn the numerals. Later on learn the question mark, the attention signal and a few others.

Of course, you will not be able to learn without help. Get some operator to send to you a few times a week. If you are able, join a radio school. Another suggestion is that if you know several others who are willing to learn the code, you could hire some local operator to send to you a few times a week.

The first few months are hard, but after you are able to copy about 17 w.p.m., the rest will come easy. Although the amateur may get a license if he can only copy 10 w.p.m., it is more likely that he will not. It is much better to be able to copy 14 to 16 w.p.m. and be sure of getting your amateur license. Although the omnigraph which sends your test may transmit only 60 characters per minute, (12 w.p.m.) it will send them at a rate of about 16 w.p.m. with long waits between the individual letters. Therefore be able to copy the signal when it is sent. A minor detail, of course, is that anyone able to receive only 10 w.p.m. will be very lonesome "on the air" as radio traffic seldom is slower than about 15 w.p.m.

You will now be able to rig up a long wave honeycomb receiver and copy the important stations. Copy NSS press or "px" as it is called. Keep a three-hour watch once or twice a week on the 600 to 800 meter commercial band and note how traffic is handled.

Do not become discouraged because the sending is faster than you can copy well. You will never learn as well as when you are copying a station which is sending about 2 w.p.m. faster than you can really copy. This sort of practice keeps you alert and mentally awake.

Get NAA a few times a week. NAA sends every night from 10 p.m. to 12 p.m. at a rate of about 19 w.p.m. If you copy everything NAA sends about once or twice a week, you will have excellent practice on weather forecasts, USSB orders, press, hydrographic reports, and time tick.

A very important point to strive for in copying is *unbroken reception*. You *must* be able to copy at least 100 consecutive characters without a mistake, break, or omission. You will not pass a commercial examination otherwise, and an amateur license will not be granted unless the copy is fair. 100 consecutive characters means everything that is sent: parentheses, breaks, (- - - -) commas, numbers, *Q* signals, stops, code groups, signatures, etc. if you cannot copy NAA evening hydrographic report for several hundred characters without an error, you should not go up for your commercial license.

A few typical examinations are included. The two-minute test is one which is tricky and difficult and would not be given on a commercial examination. However, if you can copy this, without error at a speed of 25 w.p.m., you will be able to pass your reception examination for the commercial first.

5-Minute Code Test Similar to Commercial Test

NAH NAQ 16305, 43201, ABQRQ, HAVANNA CLEAR TO MODERATE BAROMETER 29.03 ?? CH 16035 WST DE KOK P NR 1 CH RQSTF GGFBH, 6BKHN, 6½32 - - - - WST HAN NAH? NAD, WCY DE MBF. QST DE NAA, HURRICANE WARNING AR (GGFK) POL, ABQ, WZT, KOL, HOSPITAL, CLEAR DOCK AT 5PM REYNOLDS AR SUNOCO NEW JERSEY—QRK? QRD? 16305 4321 6632 89073 ABPMZ NIVUK WRF KDKA LLFG. QSY 1600 AS QST DE NPL WEATHER FORECAST FOR NEW ORLEANS AND VICINITY. HOLE IN WALL TRIESTE?

(REMIT) DRC. SOS SOS SOH DE NTL NTY NTL SK CENTRAL OVER BERLIN - - - - - - WHK BK LONDON BK. ENGLISH BANKERS CONFERENCE HERE TODAY JJF JJF DE JKC SQRMF 16AMV CK 6 DATE FLD 10.20 PM PORT CAPT SOCONY PROVIDENCE. END

218 Characters, 2 Minute Test

10984 LLAIH — LH16035 EEISE, H5HSIESH ANNM WBF, 1½ 5H545H4 676B SOS SOS SOH DE NAR (AR) (MEXICO CITO) . !: HAR QRT QRE RQN OXKDF RGFKF 12JRF OCDLI 6BEFD ACK25 496½B AN, WXH, PPW MU - - - - CQ HARVARD, PHILADEL PHIA SAN 6P. RRFS5 5½6BCLF WCY, KOK MFBH, ABK? HOH, WSA, WNY.

You will notice that you can not guess what is coming. You will have to copy *what is sent* and what you *think* the operator wants to send.

Notice the words Mexico Cito in parentheses. The careless operator copying down each word as it is sent will nine times out of ten, write down a *Y* instead of the *O* that is sent. He will do this because he reads as he writes and he is trying to guess what the other operator is going to send! Like other fortune tellers he is often wrong. The experienced operator, on the other hand, will be three or four letters in his writing behind the sender and so does not make the error.

Always write about one word behind the sending so that the sender will have time to rectify any mistake he makes before you write it down. Thus if he

(*Continued on Page* 54)

A Quality DX Receiver

Having Great Selectivity and Sensitivity and Giving Loud-Speaker Volume with Four Dry Battery Tubes

By O. B. Scott

A REASONABLE distance range, combined with good tone quality, is desired by the majority of those who construct their own sets, and the receiver described herein fulfills the demand in a remarkably capable manner, combining radio frequency amplification with regeneration, and having an audio amplifier which does not distort.

The receiver uses one stage of tuned radio frequency amplification and a regenerative detector, only one transformer, of relatively high ratio being used in the audio amplifier for local reception. A switching arrangement is provided to enable a stage of resistance coupled audio amplification to be added for DX work. This additional amplification is accomplished without increasing the strength of the magnetic field within the receiver, for resistance coupling is not inductive and therefore, has no field. The single audio stage gives great amplification with no distortion, but not quite enough to operate the loud speaker satisfactorily on weak signals. An additional transformer might impair the tone quality unless it was an exceptionally good one, and might upset the balance of the radio-frequency portion of the circuit. Resistance coupling will give the added distortionless amplification necessary for loudspeaker reception of the distant station.

The set is extremely sensitive because of regeneration in the radio frequency tube, which is accomplished by making the plate coil L_3 shown in Fig. 1, of few turns and coupling it very closely to the filament side of the detector grid coil, L_4. This close coupling tends to tune L_3 to resonance with L_4 and the radio frequency grid coil L_2. Since L_2 and L_3 are widely spaced and have their fields at right angles, the feedback takes place only through the internal capacity of the r.f. tube. This is desirable if the plate to grid capacity of the tube is of a low value and hence the UV-199—C-299 tube was employed in this portion of the circuit, as well as for the detector and audio amplifiers.

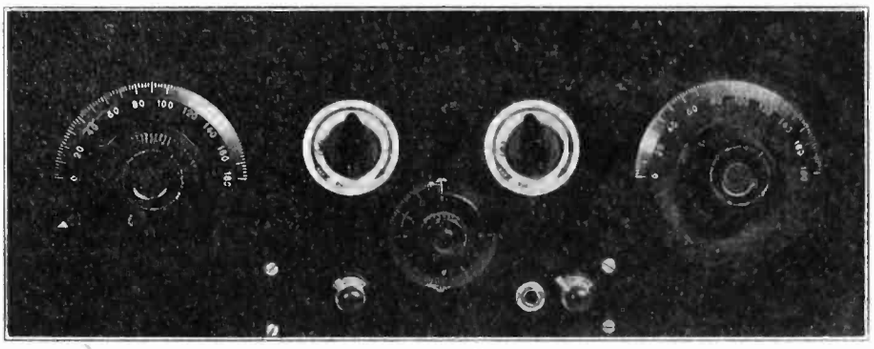
The coil L_3 is placed on the filament side of L_4 in order that the tickler L_5 will have a minimum effect on the plate circuit of the radio-frequency tube.

To be worthy of the name, a quality receiver should be built from quality parts. The antenna coupling coil used in the set was a General Radio plug-in type, which is easily mounted. The vario-coupler is of the same make and makes an ideal regenerative coupler with a little re-winding.

The factory made coupler is correctly wound for use with a .0005 variable condenser, and needs no adjusting. Those who wish to make their own an-

MATERIAL REQUIRED

1 7 x 18 x 3/16 in. Panel.
1 Sub-panel, 3 1/4 x 14 x 3/16 in.
2 .0005 Variable Condensers.
1 Antenna Coupler, General Radio Type 277-D.
1 Variocoupler, General Radio Type 268 (See text for winding).
1 Audio Frequency Transformer.
4 Sockets for 199 Tubes, Cushioned Type.
1 Resistance Coupler Mounting.
1 Grid Condenser with 2 meg. leak.
2 Brackets for shelf.
1 30-Ohm Rheostat.
1 20-Ohm Rheostat.
1 Stage-change Switch, Carter or Yaxley (double pole-double throw).
1/4 lb. No. 24 DSC.
Jack, Filament Switch, Dials, Nuts and Bolts, etc.



Front Panel View.

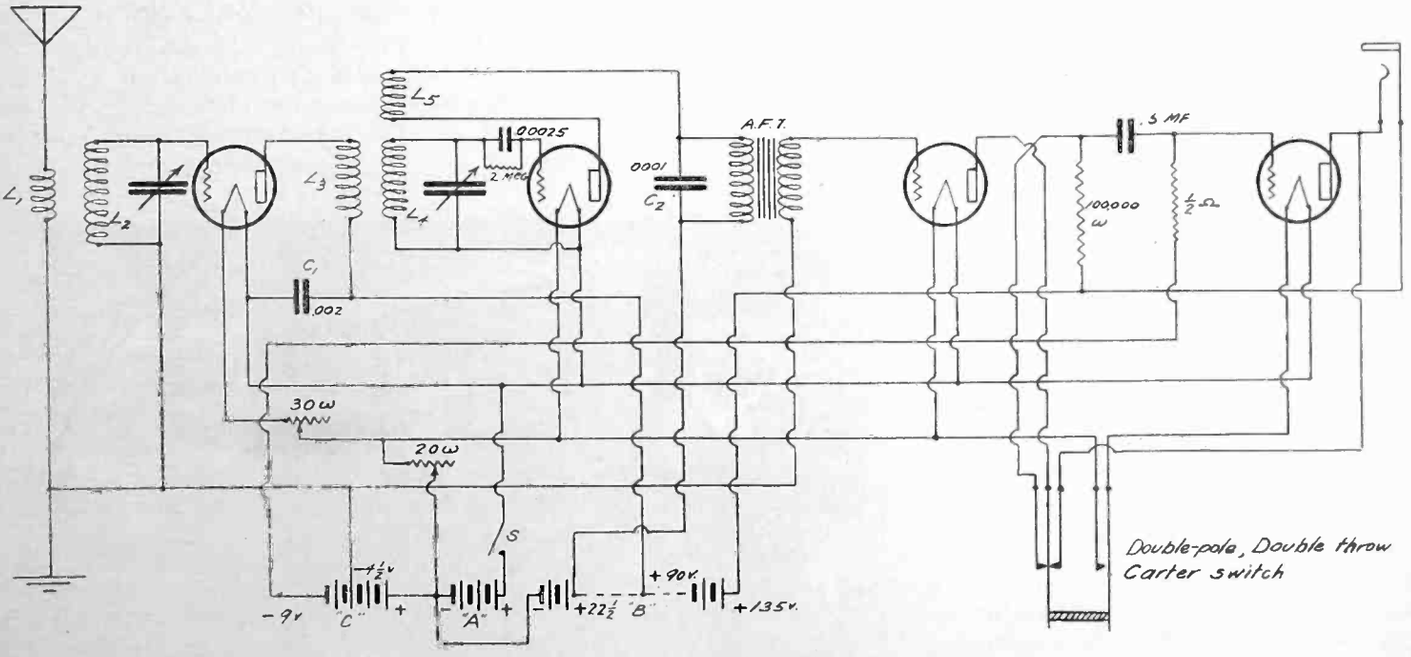


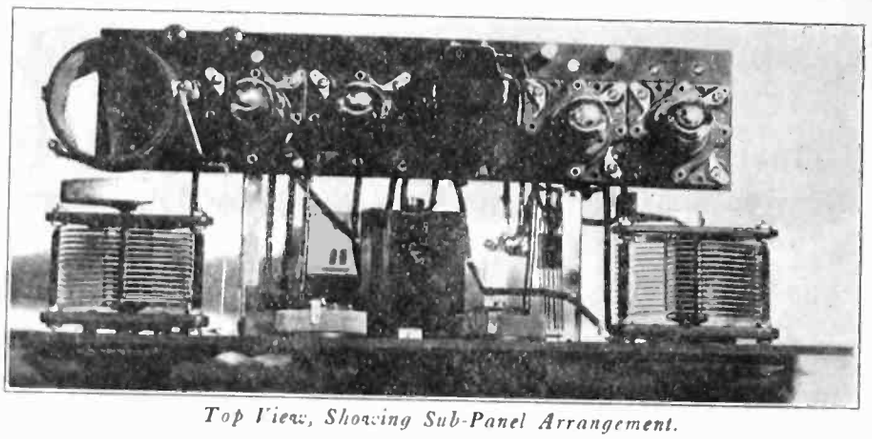
Fig. 1. Wiring Diagram of Quality Receiver.

tenna coil may do so by winding 60 turns of No. 22 silk-covered wire on a 2¾-in. tube 2¼ in. long, for the secondary, and over one end of the secondary wind 10 turns of No. 22 D.S. wire for the antenna coil. The regenerative coupler was made from a G. R. type 268 by replacing the stator winding with *59* turns No. 24 DSC for L_4, over one end of which is wound *10* turns for L_3 A thickness of cambric tape will suffice to separate the two windings. Fifteen turns should be unwound from each side of the rotor.

Attention to a few details on winding the stator coils will save a lot of time and trouble. L_3 should be started through a hole at one end of the stator. When *24* turns have been completed lay a piece of cambric tape, about ⅛ in. wide and 1 in. long at right angles to the winding, allowing about ⅛ in. free, and winding on six turns loosely. Fold the strip over the last turn, insert under the preceding five and bring out with the ⅛ in. flap. Tighten up the last six turns and draw up the tape strip, and the result is shown in Fig. 2 (a). This completes the first half of L^4. Run the wire diagonally across the middle of the stator, clearing the rotor bearings, then wind on the balance and fasten the ends as described above.

When L_4 is complete, wrap a thickness of the cambric tape around one end, holding it in place with a rubber band. Then wind the *10* turns of No. 24 DSC over the tape, fastening the coil as above. This completes L_3, as shown in Fig. 2(b).

Four or five in. should be left free on each end of L_3 and L_4 so that the wires may be soldered direct to connecting parts. This eliminates the need of



Top View, Showing Sub-Panel Arrangement.

binding posts on the coil form except for the rotor connections.

After the panel is drilled the two brackets should be mounted and the sub-panel may then be fastened to the brackets, with the holes center-punched for mounting the sockets, transformer, antenna coil, binding posts, condenser and resistor mountings, etc. The sub-panel may be drilled and the parts assembled.

The sockets are attached to the sub-panel by means of their terminal screws, which permits wiring under the sub-panel. The resistor and condenser mountings for the last stage are fastened to the sub-panel directly beneath the last socket.

A large portion of the wiring on the sub-panel may be completed before the variable condensers and regenerative coupler are mounted. If this course is followed, the builder will not find a lot of obstacles in the way of his soldering iron.

The filament circuit should be wired first; then the plate circuits, and the grid next. The connections to the condensers and jacks on the main panel are completed last.

The builder should be careful to connect the end of L_4 which is under L_3 to the filament, and not to the grid.

C_1 may be .002 mfd. to .006 mfd., while C_2 should be about .0001 mfd. The value of C_2 should be determined by experiment, selecting the one which gives the best tone quality. A small condenser is needed here to bypass the radio frequency in the detector plate circuit, for larger capacities will tune the transformer to a frequency within the musical scale range, with resultant distortion.

R_1 is 100,000 ohms, and R_2 is one-half megohm. The blocking condenser C_3, should be not less than .1 mfd.

The filament battery consists of six dry cells, two parallel sets of three in series and the plate supply should be to 135 volts, especially if one of the new

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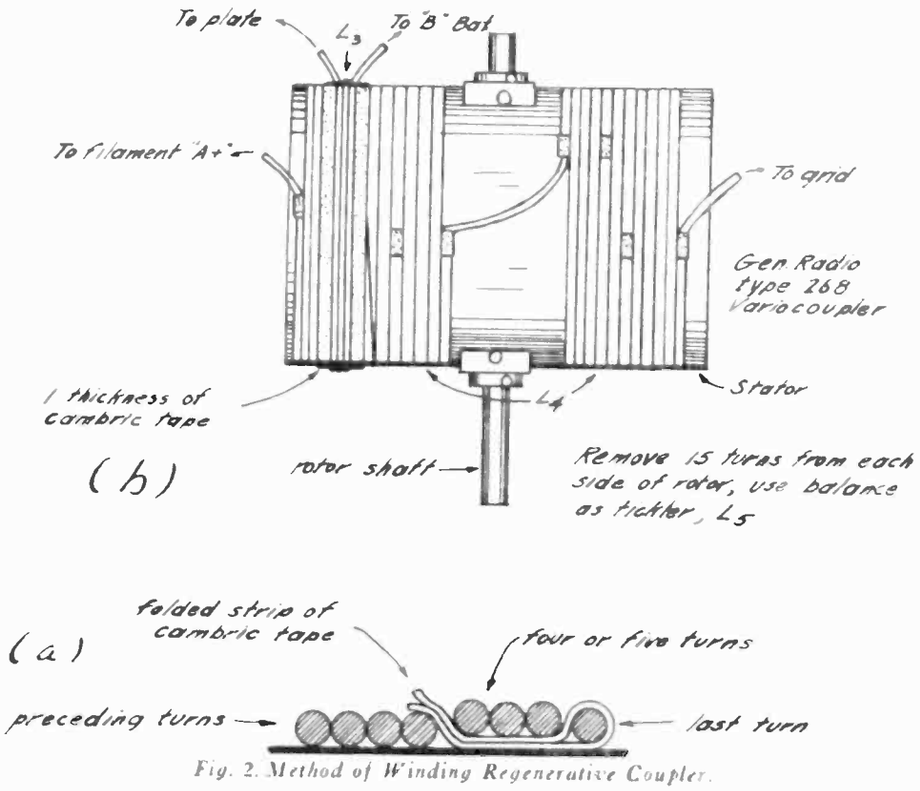
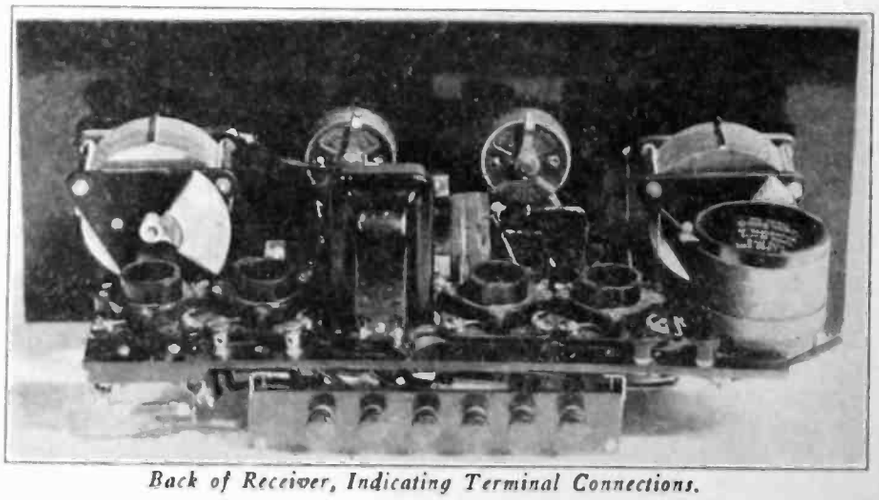


Fig. 2. Method of Winding Regenerative Coupler.



Back of Receiver, Indicating Terminal Connections.

The Single Control Browning-Drake Receiver

Modifications Necessary to Adapt a Two-Rotor Condenser To This Standard Circuit

By H. A. Nickerson

THE problem of building a radio receiver with a single tuning control is usually solved by installing a variable condenser having two or more groups of rotor plates, all mounted on the same shaft, and not insulated one from another. This method is a great convenience, since it simplifies tuning, and as the Browning-Drake circuit is particularly well adapted to single control, a method of revising the standard circuits such as appeared in April and June RADIO will be described.

The revised circuit for single control is shown in Fig. 1, no changes in the wiring of the audio frequency amplifier being necessary. The principal changes involve the re-winding of the radio frequency coils, so that the two tuned circuits, namely, the antenna circuit and the radio frequency transformer, or Regenaformer, as it is often called, will be in resonance at any dial setting of the double rotor condenser. Each half of the double rotor condenser should have a total capacity at maximum setting so that when used in shunt with either L_1 or L_2, in their revised values, a maximum of 550 meters will be reached, while at the same time a minimum of at least 200 meters may be attained.

If the radio frequency transformer is of standard make, it may be used as L_2 in Fig. 1 without alterations. If the circuit to be revised is not the Browning-Drake, and the capacity required for tuning the transformer secondary is less than .00035 mfd., the coil may be left intact and plates removed from one of the rotor groups until that particular section of the condenser has the desired capacity. The antenna coil, L_1, however, which in the Browning-Drake circuit is normally designed for tuning with a condenser of .0005 mfd. capacity, should be rewound for use with a .00035 mfd. condenser, so that it will tune to a given station with the same capacity shunted across it as would be required for L_2. This means that the apparent inductance of L_1 must be such that it must at least approximate that of L_2.

The inductance is described as "apparent" because notwithstanding the efforts of various coil manufacturers, a pure inductance is and seems liable to remain unattainable. This is particularly so when the coil is mounted inside the radio set, where various capacities, such as that of the vacuum tube elements and the minimum variable condenser setting add to the distributed capacity of the coil and upset calculations.

As used in a particular set, such matters as length and height of antenna, length of ground lead, number of turns in the untuned primary and separation of primary and secondary coils will also affect the setting of the variable condenser which shunts the coil L_1. This makes it difficult for a coil manufacturer to provide for different antennas, where single control is used, and likewise for the home constructor.

As applied to sets using a stage of tuned r. f. amplification, of which the Browning-Drake is an example, the "cut and try" method for determining the inductance to use with single control is the only feasible one. Make the grid return for the detector tube as shown in Fig. 1, so that the detector grid will be positive with respect to its filament. This is so that the stator of the double rotor condenser may be connected to the ground side of both tuning inductances, for otherwise with the grid leak in shunt with the grid condenser, in the conventional manner, the grid of the detector tube would be negative with respect to its filament, which is not good practise.

Assuming that both halves of the double rotor condenser are .00035 mfd. each, L_2 may be connected to C_2, which is one rotor, preferably the one nearest the panel. Shunt L_1 with a separate variable condenser having a capacity approximately equal to half the double rotor condenser, which would be .00035 mfd. Tune in three or more stations, with the set in actual working order, trying to find one low, one medium and one high in wavelength. Probably you will be unable to tune in a station above 450 meters with the L_1 circuit, as the coil is normally designed to fit with a .0005 mfd. condenser. This indicates that the inductance of L_1 is too low for use with .00035 mfd. and turns should be added.

The easiest method to accomplish this is to remove the existing turns and rewind with finer wire. If the coil was originally wound with No. 20 D. S. C. wire, it may be rewound with No. 24 D. S. C. so that many additional turns may be made available without the necessity of bank winding. If silk insulation is used, double covered wire is recommended, as a break in the insulation may result in one turn touching an adjacent turn, with great loss in efficiency for the coil. Wind at least 80 turns of No. 24 wire for the revised coil L_1, and again tune in the three selected stations with the separate .00035 mfd. condenser.

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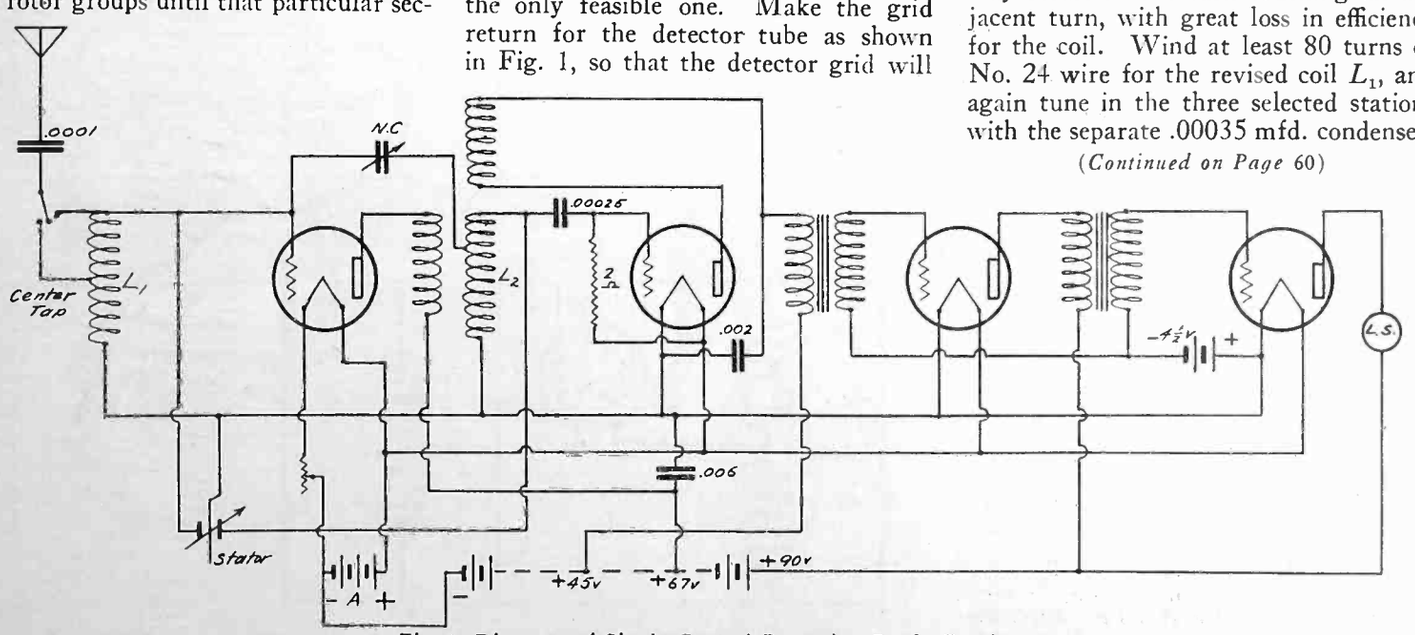

Fig. 1. Diagram of Single Control Browning-Drake Receiver.

How To Identify The Transmitting Circuits

An Explanation of the Principles of the Six Basic Circuits and of Their Practical Modifications

By Lieut. Jennings B. Dow. U. S. N.

THE fundamental requirements for an oscillating vacuum tube circuit, and therefore of a transmitting circuit, are (1) the use of a tube capable of amplifying, (2) suitable coupling for returning part of the energy in the plate circuit to the grid circuit of the tube, and (3) the connection of the tube into an oscillating circuit whose values of inductance and capacity are such that the tube will operate at the desired frequency. There are six basic circuits used in transmitting, all others being modifications of one or more of these.

In the discussion of these basic circuits it is assumed that there is no distributed capacity, that the grid of the tube is at all times negative with respect to the filament, that the tube is operated under normal conditions of filament temperature and plate voltage, and that the frequencies are such that the effects of intra-electrode capacities may be neglected. The first two assumptions require the lumping of circuit constants and the elimination of grid to filament convection currents, respectively. These assumptions are not required for the generalized portion of the discussion but are included to cover certain specific remarks in connection with relations among circuit constants.

Meissner Circuit. Fig. 1 is an arrangement for which credit is given to Dr. Meissner of the Telefunken Co. Essentially, it consists of an oscillating circuit to whose separate portions are coupled the grid and plate coils. The distinguishing feature of this circuit is the coupling L_p and L_g to separate parts of the oscillating circuit. No coupling should exist between L_p and L_g. If such coupling exists, the circuit assumes the characteristics of another type.

Because adjustments in the values of coupling between output and input circuits can be made independently and with little mutual interference, the Meissner circuit adapts itself very well to conditions which frequently exist in the oscillating circuit as well as to those originating in the individual requirements of tubes. For example, flexibility in the frequency or wavelength adjustment is often required. Because a change in the inductance and capacity of the oscillating circuit results almost invariably in a change in the resistance of the external plate circuit, it follows that for maximum output, changes in the plate and grid circuit coupling must be made. The desirability for making the latter changes independently of one another as well as independently of such preliminary adjustments as may have been made in the oscillating circuit is apparent.

In Fig. 1, the frequency of oscillation is given by

$$f = 0.159 \sqrt{L C_a}$$

where, L and C_a are in henries and farads respectively. The same formula applies in the case of the coupled plate, the coupled grid, and Hartley circuits.

Coupled Plate Circuit. Fig. 2 shows a generating circuit in which the input or grid circuit is directly coupled to the plate circuit. The plate circuit, in turn, is inductively coupled to the output circuit as in Fig. 1. The strongest oscillations will be produced when the mutual inductance M between L_p and L_g divided by the self inductance L_g of the grid coil is equal to ½ the amplification factor μ of the tube: $M/L_g = \mu/2$. This indicates the necessity for tight coupling to obtain the greatest output. Consequently the circuit, inherently, is not as well adapted to power tube work as is the coupled grid circuit.

Coupled Grid Circuit. In contrast to the coupled plate circuit of Fig. 2, a coupled grid type of generating circuit is shown in Fig. 3. This circuit is sometimes termed the "reversed feedback" or "British aircraft" circuit. Because L_g is exterior to the oscillating circuit and can conveniently be provided with a wide range of adjustment, mechanical and electrical flexibility in circuit ad-

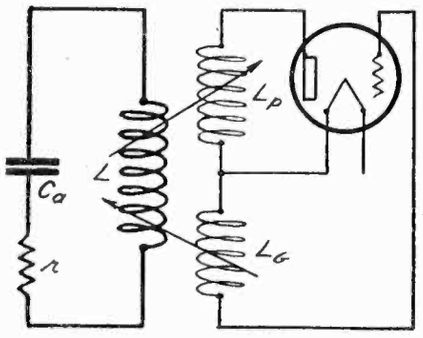

FIG. 1 MEISSNER

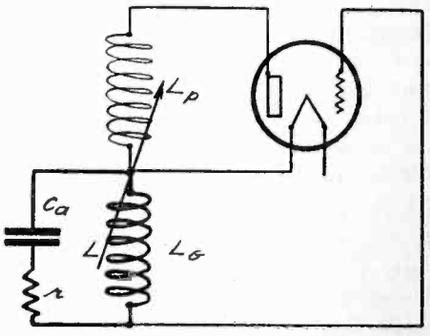

FIG. 2 COUPLED PLATE

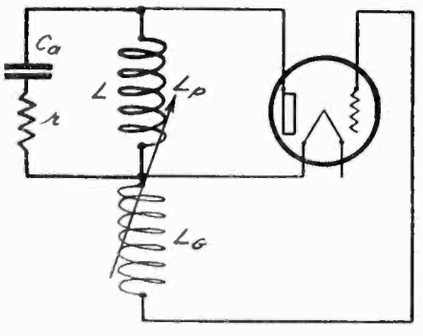

FIG. 3 COUPLED GRID

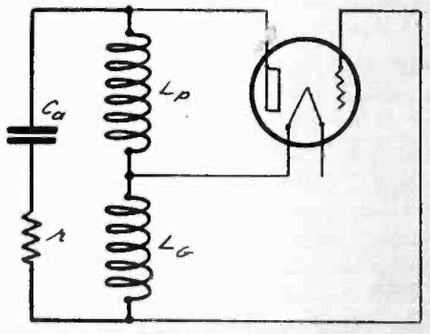

FIG. 4 HARTLEY

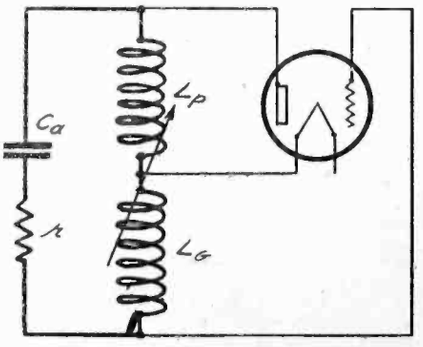

FIG. 5 MODIFIED HARTLEY

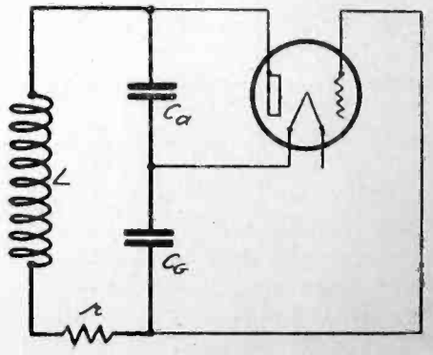

FIG. 6 COLPITTS

justments are better in this than in the circuit of Fig. 2.

The grid circuit of Fig. 3 is sometimes tuned to the fundamental or second harmonic by placing a small variable capacity across L_g. Such an arrangement, while adding flexibility and sometimes greater output, lowers the circuit efficiency.

Hartley Circuit. The distinguishing feature of the Hartley circuit, Fig. 4, is the conductive coupling of the input or grid circuit and the output or plate circuit. This is accomplished by dividing the inductance of the oscillating circuit in that, strictly speaking, there is no mutual inductance between L_p and L_g. When such coupling exists the circuit is often referred to as the modified Hartley.

In the formula for figuring the frequency of oscillations, as given in the discussion of the Meissner circuit, $L = L_p + L_g$. For the greatest output the ratio of L_p to L_g should equal μ divided by $\mu + 2$. Consequently in tubes having a high impedance factor the plate inductance and the grid inductance should be approximately equal, while for low μ tubes L_g must be considerably larger than L_p.

Modified Hartley. Fig. 5 shows the coupling of L_p and L_g to give the modified Hartley circuit. The strongest oscillations occur under the same conditions as in the Hartley. The formula for the frequency of oscillations becomes $f = 0.159 \sqrt{L_p + L_g + 2M}$, when M is the mutual inductance in henries between L_p and L_g, the portions the plate and grid inductances included in the oscillating circuit. As these are generally made up as a single coil with unavoidable coupling between them, the modified Hartley is more generally used than the Hartley.

Colpitts Circuit. This, one of the most popular, uses capacative instead of inductive or conductive coupling as is used in the others described. The inductances L_p and L_g in Fig. 4 become the condensers C_a and C_g in Fig. 6, the oscillating circuit inductance L also being substituted for C_a in Fig. 4. These substitutions isolate the filament from the direct current plate supply so that a shunted power feed circuit is used in the Colpitts. Furthermore, a grid-capacity-leak is necessary because the grid otherwise receives the same applied potential as the plate.

The frequency of oscillations is given

$$\text{by } f = 0.159 \frac{\sqrt{L\, C_g\, C_a}}{\sqrt{C_g + C_a}}$$

$$\text{whilst } C_g/C_a = \mu/\mu + 2$$

gives the condition of strongest oscillations, which ordinarily means that C_g should be approximately equal to C_a.

The Grid Condenser and Leak System. In the circuits just described, no provision was made for reducing the positive grid potential which was present during a certain part of each cycle as a result of the alternating potential induced in the grid coils. As previously explained, a current flows in the grid circuit when the grid is positive and this results in losses. Provision might have been made for the elimination of these losses by inserting a small battery into the grid circuit in such a way as to make the grid negative with respect to the filament at all times. While the C battery method is generally employed in non-generating tube circuits its use in generating circuits is not common. The more general practice consists in the use of a small capacity and leak resistance. This is indicated in Figs. 8 to 12.

For purposes of explanation, consider first the generating circuit illustrated in

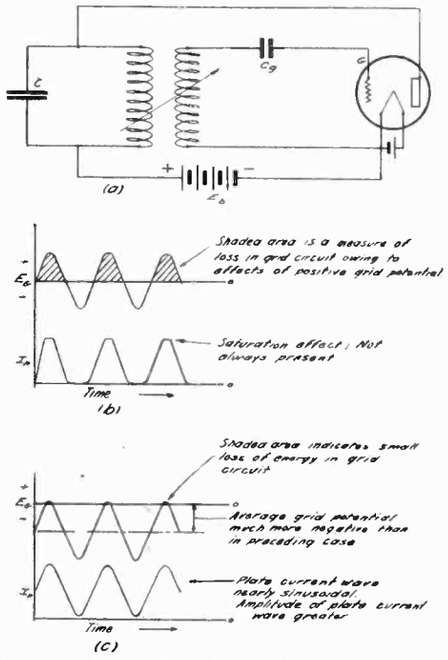

Fig. 7. Effects of Grid Condenser and Leak.
(a) Oscillating Circuit With Grid Condenser.
(b) Relation Between Grid Voltage and Plate Current for Circuit Without Grid Condenser and Leak Resistance.
(c) Relation Between Grid Voltage and Plate Current for Circuit With Grid Condenser and Leak Resistance.

Fig 7-a. Here a grid capacity only is employed to cause a difference in potential between point A and G. If A is instantaneously positive as a result of the alternating e.m.f. induced from L then the difference in potential between A and G will be given by $E = Q/C$ where,

Q = quantity of electricity flowing through the capacity (coulombs) and

C = capacity of C_g in farads.

So long as the grid is positive Q is not equal to zero. Q has, however, a limiting value dependent upon the current magnitude. The difference in potential between A and G will become less and less as C_g is increased. For an infinitely large value of C_g points A and G would be at the same potential. On the other hand, as C_g is decreased in value, the difference in potential between A and G will become greater and greater, finally reaching the condition that would exist if there were no intravening condenser or connections. It is evident then that a value of C_g may be so chosen as to give an optimum value of potential difference between A and G for given tube and circuit conditions.

If the potential difference between A and G is regulated by a capacity alone, then for all desirable values of C_g, the grid would rapidly become so negative as a result of collecting electrons that it would repel those necessary for a continuance of plate current and oscillations would stop. When sufficient electrons had leaked off either through the grid-filament path inside the tube or through the inherent resistance of C_g, oscillations would start, only to be arrested again when the potential on the grid became negative by an amount equal to E_p/μ as a result of the above mentioned collection of electrons on the grid. The whole effect would consist in the production of damped oscillations in the output circuit.

To prevent the accumulation of electrons on the grid, an external high resistance path is usually provided between the grid and filament. This permits the electrons to leak off to the filament through an external path and thus prevents the effects just mentioned.

In practice, C_g usually consists of a small mica dielectric condenser having a capacity of 0.001 to 0.002 microfarads. For small power tubes (5 to 50 watts) a leak resistance of 5000 to 10,000 ohms is ordinarily employed. When non-inductive leak resistances are used a small radio frequency choke coil should be used in series between the leak and grid to prevent the leakage of radio frequency pulsations of grid potential.

THE circuits which have already been described are fundamental types. They are suitable for laboratory work or for other uses to which local oscillation generators might be placed. In the transmitter, however, these circuits assume a slightly different appearance, the features of which will be pointed out. In the circuits which are described below and illustrated in Figs. 8-12, transmitting keys as well as grid leak resistances and capacities are indicated. The circuits are complete insofar as the transmission of telegraph C.W. signals is concerned. Various devices such as meters and filament rheostats are not indicated as these would serve no useful purpose in the present explanation.

Meissner Transmitting Circuit. The circuit of Fig. 8 is a rearrangement of that of Fig. 1 to include plate and filament batteries, grid condenser and leak, and antenna and earth connections. C_a of Fig. 1 corresponds to the antenna-earth capacity of Fig. 8. The resistance r of Fig. 1 is the resistance of the new

oscillating circuit comprising the antenna, the inductance L and the resistance of the earth connection. Because the constants of the new oscillating circuit are strongly influenced by the distributed capacities of the antenna and connecting wires, we are no longer free to use the simple equation for frequency which was given with the discussion of Fig. 1 unless the "constants" are known at the frequency of oscillation of the circuit.

The construction of L, Fig. 8, should be such as to minimize resistance, particularly high frequency resistance. L_p and L_g may be made of small double cotton-covered magnet wire (No. 18 and 22 respectively) for circuits employing 5 watt tubes. It is preferable to space the turns on L_p. The plate battery (or generator) should preferably be shunted with a capacity of 0.002 to 0.01 mfd. to pass the high frequency pulsating constituent of plate current. The various positions at which the plate battery may be inserted into the circuit will be considered later. For low power circuits the position shown is recommended, both from the point of view of efficiency and economy.

The transmitting key is placed at a point of low potential in Fig. 8 and it serves in this position to open the circuit supplying plate energy. Various other locations for this device are often used, as will be seen later.

Coupled Plate Transmitting Circuit. The type of circuit illustrated in Fig. 9 is not often used in power tube operation and is shown here only for purposes of comparison. Its chief deficiency as a transmitting circuit is that neither the grid nor the plate circuit are capable of fine control. When it is possible to so construct L_g that the more desirable adjustment condition exists (as in low power circuits) the circuit of Fig. 9 is satisfactory. In connection with Fig. 2, it was indicated that maximum output required a large value of mutual inductance between L_p and L_g. In circuits designed for operation at high frequencies, the required large value of mutual inductance necessitates a large amount of inductance in L_p and this combined with intra-electrode capacities forms a second oscillating circuit which may withdraw a very appreciable amount of otherwise useful power from the circuit.

Coupled Grid Transmitting Circuit, illustrated in Fig. 10, in principle is not unlike that of Fig. 3. L_a, together with the antenna, forms the oscillating circuit. The variable contact at the upper part of L_p serves to adjust the output circuit coupling. Coupling between output and input is adjusted either by varying the proximity of L_g to L_p, or by variation of the number of turns in L_g, or by both methods. L_g is ordinarily made as a few turns of No.

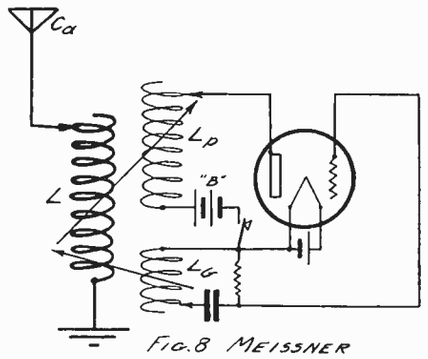

FIG. 8 MEISSNER

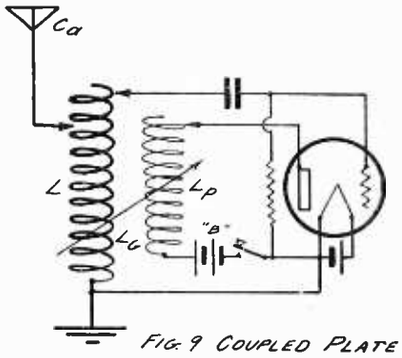

FIG. 9 COUPLED PLATE

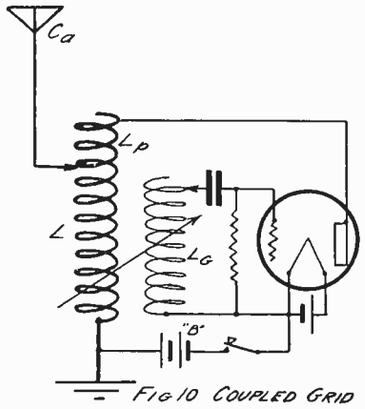

FIG. 10 COUPLED GRID

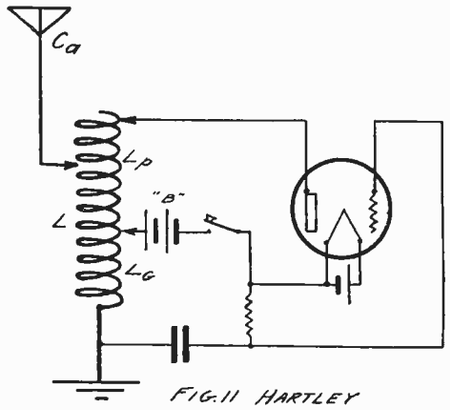

FIG. 11 HARTLEY

20 D.C.C. magnet wire upon a rotor which is mounted at the lower end of L. The latter must be constructed of much larger wire for reasons previously given. Sometimes L_g is shunted with a small variable capacity. It will be noted here also that the transmitting key is placed in such a way that it opens the plate circuit at a point of low potential.

Hartley Transmitting Circuit. If the inductances L_p and L_g of Fig. 4 are combined into one inductance and the capacity C_a is replaced by the antenna, the Hartley circuit of Fig. 11 results. It was previously stated that L_p and L_g are not coupled to one another in the Hartley circuit. In Fig. 11, however, a certain amount of inductive coupling exists between L_p *and* L_g since these are combined into one coil. Because of the simplicity of this circuit, it is quite popular. The oscillating circuit consists of the antenna-earth capacity and L. Input coupling is regulated by moving the center or filament tap up or down on the inductance. The output coupling is regulated in a similar manner by adjustment of the plate tap.

The principal difficulties connected with the operation of the Hartley circuit lie in the coarseness of adjustment. This difficulty may be reduced by a special type of construction but in the usual form it is very pronounced when attempting fine adjustments at high frequencies. When fine adjustments of frequency are not necessary the Hartley circuit is one well adapted to high frequency operation. By the very nature of the circuit, the plate to grid capacity of the tube is a shunted capacity for the antenna-earth capacity. Providing L of Fig. 11 is made equal to L_p plus L_g, the plate-grid capacity will have little disturbing effect upon the circuit. A Hartley circuit is comparatively free from spurious oscillating circuits for the reason just mentioned and with such a circuit little difficulty should be experienced in generating waves down to 10 meters in length.

Colpitts Transmitting Circuit. One of the most popular transmitting circuits is illustrated in Fig. 12, which is derived

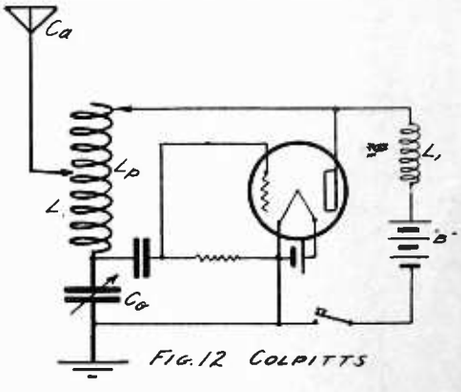

FIG. 12 COLPITTS

from Fig. 6. Here, the coupling between output and input circuits is capacitive and is varied by changing the capacity C_g, which is in series with the oscillating circuit. The tube output circuit coupling is altered by varying the inductance L_p. This is as indicated, the same coil as L. The chief difficulty with this circuit lies in the use of C_g as a part of both the oscillating and input circuits. While this is somewhat of a disadvantage, the use of C_g as a part of the oscillating circuit permits of a good output at high frequencies (corresponding to wavelengths under 200 meters) with rather high capacity antennas.

(*Continued on Page 78*)

Damping

A Simple Explanation of Its Theory and of Its Importance in the Design of Radio Sets, Microphones, Loud-Speakers and Studios

By L. R. Felder

CERTAIN concepts and ideas are of great importance in radio engineering because they are of constant use in every branch of the subject. No matter what the problem may be, these ideas will generally be found to have some bearing on it. Two of these ideas, namely resonance and coupling, have been discussed in previous issues of RADIO. A third one of considerable importance is that of damping. Many people, when they hear the word "damping" or "decrement," immediately associate it with the fast disappearing spark set, and therefore dismiss it, feeling that it has no bearing on present day problems. As a mater of fact it is intimately bound up with modern continuous wave engineering, both transmission and reception, telephony, microphone transmitters, loud speakers and so on. An intelligent grasp of the significance of the term "damping" is therefore desirable. An exposition of this idea, together with some illustrations of its practical applications, forms the subject matter of the present article.

Consider an automobile to be moving along a level street. If left to itself it will continue to move but will gradually slow down until it ultimately comes to rest. Each succeeding second of its motion it moves over a smaller and smaller distance; in other words its velocity decreases until it finally becomes zero. This may be graphically summarized by

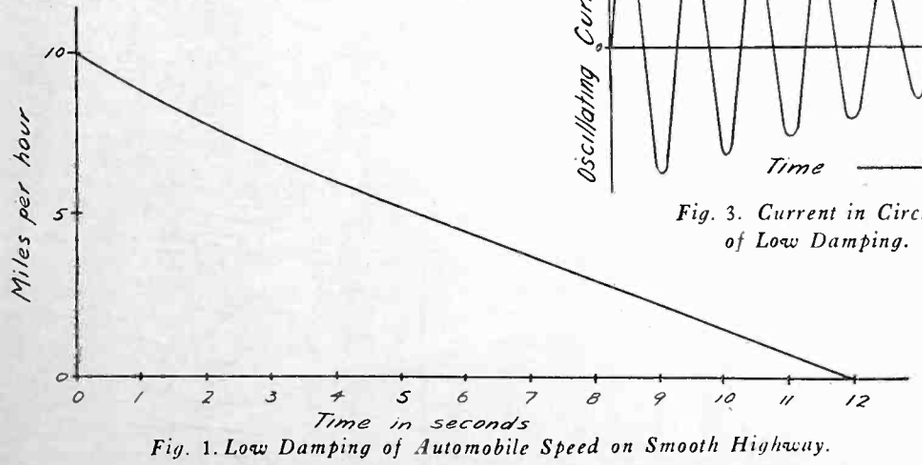

Fig. 1. Low Damping of Automobile Speed on Smooth Highway.

Fig. 1, which shows that the speed of a moving car when left to itself gradually decreases to nothing as time elapses. The decrease in velocity of the car is due to the friction between the wheels and the ground, and to friction between parts of the car itself. The car, when it starts moving by itself, possesses a certain amount of energy. After it starts moving there is a gradual decay of energy, this decay being due to energy losses in friction.

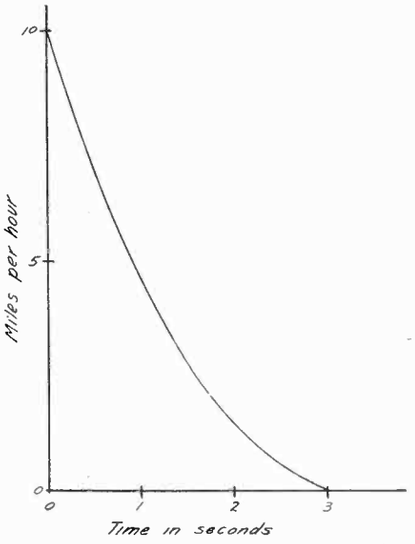

Fig. 2. High Damping of Automobile Speed on Rough Road.

This decrease of energy and loss of motion is said to be caused by "damping" and the motion of the car is said to be *"damped"* out. If the car moves along a very smoothly paved street it will take a longer time for the car to come to rest, for the friction between the wheels and the smooth pavement is small. In this case it takes a long time for the energy to decay to zero, and the motion is said to have *low damping*. Fig. 1 is illustrative of this condition. If the car moves along a poorly paved street, such as a rough country dirt road, for example, it will come to rest very rapidly, for the friction between wheels and ground is very high and the energy of the car is rapidly lost in friction. In this case the motion is said to have *high damping*, or be *highly damped*, as shown in Fig. 2.

Similarly when the engine is driving the car its speed will be less along the rough road than along the smooth highway due to the higher damping.

Damping may therefore be considered a property of any system which results in a decay of energy in that system, and which tends to limit the motion effects in the system. In radio and electrical circuits we are concerned with the motion of electrons; in other words the electric current in the circuit. If the oscillations in such a circuit are limited in amplitude, by the insertion of resistance in the circuit, for example, the oscillations are said to be damped. If such a circuit is left to itself after the oscillations have been set up in it, the oscillations will gradually die down to zero due to the fact that the original energy of the oscillations is absorbed by the resistance in the circuit. The rapidity with which the oscillations die down to zero depends upon the extent of the damping in the circuit. If the resistance of the circuit is very low it will take a long time for the original oscillating energy to be absorbed by the resistance, and the reduction of current in the circuit may be represented by the curve of Fig. 3. Such a circuit has low damping or decrement. If the resistance of the circuit is very great it will take a very short time for the current to be reduced to zero as shown by Fig. 4 which represents a circuit having very high damping.

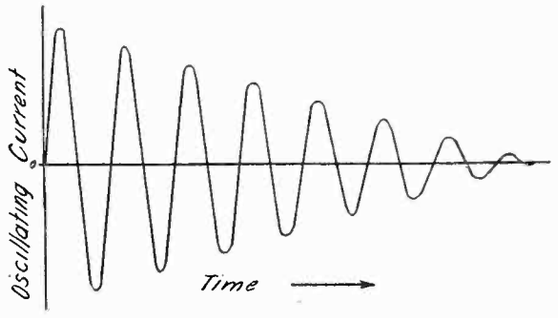

Fig. 3. Current in Circuit of Low Damping.

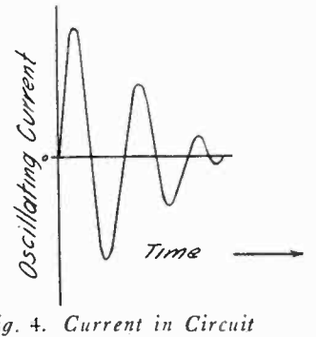

Fig. 4. Current in Circuit of High Damping.

This does not necessarily imply that the current in a circuit which has damping is necessarily reduced to zero. The current in the circuit may be maintained at a constant value and the circuit may still have a high damping factor. In the

previous illustration the circuits were left to themselves and the effect of damping was to reduce the current to zero, for there was no external source supplying or making up the losses due to damping. Suppose, however, that there were a source of voltage applied to the circuit. The damping losses in the resistance of the circuit are still present, but since there is a steady source of voltage applied to the circuit these losses are constantly being replenished, and hence the current in the circuit is maintained at a steady value. The circuit is nevertheless damped by the resistance though the current remains constant. In such a case the effect of damping is

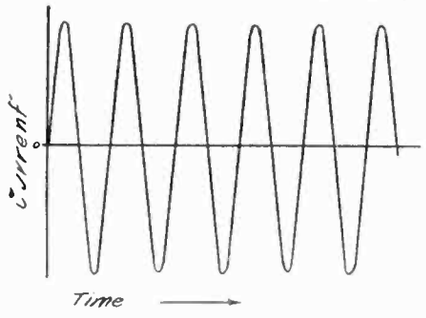

Fig. 5. Current in Slightly Damped Circuit With Sustained Voltage.

to cause a reduction in the circuit current to different values, depending upon the extent of the damping. Thus the cases of Fig. 3 and 4 when a source of voltage is applied to the circuit would be as shown in Figs. 5 and 6. For the same applied voltage to the circuit the current for high damping is much lower than that for low damping. Thus it is seen that, as stated above, damping is a property of all circuits which tends to limit the flow of current in the circuit. When the circuit is left to itself the effect of damping is to cause a reduction of the circuit current to zero.

In an imaginary circuit which had no damping an applied voltage would tend to produce an ever increasing current, for there would be nothing in the circuit limiting the motion effects, or current. And if a current of fixed amplitude were established in such a circuit and the circuit were then left to itself this current would continue to flow undiminished, for there being no damping there is no decay of energy and the current continues to flow unaltered. This would correspond to the case of an automobile being started on a perfectly smooth road with absolutely no friction between the parts of the machine and the machine and road. There is nothing to stop the car from moving.

The principle cause of damping in a circuit is the presence in the circuit of resistance *in one form or another*. Thus coils and condensers have resistance which absorbs energy from the circuit and waste it in the form of heat. Hence the total current is thereby reduced. Resistance may be introduced into a circuit in many other ways: Leakage of insulators, ground losses in an antenna, brush discharge, all introduce a certain amount of energy loss which is equivalent to a resistance loss.

When energy is extracted from a circuit by any source we may regard the source as introducing a resistance in the circuit. For a resistance inserted in the circuit will also extract energy from it. Hence this gives rise to another cause for increased damping of circuits. If two circuits are coupled very closely to one another and one of them has an oscillating current flowing in it, the other will extract energy from it, hence the original current may be reduced considerably. If the original oscillations

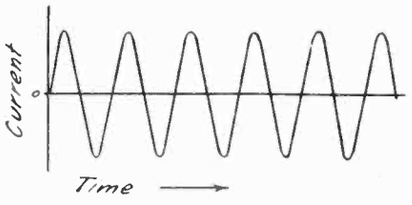

Fig. 6. Current in Highly Damped Circuit With Same Voltage as Fig. 5.

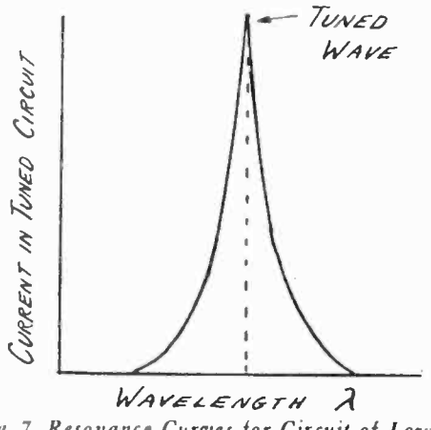

Fig. 7. Resonance Curves for Circuit of Low Damping.

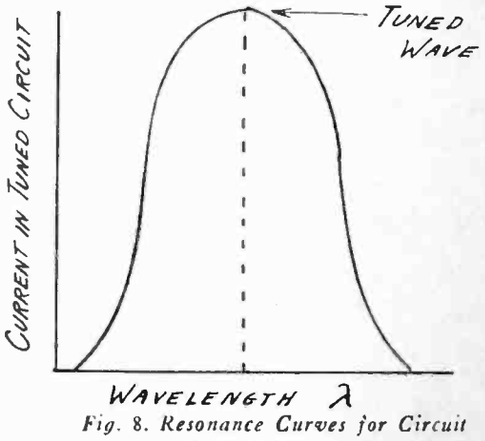

Fig. 8. Resonance Curves for Circuit of High Damping.

are due to an oscillating tube, it is quite possible for the tube to cease oscillating because the coupled circuit is extracting too much energy, or introducing too much damping in the tube circuit. Any neighboring circuits may behave this way towards one another, and this may account for the failure of some circuits to regenerate or oscillate. There may be some tuned circuits in the receiver or transmitter which are increasing the damping to an excessive value.

One of the principle effects of damping in a circuit is to increase the broadness of resonance of the circuit. Figs. 7 and 8 show the resonance curves for a circuit having first low damping, then high damping. It will be observed that when the circuit is highly damped, the current in the circuit is very high over a wide range of wavelengths even though the circuit is tuned to a definite frequency, whereas when the damping is very low the current is high only in the vicinity of the wavelength to which the circuit is tuned. Thus a highly damped transmitter which is supposed to transmit at λ meters also transmits considerable energy at many other wavelengths, hence it affects receivers not tuned to its particular wave and so introduces interference. It is this which doomed the spark transmitters. The same reasoning applies to receivers which are heavily damped, for they will be affected by transmitters sending on waves other than the one to which the receiver is tuned.

The efficiency of electrical filters is considerably increased as the damping of the filter is decreased. The only thing limiting practical filters from attaining theoretical efficiency is the fact that filter coils cannot be made without resistance or damping. As a result instead of having sharp cut-off points as in Fig. 9 the cut-off points are less clearly defined as in Fig. 10.

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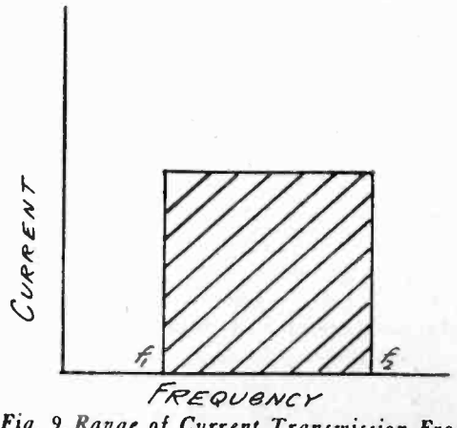


Fig. 9. Range of Current Transmission From Theoretical Filter Having No Damping.

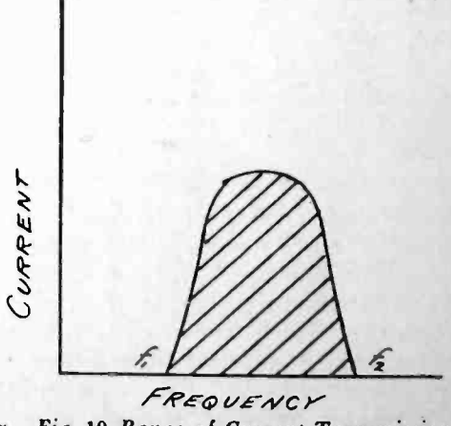


Fig. 10. Range of Current Transmission From Practical Filter With Damping.

A Standard of Coil Comparison

An Argument for Basing Coil Efficiency on the Ratio of Its Reactance to Its Resistance

By G. F. Lampkin, 8CAU, University of Cincinnati

WITH the advent of any quantity comes the need for units in which this quantity may be defined. This is necessary, naturally, so that intercourse may be conducted on a common and understandable ground; and that confusion and misunderstanding may be avoided. So with the appearance of numerous types and kinds of low-loss coils, some unit is desirable, which will express just how "low-loss" a given coil is.

The losses in a coil depend on its ohmic, or more accurately, its alternating current resistance. This in turn, is dependent on many factors; several of which have not yet been thoroughly investigated. These factors include such quantities as the wire size, the wire insulation, the turn spacing, the coil diameter, the coil length, the amount and kind of field dielectric, the "dope" used, the moisture present, and so on. When the radio-frequency resistance of a coil is measured by any one of the standard methods, these factors are automatically taken into account; and the coil resistance is obtained as a definite numerical value, at any one frequency. The resistance will of course vary with variation of frequency, being smaller at the low frequencies than at the high. This fact makes it desirable to measure the coil resistance at several points, distributed through the frequency band for which the coil is to be used. The resistance of the coil could best be shown by a curve of resistance vs. frequency, or, similarly, resistance vs. wavelength. For ordinary purposes, it would be sufficient to state the average resistance of the coil.

The use of resistance as a standard of comparison, however, has several disadvantages. Fundamentally, it does not take in all the factors which show how efficient a coil is. A one-turn coil, 6 in. in diameter, may have a negligible resistance, but it also has a negligible inductance, so far as radiocast frequencies are concerned. The method of comparison should take into account the coil inductance. Comparison by resistance has an inconvenient disadvantage for the experimenter. For all coils, to be compared, must have equal inductances; which means that when wound, a coil must be alternately measured and stripped of turns, until the correct inductance value is obtained. A similar disadvantage occurs when manufacturers attempt to rate coils by resistance. One concern markets a coil for use with a 250 micro-micro-farad condenser, which naturally has a large inductance. The resistance of this coil would of course be greater than that of a smaller coil, designed for use with a 500 micro-micro-farad condenser. The use of resistance as a standard of comparison, therefore, is both disadvantageous and misleading.

A standard of comparison which includes the important factors of coil efficiency, and which holds over practically the entire ranges of frequency and inductance, is the $\omega L/R$ ratio. The Greek letter "omega," ω, is the conventional symbol used for $2\pi f$; π having the value 3.1416, and f being the frequency in cycles per second. The inductance, L, is expressed in henries, and the resistance, R, in ohms. Therefore, when the resistance and inductance of a coil have been measured, at a known frequency, a simple substitution in the expression $\omega L/R$, will give a numerical value which will form a basis for comparison with other coils. Again, the values of $\omega W/L$, with varying frequency, can best be shown by a curve; and if this is not desirable, or practicable, the average value over the frequency range should be given.

The experimenter can make his coil inductances approximately equal, the accuracy depending on his experience and guessing ability; then he may forget about stripping turns. His comparative curves of $\omega L/R$ ratios will show at a glance the best coil. The manufacturer of a low-inductance coil will not have an unfair advantage in advertising a coil of 3.5 ohms average resistance, when its average $\omega L/R$ ratio may be less than that of a high-inductance coil, of 6 ohms average resistance.

In other words, this standard of comparison recognizes the fact that the inductance of a coil is a factor in its efficiency. The coil efficiency is proportional to the inductance; and is also proportional to the frequency. This proportionality to frequency has a balancing effect on the rise of resistance, due to skin effect. The skin effect increases with freqeuncy. The coil efficiency is inversely proportional to the resistance; the greater the resistance, the lower the efficiency, and vice versa. The net effect is, as stated before, to give a basis for coil comparison which holds over wide ranges of frequency and resistance.

Another argument, more concrete, for the use of the $\omega L/R$ ratio, is had from simple alternating current theory. The ideal inductance coil is one with zero power factor; that is, one which has zero resistance and which, therefore, consumes no power. Reference to the vector diagram of Fig. 1, for an inductance, shows that the power factor of the coil

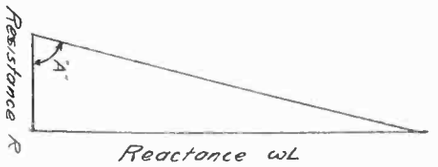


Fig. 1. Vector Diagram for Inductance Coil.

is the cosine of the angle A, which is equal to the base of the triangle divided by the hypothenuse. In the case of a coil which has a small resistance compared to its reactance, ωL, the angle A is close to 90°; and the altitude of the triangle may, with negligible error, be assumed equal to the hypothenuse. The power factor of the coil then becomes the base divided by the altitude, or $R/\omega L$. The nearer the coil approaches the ideal, the smaller will the power factor, $R/\omega L$, become; or inversely, the greater will the ratio $\omega L/R$ become. Thus the value of $\omega L/R$ is a direct measure of the efficiency, or the "low-loss" properties, of a coil.

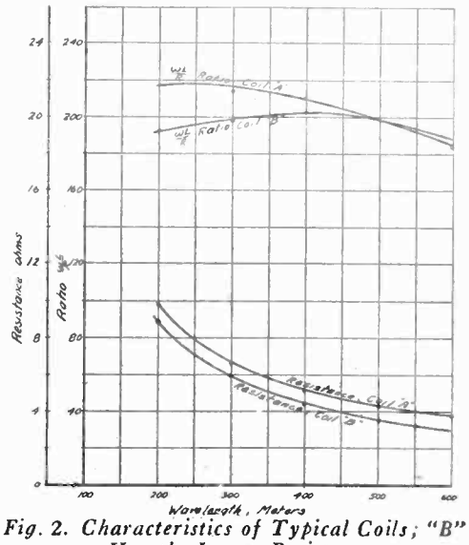


Fig. 2. Characteristics of Typical Coils; "B" Has the Lower Resistance.

An average minimum value of the $\omega L/R$ ratio for a good coil is 200. By experimentation, and careful attention to details, this value may be run much higher. Values of 400 and greater have been obtained, though they are not common. Whatever values may be obtained, however, they will show at once the worth of a coil, and will give a ground on which other coil attempts may be checked.

Straight Line Condensers

By Dr. Maurice Buchbinder

THE ordinary circular plate condenser, while good at the upper end of the wavelength scale, becomes inconvenient and inaccurate for the lower end of the range. This follows directly from the geometric properties of the device. In its simplest form we have a fixed plate and a circular moving plate of equal or nearly equal size. As the moving plate is rotated about the common axis, which is the shaft of the condenser, the area of plate in opposition changes and this area varies directly with the angle of rotation. Thus the area at 60° will be exactly twice that at 30°. Consequently the capacity—which depends directly on the area—varies with the angle of rotation. Expressed in equation form: $C = k\theta$ where k is some constant θ is the angle of rotation and C is the capacity. This equation may be plotted on coordinate paper, in which case we get a straight line as shown in Fig. 1.

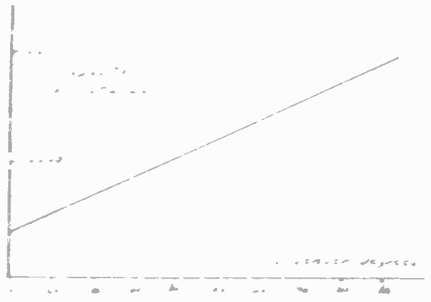


Fig. 1. Graph of Capacity Settings vs. Dial.

The condenser is used in a radio set in conjunction with some inductive device or coil for the purpose of tuning or changing wavelength. The tuning is done by changing the value of C in the circuit, that is by rotating the condenser plates. The wavelength λ depends upon the *square root* of the capacity. Thus $\lambda = k' \sqrt{C}$ where λ is the wavelength in meters and k' is a constant equal to 6.28 × velocity of light × $\sqrt{L}$, L being the inductance of the coil. This means that in order to double the wavelength, for instance we must quadruple the capacity ($2\lambda = k' \sqrt{4C}$).

Since we have already shown that $C = k\theta$, it is evident that $\lambda = K \sqrt{\theta}$ when K is a new constant depending upon several conditions. If this be plotted on cross section paper it gives a curve like the upper line in Fig. 2. The quick rise at the start accounts for the fact that the low wavelengths are crowded together while the longer wavelengths are more conveniently spaced along the flatter portion of the curve, or parabola, as it is mathematically known. Thus between 0 and 30° there is a wavelength change of 150 meters, whereas for the 30° between 150 and 180° it is only about 25 meters.

Consequently it is desirable to design a condenser so that 1° change at the beginning of the scale will cause the same change in wavelength change of the tuning circuit as will 1° change at the end of the scale. This has been done in several ways.

One of the first was designed by Dr. F. A. Kolster when he was with the U. S. Bureau of Standards some years ago for use in the Kolster Decremeter. He employed moving plates of a special form so that the capacity is varied as the square of the angle of rotation which obviously causes the wavelength setting to vary directly with the angle of rotation. The form of the plate is shown in Fig. 3 and form of the resultant curve is shown as the straight line in Fig. 2. This form of plate is used in some straight-line wavelength condensers now on the market.

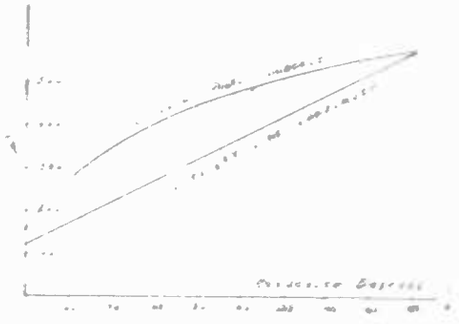


Fig. 2. Graph of Wavelength Settings vs. Dial.

Another type uses plates which slide instead of rotate with respect to one another, the sliding motion being secured by a rack and pinion operated by a knob

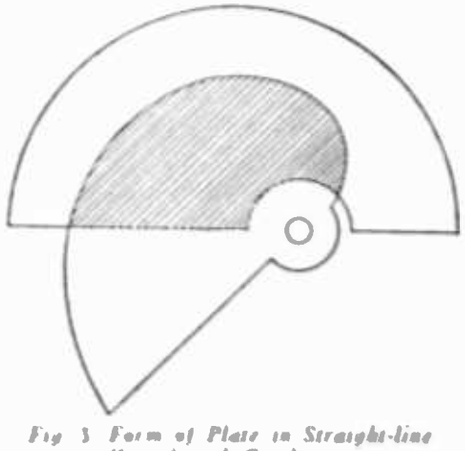


Fig. 3. Form of Plate in Straight-line Wavelength Condenser.

which is tuned so as to cause the plate to intermesh as illustrated in Fig. 4.

It consists essentially of a fixed plate, square in shape, into which diagonally slides another plate also square in form. As the two plates oppose each other an

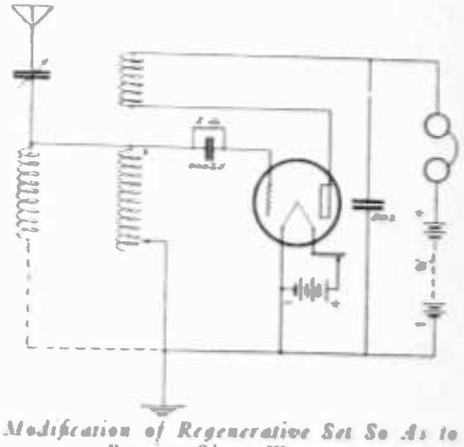
(*Continued on Page 90*)

SUGGESTIONS FOR SHORT WAVE RECEPTION

By WM. D. CRAFT

Owners of small portable sets of the regenerative type, using one or two tubes, often find results are poor when conditions do not permit an efficient antenna and ground connection. There is a simple method that will enable such sets to receive the short wave radiocasts from KDKA and WGY, which can be heard over a wide radius under unfavorable conditions that would prohibit their reception on the regular waves. Reception of KDKA's 65 meter wave is common by amateurs all over the United States.

The details given below are for a Crosley receiver, but will apply to any receiver of the same type. A coil of 7



Modification of Regenerative Set So As to Receive Short Waves.

or 8 turns, 3 in. in diameter, is made out of bell wire. A spring clip is fastened to one end of it, and clipped on the coil end of the grid-condenser, the other end being fastened to the ground binding post. Connect the antenna and ground binding posts together, and couple the antenna to the set through a small micadon of either .0001 or .00025 mfd. capacity. When using such a small coupling condenser the antenna affects the tuning of the set very little. This is an advantage in portable sets where the antenna may have different dimensions every time the receiver is set up. The antenna is connected through this condenser to the side of the extra coil that connects to the grid condenser. The modifications to the set are shown in dotted lines on the diagram and involves no change that will render the set useless for reception on regular broadcast waves.

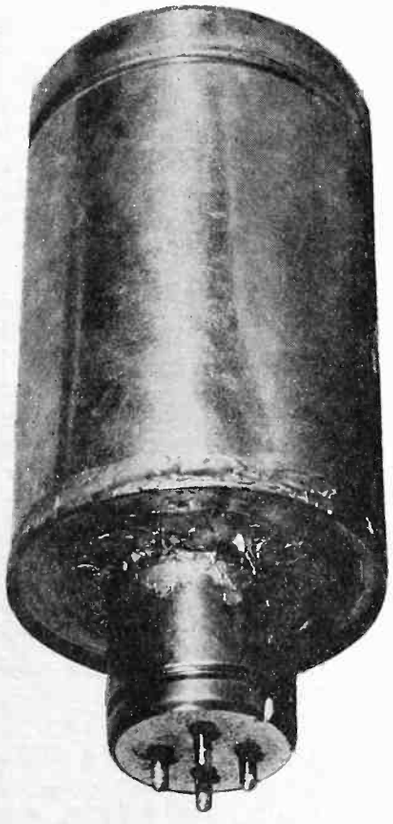
It may be necessary to increase the detector plate voltage slightly to obtain stable oscillations, which is better than burning the filament brighter than normal to achieve it. The best point for the inductance switch is where the least number of turns are included. It will probably be found that better results will be had without a ground connection. The antenna should be as near vertical as possible—about 80 ft. long, and should be kept away from all other objects as much as possible in order to increase the signal strength.

A WATER-COOLED FIVE WATTER

By FRANK R. BOWMAN, 6BUH

Much has been said and done about running "5 watt" tubes above their rated capacity and many disasters have happened to these good little tubes as a result. An electrical breakdown is very likely to occur between the seal-in wires in the stem, because of overheating and excessive voltage.

The following scheme for water cooling will prevent the "five watter" from receiving its first "hot-spot" and breaking down through the seal as the heat is conducted away and radiated much more rapidly. The glass will not get hot enough to become conducting unless the tube is overloaded considerably above the usual limit.



Water Cooled Five Watter

Secure a "tin can" approximately 4½ in. high by 3 in. diameter. Carefully solder all joints in the can so as to be absolutely sure that it is water tight.

In the bottom, cut a round hole 1-5/16 in. diameter. This can be done by drawing a circle, of the required diameter, with a compass and cutting around the line with a strong pocket knife. (Woe to the knife however.) Be sure to get the hole in the middle of the bottom of the can. The edge of the hole can be "turned out" by means of any rounded instrument, larger than the hole, inserted inside the can and worked around. This must be done to facilitate soldering. Then make a small cut about 1/8 in. long at some point in the edge of the hole, for the pin on the tube base to pass through.

(*Continued on Page* 92)

Vacuum Tube Protection

By D. B. McGown

THE use of short waves for amateur transmission has a drawback in that the vacuum tubes are often damaged by overloads which take place during the adjustment of the circuits to resonance. This damage may either cause a complete burnout of the filaments or may puncture or burn out the grid or plate elements. It usually develops in either the filament and grid leads or in the plate lead-in wires. Filament burnouts are due to excess voltage and the resulting current through them. The plate and grid leads burn out in some circuits due to the high current value of the radio frequencies set up in them, by "parasitics" or when the tube elements are used as capacities, as is the case in some of the circuits commonly used.

Blue haze, or "gassing" is also found to be a cause of such trouble but as this is a manufacturing defect, no general remedy can be suggested. The same thing applies to tubes that become defective in service due to other manufacturing defects such as improper spacing of the elements.

In most cases, however, the use of low amperage fuses will work wonders in protecting the filament and plate circuits. This is done in commercial practice and is equally appropriate for amateur use. The grid circuit can likewise be protected.

Most electrical jobbers carry spooled fuse wire, made of lead alloy, starting at 1/8 ampere, and running up to 100 amperes, with all the necessary intermediate sizes. It is calculated to blow at about 50 per cent overload for continuous service. A piece of such fuse wire 1 in. long may be clamped between a pair of setscrews mounted on some non-inflammable, non-absorbent base such as slate, asbestos, or porcelain. A pair of such fuse blocks should be placed in series with both sides of the circuit to be protected. The fuse blocks should be mounted so that the fuse wires are vertical and should not be placed near any wood, paper or other inflammable substance.

The fuses should be mounted in the filament circuit as close to the tube sockets as possible and if a. c. is used ordinary plug fuses of appropriate size should also be placed in the transformer primary circuit to protect the device in use. The plate supply circuits require longer fuses, a length of 3 to 4 in. being satisfactory. These should be well separated, so there will be no danger of flash-over between terminals of opposite polarity.

When it is considered that 1/8 ampere fuse wire is rated at 125 milliamperes, for normal load, it can be seen that this will suffice for a single 50 watt tube. Should the plate current run up to 200 M. A., as it might under improper conditions, a blown fuse will result without damage to the tube. Of course, a 200 M. A. load is not very dangerous for the average tube for a few seconds, but this figure is often exceeded when circuits are out of resonance.

If two tubes are used, twist two wires together. For larger tubes, such as the 250 watters, with a normal plate current of about 250 M. A., 1/4 ampere wire will serve. When used in the radio frequency grid and plate circuits, the fuses should be placed as near to the tube sockets or mountings as possible. Generally some experimenting will be required to determine the proper fuse sizes, starting with small sized wire and increasing the size until they just do not blow under normal conditions of load and operation. This is necessary because the exact radio frequency load cannot always be checked as it depends on the phase relationship of the current flowing in the particular part of the circuit in question. The plate supply fuses will usually blow at the same time as the grid fuse. If the plate radio frequency fuse blows, there will be no further action until it is replaced. The same thing holds if the plate supply fuses blow first, likewise, if the filament fuses blow.

All fuse wire should be tested with a low-reading ammeter, a battery, and a variable rheostat. Connect the ammeter and rheostat in series and arrange two terminals with screw clips, separated about an inch, to accomodate the wire. Now close the circuit, with the rheostat all "in," and note the reading of the ammeter. If proper values of potential and resistance have been chosen, a small current will flow, which may be increased to the normal current carrying capacity of the wire without trouble. Some experimenting and rearranging may be necessary to do this, depending on the current wanted. Gradually increase the current, until the fuse wire blows, noting the ammeter reading, as the resistance is decreased. If the wire blows out at about 50 per cent overload, it may be accepted as O.K., but if it holds on indefinitely at this value, it is too heavy. For example, 1/8 ampere wire will actually require about from 0.25 to 0.4 amperes to fuse, but this is necessary as a protective factor, or otherwise the wire would be blowing all the time in service.

If maximum protection is to be ob-

(*Continued on Page* 64)

Experiences of a Question Man at a Radio Show

By G. M. Best

TO BE the target for the questions fired by thousands of visitors to two big radio shows was the writer's recent interesting experience. These questions ranged from "the sublime to the ridiculous," from the most technical to the decidedly non-technical. Some were asked so often and were of such general interest, that the answers may be useful to many readers.

Of the serious queries, the greatest number were about the Browning-Drake and the superheterodyne circuits, which seem to be the most popular with the home constructors. Whereas satisfactory results were generally being obtained there was an evident desire to get greater distance by adding one or more stages of radio frequency amplification.

In the case of the conventional four-tube Browning-Drake, as described in past issues of RADIO, the fact that it employs regeneration, the regenerative detector, in combination with the radio frequency stage, produces a tremendous amplification, so that with a good antenna, the range of the set should be very great. The addition of another radio frequency stage will add another adjustment, unless an untuned radio frequency transformer is used, which is undesirable, and the tendency for coupling between stages is greatly increased. In an experimental model which was set up in our laboratory, it was found that by removing the tickler coil from another Regenaformer, or regenerative radio frequency transformer, and using the coil as an ordinary tuned r. f. transformer, without regeneration, mounting at right angles to the other coils, the extra r. f. stage could be added. Due to the tendency for coupling, it was necessary to control the grid circuits of the two r. f. tubes with a potentiometer of the usual 200 ohm type, the grids being connected to the slider and the outside terminals of the potentiometer to the filament bus leads at the r. f. tubes. On account of the increased interstage coupling, a toroidal or balloon coil was used in the antenna circuit, with a .0005 mfd, condenser for tuning the secondary. The addition of the r. f stage increased the range of the set considerably, although control of volume on locals was difficult, and slightly increased interference from nearby high power stations was noted. For those who are experimentally inclined, however, the addition of the r. f. tube and transformer is an interesting problem and will probably aid those who are at some distance from the radiocast centers.

The same type of question was asked about the improved Best superheterodyne, the expectation being that the addition of radio frequency stages ahead of the first detector would increase distance reception. If the experimenter is content with a single radio frequency stage, the transformer and system of coupling described by A. J. Haynes in February and July 1925 RADIO can be used ahead of the Best superheterodyne with success, but more than one stage is not practicable and will lead to complications in the form of instability. A notable failure in that respect is a multi-tube superheterodyne which employs three radio frequency stages ahead of the first detector. By winding the radio frequency transformers with wire of such small gauge that the high frequency resistance was very great, and by placing the coils in completely shielded cases so that shielding losses were large, the set works. But that is all you can say for it, and it represents a large economic waste in the form of useless apparatus and wasted battery energy. The set performs about as well with all r. f. stages cut out and the antenna coil connected directly to the first detector. Experimenters are urged to improve their intermediate frequency amplifier and associated apparatus before thinking about adding radio frequency stages to the circuit.

An example on the comments on recent superheterodyne articles which have appeared in RADIO are about as follows: "Why did you use 5 *A* tubes and 3 '99s, instead of all '99 tubes?" "Why not use all *A* tubes?" "Why did you switch from the transformers made by *Whoosis* to those of *Whazzat?*", etc., etc.

Statistics show that approximately 85 per cent of all the sets in use employ storage batteries, so storage battery tubes were shown in as many of the sockets as was possible consistent with good results. The use of three storage battery tubes, with their relatively high amplification per stage, in the intermediate amplifier circuit, results in tendency to oscillate, and requires elaborate shielding to overcome, so that the dry cell tubes were used to obviate this trouble. If the set is to be operated from dry cells, then the 5 storage battery tubes can be eliminated and all 8 tubes controlled from the same filament rheostat.

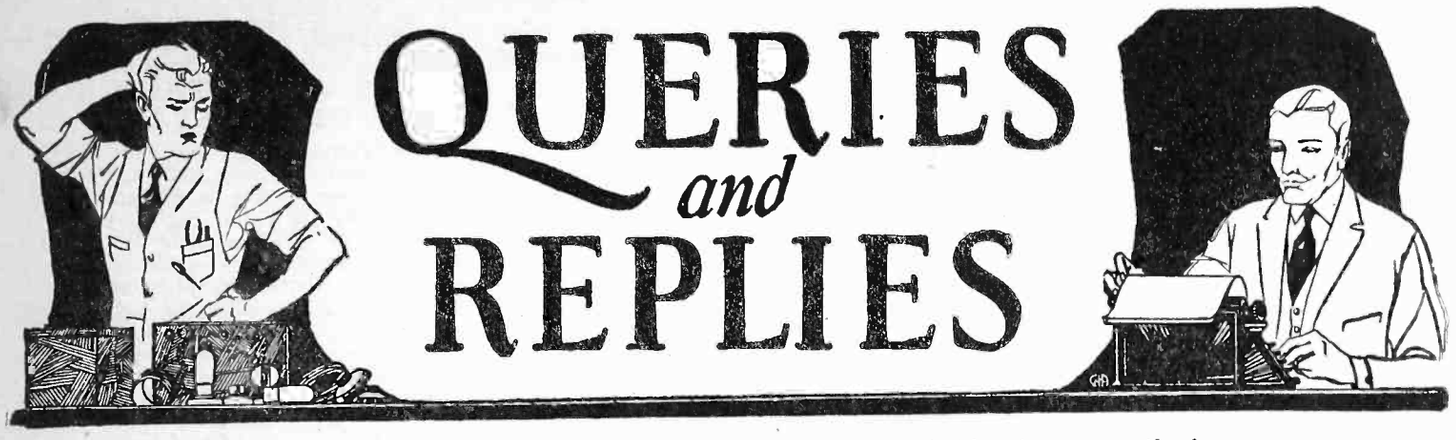
The question of what apparatus to use in a constructional article is always a serious one, and we try in a spirit of fair play to give all manufacturers of reputable apparatus a chance, so no one make of apparatus is continuously shown in successive staff articles where equally good apparatus of other manufacture is available. The fact that we use a certain make of apparatus in one of our sets does not mean that we think it is a better article than any other on the market, and hence we try to have as much variety as possible, consistent with a high standard of excellence of apparatus used. If you have built a set according to an article published a year or two ago, and desire to incorporate improvements recently described, it is not necessary to discard all your old parts and buy an entirely new lot, but simply rearrange the apparatus according to the new layout, buying only such new parts as are absolutely necessary.

"Should I junk my present air condensers and buy straight line frequency condensers instead?" was one of the prevalent questions. If you have semi-circular plate condensers of straight line capacity characteristics, you can equip them with one of the many excellent vernier dials now on the market, and obtain vernier ratios anywhere up to 80 to 1, depending upon the brand used. One firm has even introduced a dial guaranteed to convert the action of a straight line capacity condenser to that of a straight line frequency condenser due to the peculiar action of the gears in the dial. Straight line frequency condensers are straight only when used with an inductance coil of a certain specified value, so that the coils in your particular set may not be suitable for the condenser you contemplate buying, and you would be better off with your present condenser equipped with the proper dial control. At any rate, do not be stampeded by innovations to such an extent that you throw away perfectly good radio apparatus. The new condensers certainly *do* separate the stations at the lower end of the wave band, and where you are building a new set and of necessity will have to buy new condensers, it would be well to investigate the straight line frequency and wavelength types thoroughly.

B battery eliminators are the topic of many questions asked, and these always lead to the discussion of *A* battery elimination as well. To date, in my mind, the most successful *A* power unit is the one using a small capacity storage battery in connection with a trickle charger, which operates continuously and floats across the battery, so that current is always available without having to connect and disconnect a charger of high charging rate, and the expense of operation is nominal.

Many experiments are being conducted towards the production of a thermopile, which consists of a large number of thermocouples placed in one unit, and

(*Continued on Page* 83)



QUERIES and REPLIES

Questions submitted for answer in this department should be typewritten or in ink, written on one side of the paper. All answers of general interest will be published. Readers are invited to use this service without charge, except that 25c per question should be forwarded when personal answer by mail is wanted.

Is a milliammeter of any benefit, in the "B" battery lead of the Best Superheterodyne? I am told that the set can be better adjusted by the use of this meter. —R. P. D., Pueblo, Colo.

The milliammeter is most useful in measuring the plate current of individual tubes when the set is first being tested out. Several commercial superheterodynes provide test jacks in the oscillator and 1st detector tube plate circuits so that adjustments of the plate and grid voltages, as well as the amount of coupling between the oscillator and 1st detector can be made accurately. The milliammeter can be temporarily connected in each plate circuit, and thus avoid the jacks, but reading the *B* current of the entire set is of little value except in special cases, and would not warrant the expense of the meter.

In building choke coils for use in filter circuits of "B" eliminators, what is the purpose of the air gap which is always recommended, at one end of the core?—J. R. F., Chillicothe, O.

The air gap is to prevent saturation of the core. If the core were entirely closed, the direct current passing through the windings of the coil would saturate the core and reduce the inductance of the coil to a very small value, making the coil useless as a choke.

Please publish the circuit diagram of the new Victor-Northern Electric Superheterodyne.—H. B. V., Detroit, Mich.

The circuit diagram of the Victor type R-41 receiver is shown in Fig. 1. This set is designed to use six peanut tubes, type R-215-A and two storage battery tubes type R-221-D, so that an arrangement of series and parallel filament circuits is necessary for economical operation from a 6 volt battery. Either a center tapped loop, or the antenna tuned circuit can be used with the double pole double throw switch for changing the connections.

Please publish a diagram of an impedance coupled amplifier for use with a crystal detector. I have the secondaries of two Ford spark coils which I would like to use as choke coils in this circuit. —J. A. M., San Francisco, Calif.

The diagram you wish is shown in Fig. 2. It is desirable to couple the crystal to the first amplifier tube by means of a transformer, preferably of low ratio. You will require three stages of amplification to obtain the proper volume in the loud speaker, unless you use a tube having a high "mu" in the first stage, in which case only two stages will be necessary, the last tube being a power tube. If you use the high "mu" tube in the 1st stage, the *C* battery should be reduced to 1½ volts.

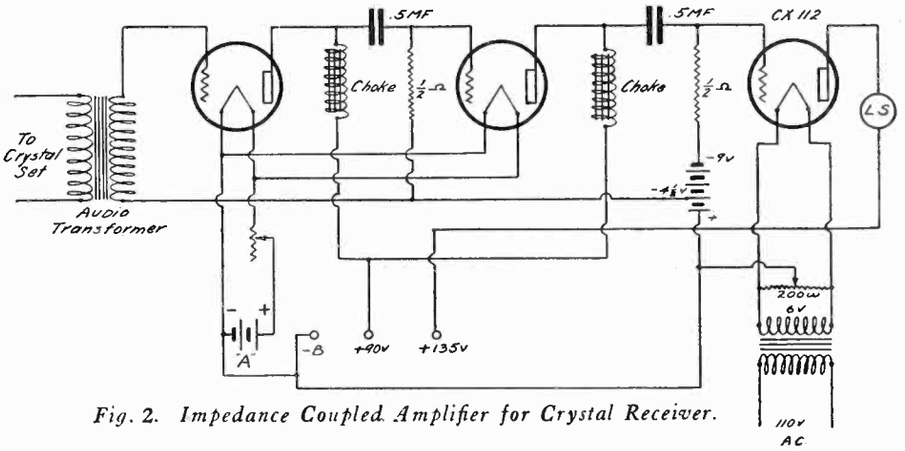


Fig. 2. Impedance Coupled Amplifier for Crystal Receiver.

Kindly give the data for constructing the three intermediate frequency transformers used in superheterodyne work. If the tubes are chosen with characteristics such that each stage oscillates at the same point, as described in July RADIO, is it necessary to exactly match the transformers?—F. S. B., Oakland, Calif.

Data for the construction of intermediate frequency transformers was given in RADIO some time ago, and is being reprinted herewith. The spools on which the coils are to be wound should be turned out of seasoned hardwood, with two slots for the windings, one slot being ¼ in. wide and the other ½ in. The slots are separated ¼ in. and are ¾ in. deep, the outside diameter of the spool being 2½ in. and the inside diameter 1 in. A hole ½ in. wide should be drilled through the center of the spool, for the core. The primary winding should consist of 500 turns of No. 30 double silk wire, wound in the ¼ in. slot. No particular order should be observed in winding the coil, the wire being placed in a haphazard manner to reduce the distributed capacity effect. The secondary winding should be 2100 turns of No. 36 single silk wire, wound in the ½ in. slot. For the core material, use either a bundle of fine iron wires, such as No. 36 gauge, or a bundle of flat strips of

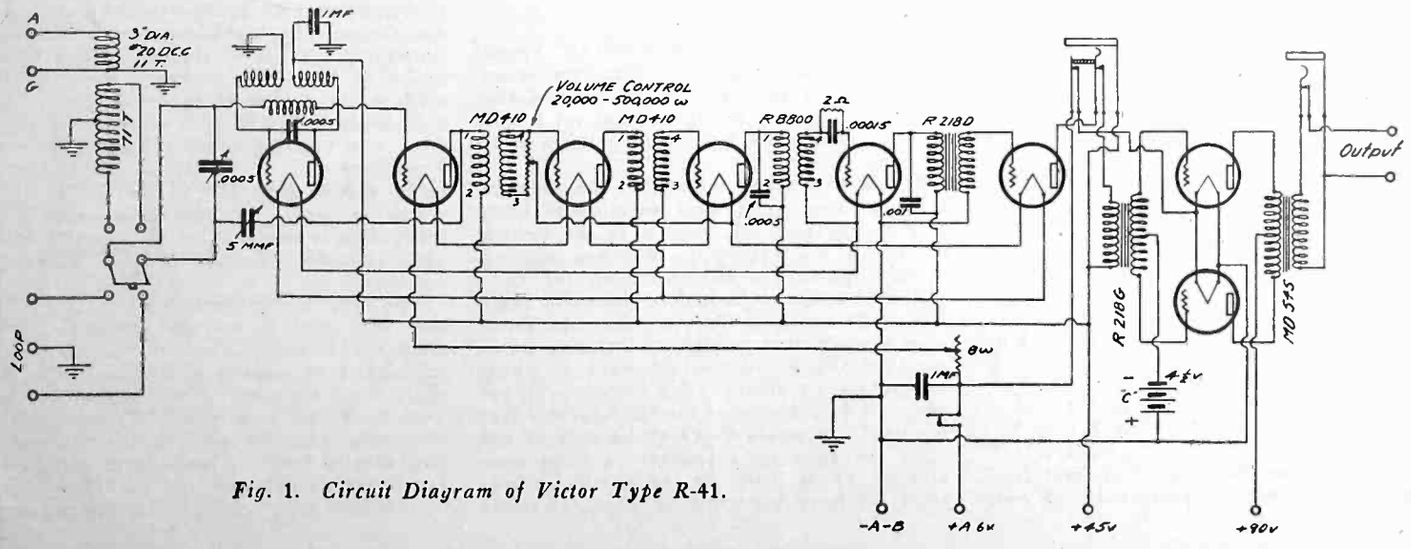


Fig. 1. Circuit Diagram of Victor Type R-41.

silicon steel, not over three thousandths of an inch thick. Ordinary heavy transformer iron or silicon steel will not do and the thinner the laminations, the better the transformer. Small lugs should be provided for terminals, the inside primary lead going to the plate, outside primary to the *B* battery, inside secondary to the filament and outside secondary to the grid. The transformers do not have to be matched absolutely, but it is a good idea to have all three of them as near alike as is possible, in order that maximum amplification can be obtained.

Would like to construct a long wave receiver for picking up the European arc stations. Please publish a diagram for such a receiver, with radio frequency amplification.—E. G., Fresno, Calif.

A circuit diagram for two stages of r. f. amplification, detector and one stage of a. f. amplification is shown in Fig. 3. The 1st

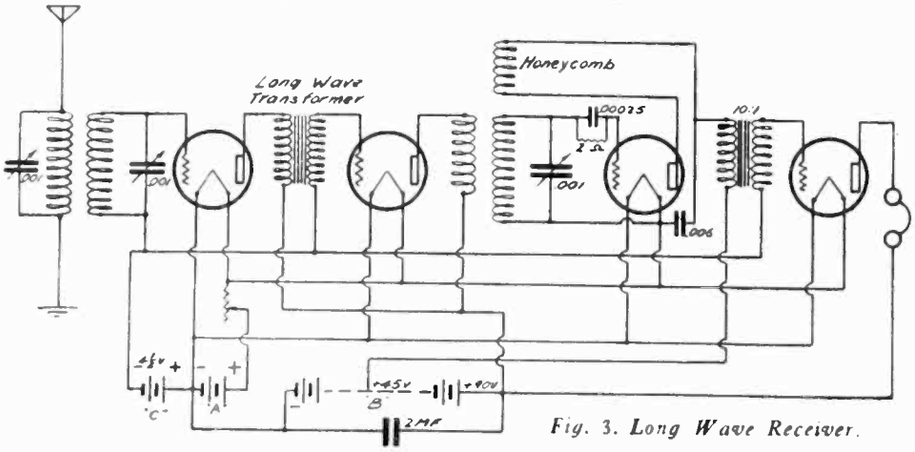


Fig. 3. Long Wave Receiver.

r. f. transformer should be an iron core intermediate frequency transformer such as is used in superheterodyne construction, and preferably of the 30 kilocycle type. The coupling between the 2nd r. f. tube and the detector may be a set of three honeycomb coils, the primary 500 turns, secondary 1250 and the tickler 1000 for waves up to 25,000 meters. A 10 to 1 ratio audio transformer, or one of the special 1000 cycle transformers designed especially for telegraph reception will give enough amplification so that only one audio stage will be necessary.

LETTERS TO THE EDITOR

Resistance Calculations

SIR—I wish to call attention to an error in the RADIO Note Book on page 30 of the September issue of RADIO.

It is true, as stated, that "In the case of parallel circuits, where two or more resistances are connected between two points in a circuit, the joint resistance of the two or more is less than the resistance of any one of the branches," but the remainder of this statement, viz.: The joint resistance "being numerically, equal to their product divided by their sum," is not true when there are more than two branches.

To calculate the joint resistance of two or more resistances in parallel, one must know how to calculate the reciprocal of a number and how to add fractions or decimals.

The reciprocal of a number is obtained by dividing *one* by the given number. For example, the reciprocal of 2 is 1÷2 or ½ or .5, likewise:

The reciprocal of 10 is 1/10 or .1
" " " 1/10 is 10
" " " .1 is 10
" " " .4 is ¼ or .25
" " " ¼ is 4
" " " .25 is 4

The reciprocal of a fraction is found by inverting the fraction, thus.

The reciprocal of 5/2 is 2/5
" " " 2/5 is 5/2
" " " 1/7 is 7/1 or 7
" " " 7 or 7/1 is 1/7

Either common fractions or decimal fractions may be used as preferred. If common fractions are used, they must be changed to a common denominator before they can be added. For example:

2/3+3/4=8/12+9/12=17/12
1/4+3/8+5/12=6/24+9/24+10/24=25/24.

In direct current calculations, the reciprocal of resistance is called conductance; likewise the reciprocal of conductance is resistance.

When several branches are connected in parallel, their joint conductance is the sum of their separate conductances.

To find the joint resistance of several branches when their separate resistances are given, we must:

1. Calculate the conductance of each branch (viz: 1÷resistance).
2. Add these several conductances to get the joint conductance.
3. Calculate joint resistance (viz: 1÷joint conductance).

This process may be expressed as a rule thus:

1. Find the reciprocals of the several resistances.
2. Add these reciprocals.
3. Find the reciprocal of this sum.

Joint resistance may be expressed algebraically thus:

$$R = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \text{---}}$$

where R is the joint resistance and r_1, r_2, r_3, etc. are the several parallel resistances.

Example 1. Find the joint resistance of three parallel resistances of 2/3 ohm, 2/5 ohm and 1 ohm respectively.

1÷2/3=3/2; 1÷2/5=5/2; 1÷1=1.
3/2+5/2+1=3/2+5/2+2/2=10/2=5.
1÷5=1/5 ohm, ans.

Example 2. What is the joint resistance of three parallel resistances of .1 ohm, .2 ohm, and .5 ohm respectively?

1÷.1=10; 1÷.2=5; 1÷.5=2. 10+5+2=17.
1÷17=1/17 ohm, ans.

I hope that my explanation will prove helpful to your readers.

Yours truly,
A. H. MARSH,
Santa Barbara, Cal.

SIR:

I have read with interest Mr. Frank Bowman's discussion of antenna resistance on page 32 of your August issue. The discussion is logically conducted and yet I fear that its conclusions must not be taken seriously.

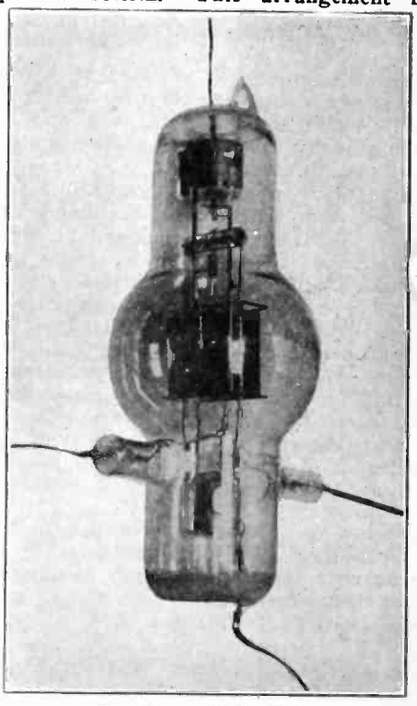
Mr. Bowman has fallen into the common error of making general conclusions from specific instances. Inasmuch as the figures on which his reasoning is based applied to only particular circumstances, the conclusions should be limited in the same fashion. I do not think therefore that Mr. Bowman is warranted in such an inclusive statement as "Therefore the best wave at which to operate an antenna lies between 50 per cent and 75 per cent of the fundamental frequency." It would however be safe to say "For the sizes of antennas we have considered, or at least for the particular stations we have been talking about, it seems likely that the best results will be gotten when working between 50 and 75 per cent of the fundamental wavelength."

ROBERT S. KRUSE, Hartford, Conn.

LEADS ARE SEPARATED IN NEW DE FOREST "H" TUBE

A new transmitting tube, in design the most radical departure from any tube ever placed on the market, is the latest achievement of the De Forest engineering laboratories. This makes possible the use of extremely high voltages with no chance of flash over. Under this plan the tube's efficiency is not only increased, but the danger of breakdown or burn-out is reduced.

In construction the "H" tube differs from the ordinary transmitting tube by having its leads placed like the four points of a cross, one out from either side,—and one top and bottom. This arrangement has



De Forest "H" Tube

been found to be highly satisfactory, for experience has proved that formerly when a heavy voltage was applied to the plate, it had a tendency to jump over to the other leads unless they were sufficiently insulated, and even where extreme care was taken in providing for this insulation, the glass stem through which the leads were brought would act as a conductor.

In construction, the new "H" follows the general design of the Singer tube. The filament operates on tungsten emission, drawing approximately 2.3 amperes at 10 volts.

The tube has a normal output of 20 watts at a plate voltage of approximately 700 volts, but due to the unique features in its design, 3000 volts may be applied to the plate without causing any breakdown or in any way shortening the life of the tube. The application of high plate voltages naturally increases the output of the tube and it has been found that with 2000 volts on the plate, the output varies between 150 and 200 watts, depending entirely on the circuit and to a large extent upon the necessary "C" bias which is used. The maximum safe plate dissipation is approximately 170 watts. With 1200 volts in the plate no "C" battery is necessary.

The tube, of course, is used for transmitting only and is sold to amateurs direct from the factory. The "H" is at present unbased, thus making it adaptable for any short wave experiments which may be conducted. When amateurs are working with extremely high frequencies, naturally it is desirable to keep all leads in the circuit as far apart as possible, and the construction of this tube now accomplishes this result.

With the Amateur Operators

HIGH FREQUENCY PROTECTION FOR THE TRANSMITTER SUPPLY

By EDWARD W. BERRY

On wavelength of 150 meters and over, the usual filters consisting of a choke and several 1 mfd. condensers, arranged either in the π or T type of section serve a double purpose, for they act as a filter and also as a protective system for the plate supply against high frequency feed backs. With the advent of the shorter wavelengths and their corresponding high frequencies it has been found necessary to provide a better means of protection both for the plate and filament supplies.

This has been necessitated because the capacity of the windings of the large chokes, small as this capacity may be, easily by-passes the very high frequencies. Of course

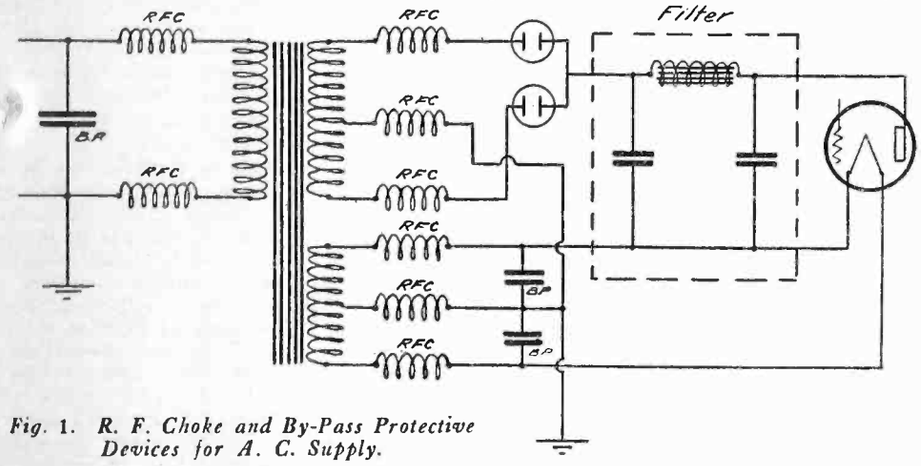


Fig. 1. R. F. Choke and By-Pass Protective Devices for A. C. Supply.

in the π or T type the final condenser across the supply terminals tends to by-pass and short circuit the potential of the stray current. Bitter experience has proven that at 40 meters and lower damaging high frequency is apt to get into the windings of the generator or transformer by induction, caused either by the generator or the transformer being too close to the transmitter or by improper protection of the feeding lines.

In preventing high frequency feed back surges, remove the filament and plate supply as far from the high frequency circuits of the transmitter as is practical, placing the generator in the next room or down cellar. Don't use it as a prop for the shelf your tubes are on, for ridiculous as this may sound, the writer has found this in two stations that were trying to function on 40 meters. In one station, after the third armature had been burned out, the operator consented to move his generator to the other side of the room.

Ground the negative side of the plate and filament generators, or in the case of the a. c. filament supply, the mid-point of the transformer secondary. If an untapped transformer is used the common point of connection of the plate and the filament supply should be grounded. In the high voltage generator the series field should be connected directly to the negative side of the commutator. This permits the grounding of the frame of the generator without subjecting the series field to the full potential of the generator.

In the case of the shunt field it is of course impossible to reduce the full potential of the machine between it and the generator frame. Generators of reputable make are insulated to withstand, and are actually tested at an alternating potential of at least twice the potential of the machine, the frequency of this test usually being 60 cycles. This means that unless damaged the generator will easily withstand the grounding of the frame and the negative terminal.

In the case of the distributed winding type of generator with its low voltage field winding and high voltage compensating winding, or the separately excited generator, in addition to the grounding of the frame and negative side of the high voltage, the negative side of the separate field should be grounded. In the case of the motor generator the grounding should not be applied to the generator end alone but also to the motor. This applies to both a. c. and d. c. motors. Likewise in transformers or alternators one side of the primary or alternator lead should be grounded.

If power is obtained from a public utility concern one side of the line will generally be grounded and any attempt at further grounding will be both unnecessary and dangerous. If an inverted rotary converter is used either as a direct filament supply or as a source of primary supply for a transformer, *do not ground either a. c. terminal if it is of the tapped winding type,* if no booster winding or bucking winding is used it will result in a dead short circuit of the supply lines. If an auxiliary winding of either the booster or bucking type is used the result will be at least a burned out converter.

A simple method to test the possibility of safely grounding the a. c. end of a rotary converter is to "light out" the circuit between the collector rings and the commutator on the d. c. end. If any current at all can be passed from the collector rings to the commutator then the converter has a single winding common to both d. c. and a. c. ends and if the d. c. end is grounded by the Power Company the grounding of either a. c. terminal will result in the short circuiting of the d. c. supply every complete revolution of the armature. If on the other hand no current passes from rings to commutator, the converter has two separate and distinct windings for each end, and grounding one side of the a. c. end will be an added protection. In the dynamotor the two negative terminals should be bonded to the frame and grounded. Here again if the supply lines come from a Power Company great care must be taken to see that the proper line is grounded.

Another method of protection is to place a condenser of approximately 1 or 2 mfd. across the windings of the generators, transformers and supply lines. These are at the present time in such common use that they are a familiar object, but there is, however, a laxity in their use in the primary side of transformers and at the motor terminals. In the old days when "rock crushers" were in style operating at wavelengths of 200 meters, they were to be seen in practically every station. With 40 meters in vogue at the present time, 9 out of every 10 amateurs would have difficulty in naming a main line protective unit. With the low wavelength there is more reason than ever for the use of protective devices in the primary side of power supplies.

There are some places where it is not desirable to use condensers for protection of the high voltage supply, particularly at the very low wavelengths. Here the condenser across the line may be supplanted by a radio frequency choke in each line. Even with condensers across line the r. f. choke should also be used as an extra protection between by-pass condenser and the windings to be protected. To a great many this seems unnecessary so let me draw a little analogy. Supposing your auto became stalled on a small railroad siding. A train of a hundred freight cars comes down the main track. Ninety-nine of them take the switch all right and go down the main track but the last car breaks loose, splits the switch and starts down the siding. Does it make you feel any better or does it decrease the damage very much to know that only 1 per cent of trouble came the wrong way? That is just about the way I feel about a by-pass condenser. It forms the path of least resistance along which 99.9 per cent of the high frequency will probably go, but it needs to be reinforced by a sign to stop that remaining .1 per cent of trouble, so that a r. f. choke should be placed in both leads between the windings and the condenser. If for the sake of getting down on the very low wavelengths it becomes necessary to do away with the by-pass condenser, do so, but do not omit the r. f. chokes.

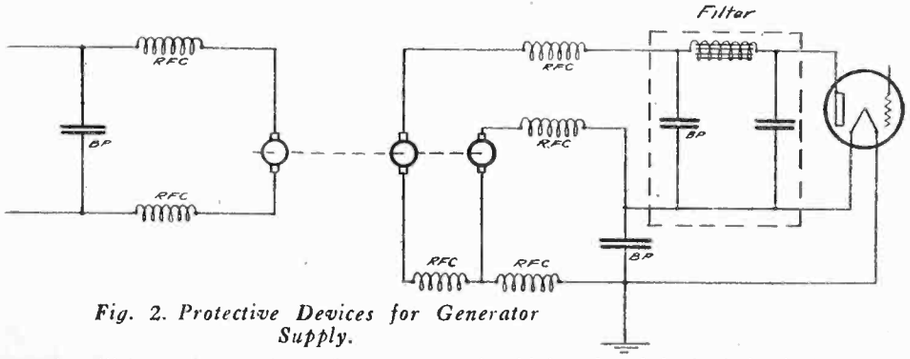


Fig. 2. Protective Devices for Generator Supply.

The principal points for radio frequency choke protection are, in the grid leads next to the tube, in both filament leads, in both plate leads and in both leads of the primary source of supply whether motor or transformer. At the ultra high frequencies it may be found necessary to dispense with the choke in the grid lead. The Meissner circuit with its separate and distinct grid and plate coils seems to have a natural protection. Even here it is better to play safe and protect with r. f. chokes in plate and filament leads.

TRANSMITTING TALK

By L. W. HATRY

In selecting the number of tubes to be used in a transmitter, it is doubtful if more than three tubes will increase the energy output, on any wavelength within the 150-200 meter band. Unless operated on plate voltages much above normal four tubes seldom give more power than three. In fact, it is a fair temptation to set the limit of the number of tubes in parallel to two, because so little gain is experienced in using more, with the exception of the full-wave self-rectified transmitter, which allows the use of four tubes with noticeable profit. If the plate supply is connected in the normal manner and the tubes operated in parallel, a gain seldom shows with more than three tubes.

Overloading the tubes in a multi-tube arrangement results in a slight gain, increasing with the wavelength, especially above 250 meters. The best practice lies in using a couple of tubes with fair load, keeping them from showing more than a faint blush, and getting the advantage there is in the steady output so obtained.

On the 75-85.7 meter wavelength band three tubes are not recommended, for they produce parasitic oscillations among themselves on a very short wavelength, resulting in heating of the tubes, and waste of power. This can be partially alleviated by miniature chokes as indicated by Fig. 1.

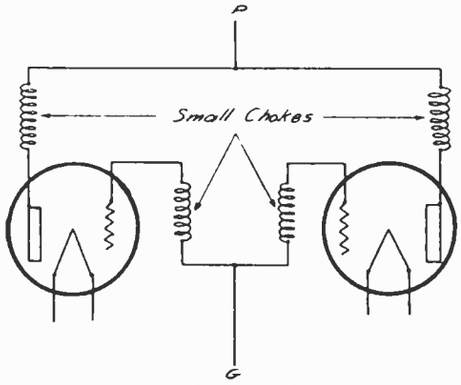


Fig. 1. Use of Chokes in Grid and Plate Leads.

These chokes are about ½ in. in diameter, of 10 turns each and wound with resistance wire. On the bands below 75 meters, no more than one tube should be used, for two tubes generally prove no better than one, and are often a detriment. The results of multi-tube transmission on these short waves are generally little distance, unsteadiness of note, bad tone and occasionally heating of the tube elements.

As has often been mentioned we have a bad habit of overloading our tubes, resulting in wave-change, warbling note, bad tone and harmonics. In fact, the Western Electric Company owns a patent on a simple mechanism for the "Production of Harmonics With Overloaded Vacuum Tubes."

Many have noticed how you have to chase a fellow with the secondary tuning condenser after he has been transmitting for a short time. This is caused by the heating up of the transmitting tube and its consequent change of capacity through expansion. The transmitting wavelength will often jump between two points about a third of a dial division apart. This occurs almost entirely with transmitters using more than one tube and if the owner of such a transmitter would take each tube out of the socket and then measure the wavelengths the transmitter emits with each tube individually and in its own socket, he might find a difference that would surprise him. It is this difference that causes a swinging of the wavelength from that of one tube's circuit to that of the other, which is the waveshift noticed. It is best to sacrifice a little to gain the advantage of a wave that does not change, even though the change is slight and occurs only once each time the transmitter is used.

Since the capacity of the tubes is relatively small, if we use as much shunt capacity in the primary circuit as we can afford, possibly we can reduce the percentage of capacity change due to expansion of the tube elements to a point where its effect on the emitted wave will be negligible. Therefore, it is good practice to use a primary shunt condenser, and we have another argument against the use of more than one tube, for the more tubes connected in parallel, the greater this deviation of tube internal capacity will become because it places the internal capacities in parallel.

The maximum capacity of the variable condensers used in the antenna circuit of the transmitter need not be very great. Using a set on the 150-200 meter band of wavelengths requires antenna condenser capacity not greater than 200 micromicrofarads.

The band of 75-85.7 meters calls for no greater capacity than 100 micromicrofarads, which is somewhat greater than necessary but there is convenience in having the excess capacity available. On the bands below this, a maximum capacity of 50 m. m. f. is required, and at 20 meters you can generally get along with even lower maximum capacities.

Let me take a rap at the use of more than one variable condenser in the antenna circuit. It was sensible in the days when we used conductively coupled sets because there was a reason for it, but is not sensible now that we use inductively coupled sets, and so far as I can see, it defies analysis to find a reason. The only result of so using two condensers is to reduce the effective capacity of each, as they are in series, and to add another tuning control. The two condensers may both be put in series in the aerial lead instead of one in the aerial and one in the counterpoise, with equal results.

Receiving condensers prove OK in transmitters up to 25 watts. At high voltages, sparking will occur, and this can be partly overcome by using as much capacity as possible, reducing the amount of helix included to the minimum without sacrificing effectiveness.

This is true of the primary circuit shunt condenser. The smaller the amount of coil that it shunts, the lower the voltage across the condenser. This effect is partially due to the ration between the amount of coil included and the amount present, which is a reduction ratio, and partially due to the fact that a condenser, as its capacity is increased, tends to decrease the voltage present across its terminals. There need be little worry as to the amount of helix included by the variable condenser in Fig. 2. Include what is necessary, trying more than one choice of helix turns until satisfied. All of the schemes of Fig. 2 prove similar in actual results, although that of *A* is generally best because the rotary plates are at ground potential.

There is no need for difficulty in shifting from one wave-band to another, and every amateur should have two separate wavelengths, one to a waveband. Assuming, for the sake of illustration, that you have a set that is intended to work on 150 meters. If it uses the coupled Hartley, (electromagnetically coupled) it can be used on the 75 meter wavelength as well, just half the 150. The Hartley is mentioned because it is the most common circuit in use. The antenna circuit helix must be large enough to tune to 150 meters, which size is difficult to specify since antennas differ so much. At any rate figure on from 10 to 15 turns of coil on a 4 in. diameter. The primary circuit, on the contrary, is kept at a size just right to tune to 75 meters without a shunt condenser. Then with a shunt condenser the primary transmitting circuit is tuned to 150 meters by the usual method of reading resonance by maximum antenna current. To shift from 150 to 75, tune the primary by disconnecting the condenser and changing a clip if necessary. Couple on the antenna circuit and it will be worked at its second harmonic or half the wavelength to which it is tuned. The primary circuit helix needs to be about 20 turns, 4 to 6 inches in diameter, of the usual types of strip or wire.

The same process is followed for operation on 80 and 40 meters, or any wavelength within the 75-85.7 meter band and its half The difference comes in the size of the primary helix, which must be small enough to cover the half wave without condenser assistance. The antenna is either cut down, or made small enough at first, to work a short distance below the fundamental on 80 meters, or the 150 meter antenna can be worked at the 2nd and 4th harmonics. The primary for 40 meters is about 12 turns on a 6 in. diameter, but no matter the amount required, it is a good idea to remove the unused portions. Then, to tune to 80 meters wavelength, the primary is shunted with a condenser of suitable size.

The change from 40 meters wavelength to 20 meters can be similarly made although it is a less effective change where the frequency is so high. The trouble lies in the fact that the capacity necessary for the wavelength change will be rather excessive for the 40 meter wavelength.

For the change from 75 to 150, the primary shunt variable condenser will need a maximum capacity in the vicinity of .00015 mfd. and for the changes on the lower bands a variable condenser with a maximum capacity of .0001 is about right. In either case the condenser will work with greater ease if some sort of vernier dial is used for controlling it, as its resonance point is generally both sharp and critical.

Choke coils for the transmitter as ordinarily wound, are large enough to work from wavelengths of 200 meters down to possibly the lower wavelength of the 40 meter band, but when one gets below 40

(*Continued on Page* 64)

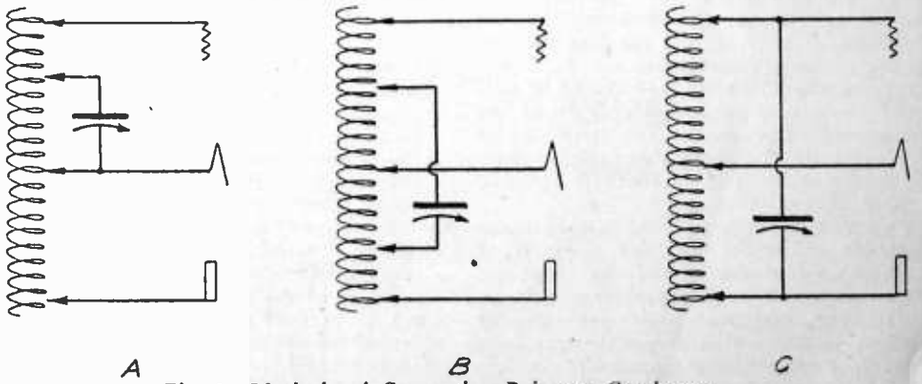


Fig. 2. Methods of Connecting Primary Condenser.

SECOND PACIFIC DIVISION A. R. R. L. CONVENTION

By WALLACE S. WIGGINS, *6CHZ*

Accompanied by shrill calls on whistles, auto horns and musical (?) instruments, the Second Annual Convention of the Pacific Division, American Radio Relay League, was held with all enthusiasm at Santa Ana, Calif., October 2, 3 and 4. The convention accomplished several things of importance to those of the division and others of the league. Among the speakers were Commander Hooper, late chief of radio operations, Pacific fleet; Col. J. F. Dillon, supervisor, 6th Radio District of the U. S.; Lieut. Fred Schnell, U. S. N. R. F.; Ed Willis, U. S. N. R. F.; Mr. A. H. Babcock, director, Pacific division; Hugo Benioff, Lick Observatory; Prof. Karl Strem, professor of physics, Whittier College, and M. E. McCreery, manager Second Section, Pacific division.

The convention opened on Friday, with registration in the morning and the traffic meeting in the afternoon. The question of wavelengths, removal of the Hartford headquarters of the league to Chicago, and the establishment of a centrally located station for headquarters' use to broadcast latest dope on league matters, were some of the points taken under consideration. At a later meeting, it was unanimously voted that the traffic department of the league should be moved to some centrally located point as an experiment.

At the meeting on the evening of the same date, the convention was officially called to order by Dr. J. E. Waters, presiding chairman, who extended a formal welcome to all those present in behalf of the Orange County Radio Association, and introduced Col. J. F. Dillon as the first speaker. The colonel reviewed the activities of the A. R. R. L. and stated that California as a [illegible] was one of the smoothest running [illegible] regard to radio activities in the [illegible]. He attributed this fact to the co- [illegible] the amateurs in the state and [illegible] organization is just what [illegible] make it, and concerted action [illegible] members is required for the [illegible] organization." In concluding, [illegible] said that international radio Kell[illegible] was a highly important Com[illegible] relations for the future, in [illegible] nitio[illegible]

which the amateurs of today would share. It might be noteworthy to mention here that this fact was again taken up and even enlarged upon by Commander Hooper in his speech after the banquet.

Other speakers of the evening were Lieutenant Schnell and Ed Willis. Lieutenant Schnell gave a highly interesting account of his entire cruise to Australia as officer in charge of "NRRL," with many entertaining details. Need it be said that those of us attending the meeting of that night will long remember the details of the elephant episode at Hawaii, or the "spots" and the "pubs"? Other high spots of the story will also be remembered; of the superior operation and ability of the short wave sets over those of the standard navy type; of the surf board riding at Waikiki (Hil); of narrowly missing a very long swim when there wasn't a light on board; of the character and impressions of the Aussies and their stations; of the meetings of Anzac hams with noise being "conspicious by its absence" (exactly the opposite of an American meeting); of the experience with "mal de mer"; of the audibility of American ham stations and the unusual and extreme audibility of 6CGW and 6BUR; of this idea of "sync" notes being best by far (QST hw? !!*??); of the various difficulties experienced throughout the cruise and their mastery. We could go on giving many details of the interesting experiences of Lieutenant Schnell, but lack of paper forbids. You should have been there!

Ed Willis, who operated one of the navy sets on the cruise and who is also known as the operator of 6TS, outlined the advantages and purpose of the U. S. Naval Reserve Force as an organization for the prevention of war. His speech was interesting and well received. More power to the U. S. N. R. F.!

Saturday morning was occupied by ham fests, a parade and a code contest. The latter was based upon correctness of transmission and rhythm in sending. The contest was won by Lester Picker, 6ZH, the well known operator at San Ysidro, Calif.

At the afternoon technical meeting Mr. Hugo Benioff was introduced by E. de K. Leffingwell, prominent southern California amateur and formerly active in Alaskan exploration. Mr. Benioff told of his experiences and activities in seismological work and talked on the subject of the application of radio knowledge by the amateur to future life work. His talk was exceedingly interesting and educational.

Following the talk by Mr. Benioff, a paper was read by L. Elden Smith,

(*Continued on Page* 81)

CALLS HEARD

By 8RY, Sullivan, Ohio

A-2cs, 2yh, 3bq, 3tm, 3yx, 5ah 5bn, 9dr, B-4rs, F-8éé, 8ct, 8fq, 8jct(?) 8yor, G-2nm, on fone, 2nb(?), 2kf, 6rm 6tm, HU-fx1, kfuh, 6aff, 6buc, I-1co M-xda, 1g, 1j,(?), 1x, 1aa, 1af, N-Osv, PR 4rl, 4ur, Q-21c, 2mk, S-smzs, U-6az 6dh 6li, 6nw, 6sk, 6wt, 6aao, 6agk, 6amm 6aqp, 6asv, 6bas, 6bbv, 6bvq, 6bvs, 6cah 6sca, 6dag, 6dam, 7lu, 7ly, 7uj, 7uv, 7aek Z-1ao, 1ax, 4ag, 4al, 4as, 4av, Misc-6zac ane, pkx, Vmg, naj, npm, npu, ncgl, nedj nisq, nrrl, nve, wap, wnp, wvz. Pse QRA these—fw, f8z, sc3, 99x, nqgl ??? u8RY has big list of foren QRA's, send me ones u want and I wl be glad to help u out QTC?

By Albert E. Scarlett, Jr., 23 Cooley Place, Mount Vernon, N. Y.

U. S. A.: 6agk, 6alj, 6amm, 6bwl, 6cgw, 6che, 6cka, 6ctv, 6dal, 6dh, 6vr, 7uz, kel. Canada: 5hc. Panama Canal Zone: nisr, 99x. New Zealand: 1ao, 2ac, 2aq, 2xa, 4aa, 4ag, 4ak, 4al, 4ar. Australia: 2bb, 2cm, 2cs, 2ds, 2ij, 2lo, 2tm, 2ul, 2yi, 3ef, 3tm, 3xo, 3lm, 3yx, 5ah. Java: Dutch East Indies: ane. Argentina: afl, bal, cb8. Samoa: 6zac, npu, nrrl. Tahiti: nrrl. Hawaii: npm. Mexico: 1af, 1b, 9a, xda. Brazil: 1a. France: 8ct, 8gs, fw. Off Africa: sgc. Greenland: wap, wnp. Cuba: 21c, 2mk, nve. Germany: aga, pof. Holland: pcmm, pcuu. Porto Rico: 4kt, 4rl, 4sa. England: 2kf, 2kz, 2nm, 5by, 5dh, 5nn, 6rm, 6tm. Pacific Ocean: nisr, nisv, numm. Unknown: ftj, jb. All heard on 80-ft. indoor antenna. All six continents during September.

At 9WF Nunn-Landon Co., Milwaukee, Wis.

All 40 meters broad dalite. 1aep, 1bg, 1ef, 1my, 2acs, 2adu, 2awf, 2cxl, 2ry, 3ade, 3jo, 3ld, 3io, 4aad, 4aal, 4ee, 4km, 4fp, 4gl, 4mf, 4si, 4tn, 5atf, 5eh, 5ft, 5ig, 5oq, 5qh, 5ut, 6bq, 6ccp, ncgl, wvc. Night: 1abn, 1atg, 1aff, 1ayl, 1bad, 1bzp, 1dl, 1nt, 1se, 1xu, 1za, 2aky, 2bir, 2csa, 2buy, 2bwa, 2ku, 3kp, 4aae, 4wj, 5aav, 5akl, 5arh, 5apm, 5uk, 6aut, 6bvy, 6cnh, 6csw, 6csr, 6jp, 6ll, 6vc, 7ij, wiz, naj, nisr. French 8dp. Can.: 1ar.

By 6AE 4409 So. Harvard Blvd., Los Angeles, Calif.

U. S.: 1anq, 1bgc, 1fx, 2brb, 2cxl, 3hg, 4bv, (4do), 4fl, 4iv, 4ilr?, 4rm, 5aav, 5adl, 5ado, 5aid, 5aj, 5he, 5asd, 5asv, 5amg, 5aks, 5atx, 5uk, 5akn, (5amw), (7uj), 7uv, 7rl, 7aek, 7ya, 8ay, 8bf, 8cau, 8cwk, 8gq, 9aey, (9bht), 9bez, (9bwb), 9bpy, 9bgy, 9bn, 9bcn, 9cfy, 9dng, 9czz, 9dcc, 9drd, 9eae, 9cip, 9xn, 9zk. Hawaiian: (6ajl), 6aff. Canadian: 5ef, 5go. Mexican: 1aa, 1k, 1x, 9a. Kamiloa: Kfuh. Naval: Npm, nkf, napg, npu. Others: Ane.

By 1ADW, 44 Stone St., Danbury, Conn.

3aer, 3aev, (3afw), (3agd), (3ala), 3avn, 3axs, 3bel, (3bit), (3blc), (3blp), 3bss, 3cdv, 3iv, 3mk, (3pt), (3qy), (3sb), 3sk, (3ug), 4aif, 4ev, 4ht, (4hw), 4lv, 4nb, (4rw), 4rz, 4sa, 4sc, 4tg, 4tv, 4uk, 5adv, 5all, 5ann, 5apm, (5aqn), (5awf), 5he 6alj, 6css, 8ac, 8awa, (8arw), 8baq, (8bay), 8bcz, (8bdz), 8bgn, 8bhm, 8bjz, 8bpv, (8bto), 8cdv, 8ced, 8cgf, 8ckp, 8cnx, (8cuk), 8cyd, 8ddj, (8dfo), (8dme), 8dmz, 3dgl, 8dgp, (8dpe), (8eu), (8qb), (8rt), (8wh), 9adk, 9adx, 9agp, 9agu, 9avi, (9asx), 9atv, 9bak, 9bcx, 9bdh, 9beq, 9bfg, (9bgi), 9bgw, 9bmm, 9bno, 9bob, 9bsp, (9bwj), 9bxg, 9cli, (9cjw), 9cpp, 9crf, 9cvf, 9cwo, 9dac, 9dbz, (9dde), 9dgw, 9dix, (9dkc), 9dm, (9dol), 9dry, 9dte, (9egz), 9ejl, 9ok, 9ri, 9za, 9zt. Canadian: 2bv, (3fu). All cards qsled. Qrk ladw on 80 and 40 meters?

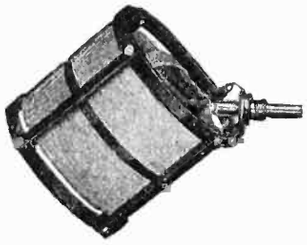
By E. O. Knoch, 6BJX, 2823 East 6th St., Los Angeles, Calif.

Australia: 2cm, 2ds, 2jw, 2lo, 2yi, 3bd, 3bv, 3ef, 3ju, 3kb, 5ah, 5bg, 5da, 6ag. Canada: 4gt, 4ef, 5go, 5gt, 5hp, 9ck. Chile: 2ld, 9tc. Hawaii: 6aff, 6buc, 6dcf. Mexico: 1aa, 1af, 1b, 1k, 9a. Philippine Islands: 1au, 1cw, 1hr, najd, nirx, nuqg. Porto Rico: 4sa. Cuba: 2mk, Samoa: 6zac. New Zealand: 1ao, 1ax, 2ac, 2ae, 2xa, 4ak, 4ar, ane, kfuh, *kudg China,* naj, napg, nedj, nisr, nisy, npm, npn, npo, npu, nrrl, numm, nve, wap, whw, f8z, fxl, jb.

(*Continued on Page* 42)

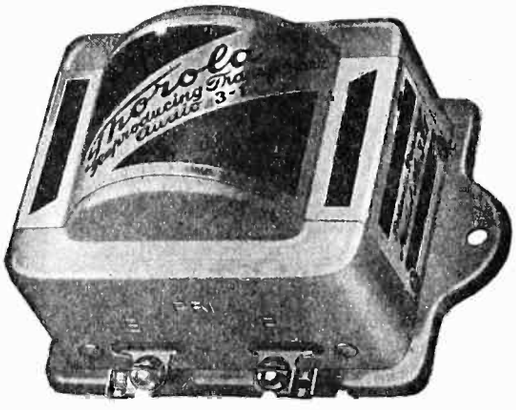
FROM THE RADIO MANUFACTURERS

The Aero-coil oscillator for superheterodynes is one of a number of applications of an air-space-wound inductance for use in circuits carrying radio frequencies. The special winding employed



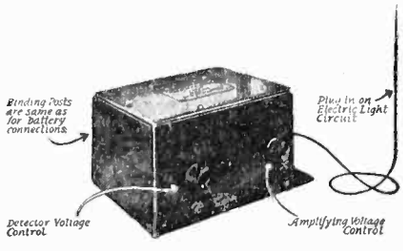
requires no binding material or form to be ruggedly self-supporting, aside from the bakelite end-rings and cross-pieces. It is claimed to have very little distributed capacity and very low high frequency resistance so as to give most efficient results.

The Thorola reproducing transformer has a 3 to 1 ratio and gives a practically straight line voltage amplification curve over a wide range of audio frequencies.



It is well-shielded to eliminate magnetic interaction between stages and has a silicon steel core designed to minimize magnetic leakage.

The Precision "B" power unit is a compact battery eliminator housed in a bakelite cabinet 6½x5x8½ in. This is an electrolytic rectifier with electrolytic condenser, both placed in a sealed container



so as to be non-spillable. It gives adjustable detector plate voltage up to 45 and amplifier voltages from 45 to 120. It is low in first as well as operating cost and supplies as many as eight tubes without noticeable hum.

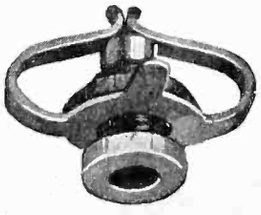
The Philco socket power unit is supplied in three types, "B" to replace B batteries for any radio set, "A" to supply filament current at 5 or 6 volts to sets having storage battery tubes and "AB" to supply both filament and plate

current to 3-volt dry battery tubes. It consists essentially of a storage battery of proper voltage with a trickle charger so that it may be plugged into a lamp or wall socket to supply all the current requirements of a radio set.

The Exide radio power unit is a combination of a 4 or 6-volt storage battery with a trickle-charger which is kept connected at all times while the radio set is not in use to the 110 volt a. c. house current lines. A compact metal housing fin-

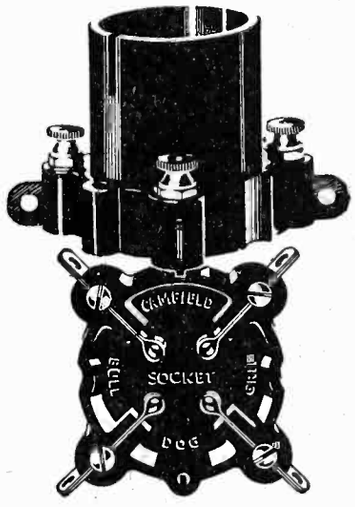
ished in a mahogany color accommodates both battery and charger. An unusually large space is provided above the top of the battery plates for excess electrolyte to compensate for that lost by evaporation and charging. The charger is a vacuum tube rectifier.

The King Quality Cord tip jack does away with the necessity of a special phone plug or front panel binding post by providing a panel-mounted jack that gives positive electrical contact for all



standard phone tips. It can be furnished with a pair of red and black insulating washers to indicate polarity. This device will also be found handy in general experimental work and for connecting batteries.

The Camfield Bull Dog Grip socket is designed to take three different types of tube bases. The Navy standard base, the new X storage battery tube base and the new X dry battery tube base are



all interchangeable in this socket without the use of an adaptor. The heavy phos phor bronze contact springs grip the prongs on all sides so as to give good ... the amount electrical contact. ...a to remove the ...o tune to 80 meters ...ry is shunted with a size.

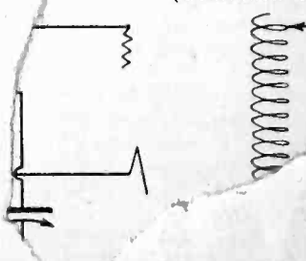
40 meters wavelength to similarly made although ...e change where the fre... The trouble lies in the ...ity necessary for the wave... ...ll be rather excessive for ...elength.

The Van Horne 3VA tu... to give the amplificatio... the 201-A type storage ba... lower filament power co...

...ge from 75 to 150, the pri... variable condenser will need ...um capacity in the vicinity of .00015 ...and for the changes on the lower bands ...riable condenser with a maximum ca... ...ty of .0001 is about right. In eithe... ...e the condenser will work with greater ...se if some sort of vernier dial is used for ...ntrolling it, as its resonance point is ...nerally both sharp and critical.

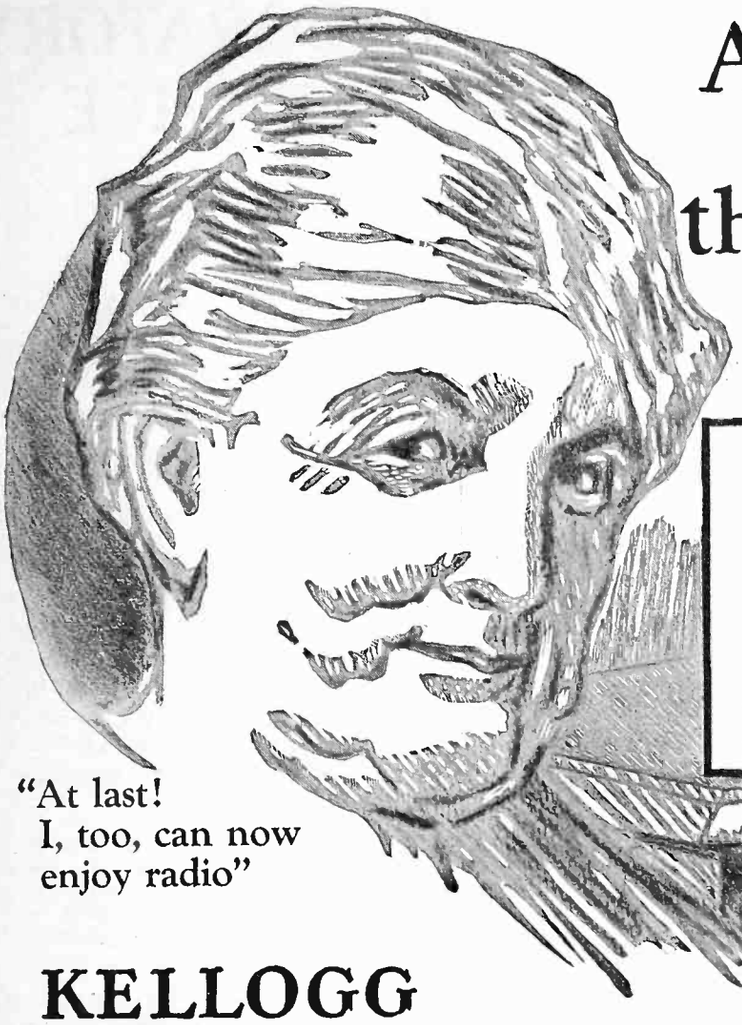
Choke coils for the transmitter as ordi... ...arily wound, are large enough to work ...rom wavelengths of 200 meters down to ...possibly the lower wavelength of the ... ...meter band, but when one gets be...

(*Continued on Page* 64)



has an ...lification constant of 6.5. It can be ...sed to advantage in circuits where ordinary dry cells tubes do no... give sufficient volume.

A New Kind of Selectivity that Makes Tuning *a Real Pleasure*

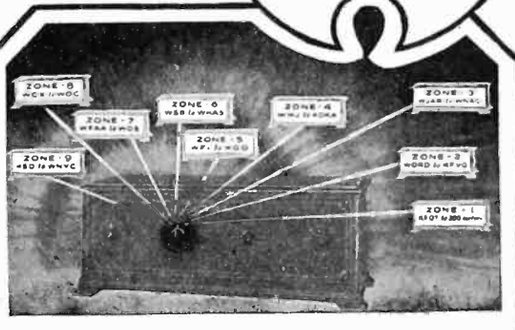


"At last!
I, too, can now
enjoy radio"

Standard Model 5-Tube Wave Master
in beautifully finished cabinet of solid genuine Mahogany. Price,
$125.00

The Wave Master Consolette
A beautiful genuine mahogany model with inbuilt horn.
$235.00
Also made in a handsome Console Model. Price
$275.00

Kellogg Symphony Reproducer
$25.00



KELLOGG
Has Produced the Radio Set for YOU

BY PERFECTING, in the new 5-tube WAVE MASTER, a new kind of *selectivity*, the Kellogg Switchboard & Supply Company has given a new definition to that much abused word.

No professional skill is required to tune the WAVE MASTER. A person who has never before touched a radio receiver can instantly bring in desired stations clear, "sweet" and strong.

With its single Selector dial, the WAVE MASTER gives you what otherwise you can get only by using NINE separate receiving sets of any other types, each one differently adjusted.

For each point on the Wave Zone Separator, you find on the Station Selector dial an entirely different group of broadcasting stations.

Think of the greater selectivity! Think of the wide separation of stations in any one of the nine wavelength divisions. Think of the freedom from interference and the crowding so common on the dials of ordinary sets.

For 28 years the Kellogg Switchboard & Supply Company have been makers of precision telephone instruments, switchboards, etc. Kellogg high-grade parts have been favored by expert and professional designers of receiving sets since the beginning of radio.

Write us for the name of your nearest dealer. We will also send, on request, a complete explanation of the WAVE MASTER circuit. Ask for Folder No. 2-L.

Radio Dealers and Jobbers

The WAVE MASTER franchise, backed by Kellogg resources and our powerful advertising campaign, is most valuable. Open territories are going fast. Write or call on us at once for our money-making proposition.

KELLOGG SWITCHBOARD & SUPPLY COMPANY
1066 West Adams Street, Chicago, Ill.

A Separate Circuit for Each 40 Meter Wavelength Band
One-Dial Control, Yet Greater Selectivity.

KELLOGG WAVE MASTER
SWITCHBOARD & SUPPLY CO.

Tell them that you saw it in RADIO

Designed for *1926* conditions

MAR-CO R.F. RADIO PRODUCTS KIT No. 2 *for the* Marcodyne Circuit

THE trend in radio design today is along very definite lines. The ideal set combines extreme selectivity, with plenty of power, plenty of "responsiveness." And these qualities should be obtained thru such efficient arrangements, that the number of tubes, and consequently the up-keep cost, is LESSENED.

To meet these 1926 needs, the MARCODYNE circuit was devised. It combines—SUCCESSFULLY—tuned radio frequency amplification with regeneration. In this set, four tubes are made to produce plenty of power, sufficient for local stations without the use of an aerial. The selectivity is remarkable, and yet, with the use of the new MAR-CO dials, tuning is ridiculously simple.

Efficiency is materially increased by special plate coil design to fit different types of tubes.

All in all, the MARCODYNE principle, built with the essential parts in the MAR-CO kit, points the way to the kind of set design 1926 conditions demand.

PUT YOURSELF A YEAR AHEAD

The kit, containing the essential MAR-CO parts, is only $25.00. A majority of the other necessary items you probably have on hand. Thus, for a comparatively small expenditure of time and money, you may own a set which is easily a full season ahead of current practice in set design. Ask your dealer for additional information about this kit. Or, write today for a free report of interesting experiments with this 1926 circuit.

Manufactured by

MARTIN COPELAND CO.
Providence, Rhode Island
Branch Offices in
New York, Chicago, Boston and San Francisco
Jobbers in all important cities

Read by 35,750 Families

—This leading Pacific Coast weekly program and schedule magazine contains 64 pages of the most reliable data in print.

50 cents for the next 12 issues—mailed to your home.

RADIOCAST WEEKLY
"The Recognized and Accepted Authority"
Pacific Bldg. - - San Francisco

LABORATORY SERVICE

By G. M. BEST

"RADIO'S" New Calibration Laboratory Is Second to None

THE complete laboratory of the Pacific Radio Publishing Company is at your service. We make tests—calculations—give you expert advice on your radio problems. Gerald M. Best is in charge of our own laboratory. We have an assortment of the finest testing equipment available.

Use this service. Let us answer your radio questions for you. We give you expert advice on your radio problems. Our service is most accurate—entirely dependable and PROMPT.

We will answer ten of your radio questions if you subscribe to "RADIO" for only one year. With your subscription to "RADIO" you will receive ten coupons entitling you to answers to ten radio questions.

The regular cost for answering ten questions is $2.50. Save this money! Subscribe to "RADIO" and get your answers without cost.

Use the coupon. Attach your remittance of $2.50 to it and mail now. Your investment of $2.50 will pay big dividends. The coming issues of "RADIO" will surprise you.

This offer will shortly be withdrawn

Now is the time to act!

— — — — — COUPON — — — — —

"RADIO," Pacific Building,
San Francisco, Calif.

Here is $2.50. Send me "RADIO" for one year and 10 free coupons entitling me to answers to ten radio questions.

Name.....

Address.....

City and State.....

Perfect Precision!

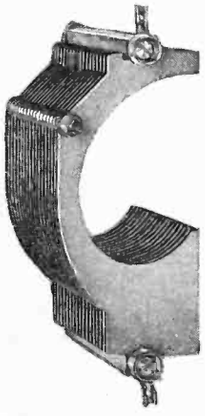
Radio technicians and engineers as well as seasoned amateurs know that "General Instrument" is satisfied with nothing short of **perfect precision.**

For example: The "General Instrument" laboratories developed the eccentric type straight line frequency condenser at great expense—only TO ABANDON IT!

Try to rotate an eccentric type straight line frequency condenser and note the effect on the bearing and then you will realize why "General Instrument" discontinued the eccentric type and created the CONCENTRIC straight line frequency condenser.

CONCENTRIC straight line variable condensers represent the latest development in condenser engineering. Observe the even distribution of weight of the rotor plate.

"General Instrument" thinks more of its reputation than the cost involved in creating a perfect instrument. Hence—the CONCENTRIC straight line frequency condenser.



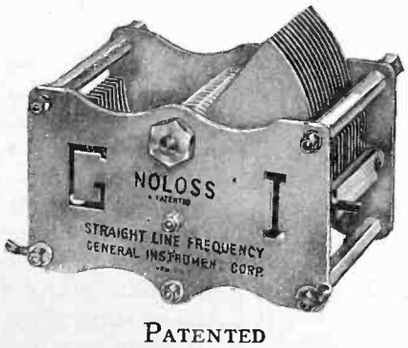
STATOR

CONCENTRIC Straight Line Frequency Condenser

(Pyrex Insulated)

The Perfect instrument created by General Instrument. Type 80.

TYPE 40



PATENTED

The Inimitable Rheostat

Built only by "General Instrument," this rheostat can NOT be imitated. To get it, you must make sure of the name "General Instrument."

OBTAINABLE AT BETTER CLASS RADIO DEPARTMENTS

General Instrument Corporation

Manufacturers of Laboratory Equipment

423 Broome Street New York City

Tell them that you saw it in RADIO

USE OUR TESTING LABORATORY. SEE PAGE 64.

VACUUM TUBE COSTS

(*Continued from Page* 12)

tell of in a future interesting story. The big tube manufacturers, including the largest licensed corporations, still face the danger of injunctions that descend like thunderbolts from lowering skies; also obstruction of distribution, damaging propaganda, and even the bribed defection of employees and the instigation of sabotage in their factories.

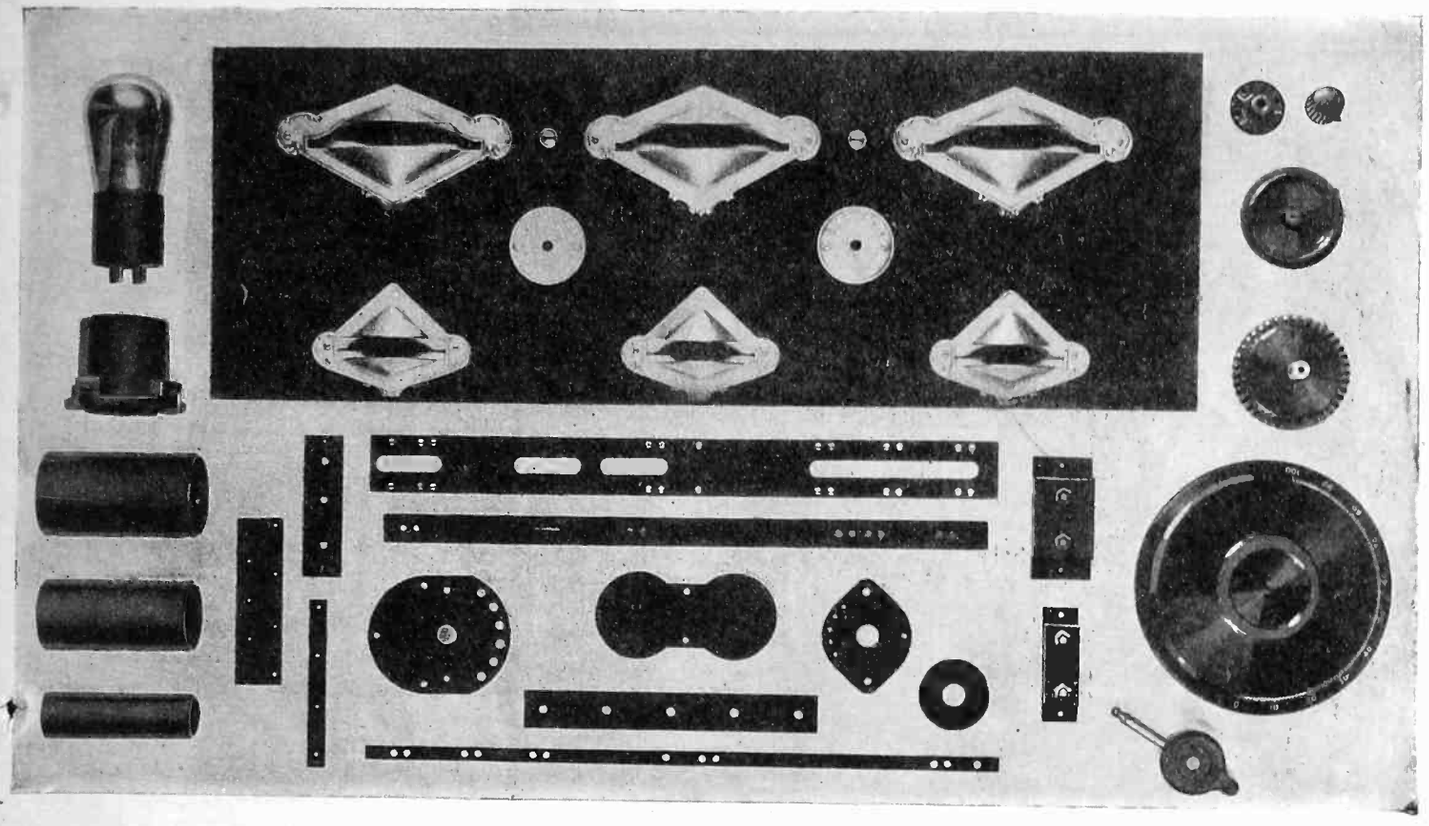
Last year, I described in these pages something of the methods of operating large plants behind locked doors, and I shall state here that the secrecy with which the tube factories are conducted today is absolutely astounding. If you are not a duly initiated habitue, you have about as much chance of finding out where any given one of these plants is at as you have of meeting an inhabitant of Mars on the street; and if by some wild coincidence you did run across one of them, you would have about as much chance of getting in as you would have of conversing with the Martian, were you to meet him. This extreme, but justifiable exclusiveness is practised even by the manufacturers of licensed tubes. The head of one of the biggest tube-distributing organizations in the United States is unable to get into some sections of the factories in which his own tubes are made. The purpose of this rigidly-adhered-to policy is to prevent spying, and to prevent thefts of filament-wire and of secret processes and formulas. But still these things go on.

We shall say, therefore, that the manufacturer sells his tubes to a distributing organization for seventy cents apiece. The distributing company has to advertise the product, and build up a large system for disposing of the output of the factory. It will cost anywhere up to twenty cents a tube to do this; that is, to make the tube known to the public, and to put it into the hands of the radio jobber.

It is evident that the distributing organization, in order to make anything, can hardly afford to sell the tubes to the wholesaler for much less than one dollar each. The wholesaler next demands thirty or forty cents for his share in the work of distribution, making the cost to the retail dealer from $1.30 to $1.40. The retail dealer, in turn, cannot exist in business without his 30%, making the final retail price of a first-class tube pretty close to two dollars. And so there you are.

It may seem to the reader that there is too much of the game of pass-it-along-without-adding-anything-to-its-value being played in the distribution of the products of the tube factories. In reply, it must be admitted that we in this country do suffer sometimes from a too-elaborate system of distribution, not only of radio tubes, but of almost all manufac-

(*Continued on Page* 48)



Imagine a Radio Set stripped of these parts

What a useless collection of wood, wire and metal it would be. Realizing that the parts and accessories shown here are wholly or partly of Bakelite, gives you a vivid picture of its importance to Radio.

Today Bakelite is used in a greater variety of radio parts than ever before---and the number grows constantly. This dominance of Bakelite in radio reflects the experience and the opinions of radio manufacturers, great and small.

Radio set and parts manufacturers have every facility for testing all insulation materials and over 95% have standardized on Bakelite. This indicates how really important it is for you to make sure that the set or parts that you buy are Bakelite insulated.

Write for Booklet 30

BAKELITE CORPORATION
247 Park Avenue, New York, N. Y.
Chicago Office: 636 West 22nd St.

Western Representative:
ELECTRICAL SPECIALTY CO.

443 S. San Pedro St.
Los Angeles

75 Fremont Street
San Francisco

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Bakelite is an exclusive trade mark and can be used only on products made from materials manufactured by the Bakelite Corporation. It is the only material which may bear this famous mark of excellence.

BAKELITE

REG. U.S. PAT. OFF.

BAKELITE
is the registered trade mark for the phenol resin product manufactured under patents owned by the Bakelite Corporation.

THE MATERIAL OF A THOUSAND USES

(*Continued from Page* 46)

tured products that we pay out our money for. The wholesaler or jobber is a more or less indispensable evil in many businesses, as he carries the big stocks that the small retail dealer could not afford to carry. If there were no jobbers, the dealers would have to order direct from the factories, often at very distant points, with consequent delay to the consumer.

Returning to our radio tubes, it is unlikely that the basic manufacturing costs will ever be materially lower than they now are. However, with the stabilization of the industry, the ultimate perfection of tube-making machinery, decreased obsoletion, reduced shrinkage of the product, and the increasingly enormous volume of business that can assuredly be expected every year, it is almost certain that manufacturers and distributing companies will work on closer and closer margins as time goes by, and some manufacturers will do their own distributing, with the foreseeable result that the list price of the best tubes on the market may get as low as $1.50. If the factory sells directly to the dealer, a price of a dollar must be admitted as a future possibility. These are about the lowest figures that I can see for a first-class tube.

"So they make them for hardly forty cents!" I can see the reader exclaim, indignantly. "Then how about the time when they used to soak us six-fifty apiece —and even nine dollars! Did they cost so much more to make, then?"

The answer must be, No. Radio tubes did not at any time cost more than seventy cents apiece to manufacture, in the case of the six-volt type. The three-volt tubes were more troublesome, but they never cost more than eighty-five cents to make, after their production was well begun. These greater earlier costs were mostly due to shrinkage. The profits in selling tubes at six dollars were vast; the bulk of these profits passed into the hands of certain persons as patent royalties. Whether the right persons got these immense royalties is open to doubt. This matter has been wrangled over in the United States courts for the last five years, and longer, and probably will be for the next fifty.

"Then," I hear the reader continue, "if good tubes cannot be sold at retail for less than one-fifty or two dollars, how is it that the stores are full of them at prices as low as 89 or 59 cents? Are these inferior tubes?

Exactly—yet not always. I have already remarked that tube manufacturers suffer a varying shrinkage of their product. This does not mean necessarily that the tubes figured into the shrinkage are a dead loss. Those that break in machines are gone, of course, but few are lost in this way. Most of them come through, apparently in good shape;

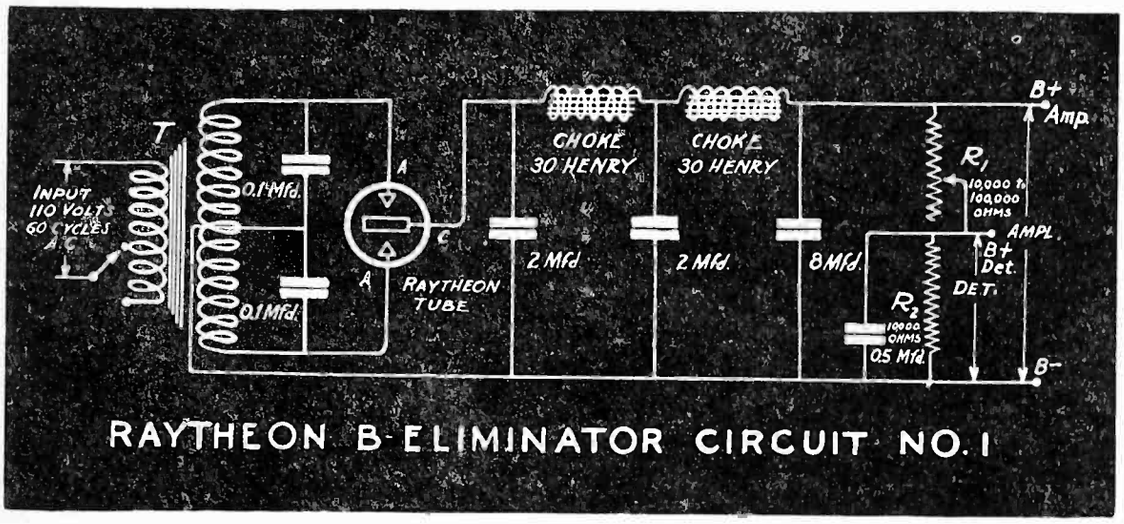
(*Continued on Page* 50)

Fine Radio **TOBE** Apparatus

DEUTSCHMANN

The Raytheon

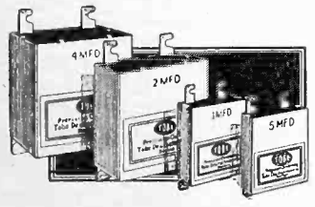
B--BATTERY ELIMINATOR CIRCUIT



RAYTHEON B-ELIMINATOR CIRCUIT NO. 1

This new plate supply unit depends largely for its successful operation upon the proper filter condensers.

The following T O B E condensers should be used:—



2 type 705 .1 MFD price $0.70
1 type 707 .5 MFD price $0.90
2 type 709 2. MFD price $1.75
2 type 711 4. MFD price $3.75

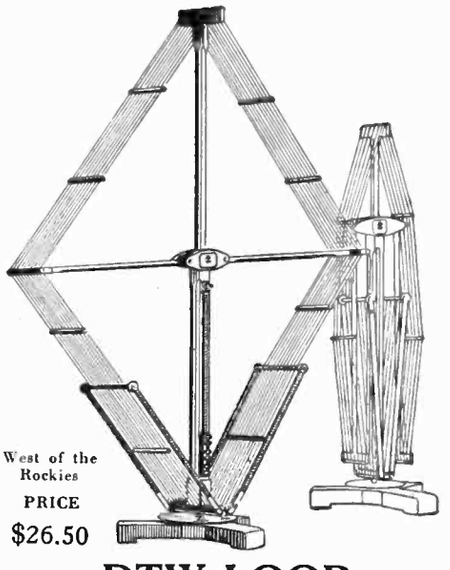
These condensers are our shielded high voltage type, as featured in Popular Radio, Radio Broadcast, Radio and Radio News.

Transformers and Chokes for this circuit are manufactured by:

Acme Apparatus Co., Cambridge, Mass.
All-American Radio Corp., Chicago, Ill.
Dongan Electric Mfg. Co., Detroit, Mich.
General Radio Co., Cambridge, Mass.
Jefferson Electric Mfg. Co., Chicago, Ill.
Thordarson Electric Mfg. Co., Chicago, Ill.

The rectifying tube is the "Raytheon" manufactured by the American Appliance Company, Cambridge, Mass.
Resistances R-1 and R-2 are No. 10 Bradleyohms or the equivalent.

Tobe Deutschmann apparatus comprises in addition, a complete line of transmitting condensers and transmitting tubes. Write for descriptive literature.



West of the Rockies
PRICE
$26.50

DTW LOOP

(collapsible)

The leading loop for super-het or any circuit. The one loop in all America chosen by McLaughlin for his single control set. Has 27 inch sides. Genuine Litz wires. Graduated base for compass settings.
Made to laboratory standards for a lifetime of efficient use.

San Francisco Office-821 Market Street, San Francisco, Calif.

Tobe Deutschmann Co.

CORNHILL BOSTON MASS.

(*Continued from Page* 48)

but when put on the checking-machine, they show deficient emission and amplication.

It may seem a peculiar fact that tubes produced in absolutely identical fashion by a battery of accurately-adjusted machines will vary to such an extent as they sometimes do, in their operating characteristics. The reason is largely to be attributed to the slight and almost unavoidable variation in the quality of the thorium content in the filament wire, to an imperceptible displacement of the elements, and to a variation in the vacuum obtained in different tubes, or to troubles that arise in the process of bombardment.

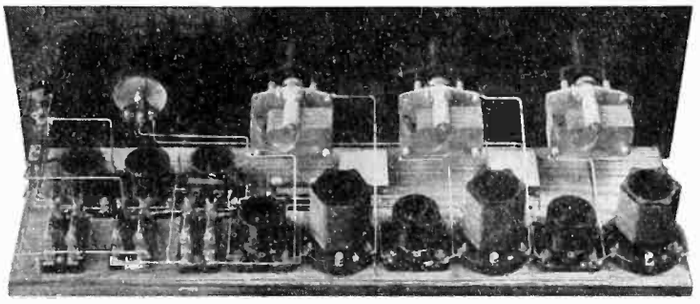
Despite all precautions, a certain number of tubes arrive at the checking-table that are not up to standard. They work; but they are not first-class. These are light-and-play tubes, and the manufacturer is often glad to dump them for forty-thirty, or twenty cents—or for whatever he can get. These tubes are guaranteed to light, and to play in audio frequency. They are always deficient in volume and tone, as compared to a high-grade tube, though occasionally they will work loudly in some particular socket of one's radio set. They are never sold under the same trade names as the manufacturer's good tubes. This is worth remembering.

Most of the better manufacturers look with strong disfavor upon dumping these rejects and seconds, since they frequently pass into the hands of unscrupulous persons, who resell them with all kinds of extravagant guarantees as to their quality. But there are dozens of small tube manufacturers, who because of poor materials and inexpert engineers turn out a product that is sometimes almost 50% light-and-play tubes. They cannot afford to scrap all these; so they sell them for whatever they can get. Here are ye 59-cent tubes!

But—as I intimated above—not always. It has happened often during the last year that a manufacturer of good tubes has gone bankrupt, or nearly bankrupt, and has been forced to sell his reserve stock for a few dollars in cold cash to some broker, who in turn disposes of it to large retail store operators. Then again, some large retailers of good tubes are buying them secretly direct from the manufacturer, avoiding the usual channels of distribution, and then sell them at an attractively low price, as a leader. But anything offered much below $1.50 or $1.25 is pretty likely to be either bankrupt stock or light-and-play rejects. The dealer who advised the vexed young man with the too-loving wife to pay one-fifty apiece for his tubes, instead of buying Squawking Ducks at fifty-nine cents was giving good advice—even though he didn't know any more about what tubes cost to make than his customer did.

(*Continued on Page* 52)

SM SILVER SIX



FACTS
THE "WHY" OF THE SIX"

As Described in Radio Broadcast of November and December.

SELECTIVITY is such that out of town stations may be brought to Chicago through twelve powerful local stations. Selectivity can be regulated at will, from a degree satisfactory for ordinary reception, up to the surprising limit where side-bands are cut.

SENSITIVITY is so great that nothing will surpass the "Six" except special laboratory-built super-heterodynes. Either coast may be brought in to Chicago during the summer months on a small antenna—in many cases on a loop.

FLEXIBILITY permits the use of antenna or loop with either detector, one or both stages of radio frequency amplification. Interchangeable R. F. Transformers, with adjustable antenna coupler, permit operation on all waves from 50 to 550—or higher if desired.

VOLUME is so great as to paralyze any but the best loud-speakers. Yet it may be adjusted to any degree by a single knob.

QUALITY cannot be excelled due to resistance coupled amplification. It is the only receiver that will bring real appreciation of "cone" speakers.

CIRCUIT consists of two stages of R. F. amplification with special oscillation control uniformly effective at all wavelengths, grid-biased detector and three stage resistance coupled audio amplifier.

EASE OF CONTROL allows use of one, two or three dials at will.

TUBES may be either dry cell or storage battery, with UV201-A's recommended. "B" Battery Consumption at 135 volts is below 10 milliamperes—less than one-third that of other six-tube receivers.

ASSEMBLY requires but a few hours, using only parts supplied in kit.

Mail this Coupon

Silver-Marshall, Inc., Chicago, Ill.

Gentlemen: Please send me:

A—Complete building data on the Silver "Six," for which I am enclosing 50c.

B—Descriptive circulars on S-M Products.

Name.....

.....

.....

An Auditor built the "SIX"

Mr. Plenge, a Chicago Auditor, writes:

"I cannot refrain from writing you about the wonderful results the 'Six' obtains—have built several hook-ups, but none has ever performed as well as this — Set is extremely easy to wire — finished the job in 3 hours — Second station I received was KOA Denver, through locals — Monday night I brought in 21 DX Stations with clarity and volume equal to locals—'Six' possesses fine tone and unusual degree of selectivity—Sure is a wonder!"

So did a Haberdasher

Mr. Streeter, a Chicago Haberdasher, writes:

"Bought your Silver 'Six' Kit and put the set together easily and quickly—on Tuesday night pulled in 17 out-of-town stations through the Chicago locals all around me—Can blank out WQJ (a mile away) on two degrees of dial—KOA Denver comes in at 40, WSAI at 40½, and WLS 41½—able to separate each from the other—Recommend the 'Six' for tone, ease of tuning and volume . . . wrecked a small cone type speaker with volume from local—Count me as an SM booster."

Anyone Can Obtain the Same Results

TYPE 600 KIT, including all parts necessary to build the complete "SIX" **$53.00**

TYPE 610 KIT, essentials only, including 3 condensers, 3 inductances and 3 inductance sockets **$27.75**

See These and Other SM Products at Your Dealer's

Silver-Marshall, INC.

106 South Wabash Avenue

CHICAGO

(*Continued from Page* 50)

In conclusion, I am glad to say that the expose of the doings of the unscrupulous pikers in the tube business that was published in RADIO a year ago has done its work so effectually that every single one of the fraudulent concerns aimed at has had to abandon the business. When I quietly made the rounds of Newark this year, I could find, as one Pete Peter says, "nuther hide nur hair of 'em."

It is entirely unfair at the present day to stigmatize tubes as "bootleg" because they are not made by some certain manufacturer, or to assume that they are inferior because of that fact. In the face of the findings lately in our courts, it is beginning to look as if all tube-makers, with but few exceptions, are equally involved in the alleged unauthorized appropriation of patents.

The competition of the newer manufacturers, while not the only thing that has brought the price of good tubes down close to the two-dollar mark, is nevertheless the main thing that has done it. The independent tube game certainly had an ignoble beginning in alleys and cellars; but in the space of two years it has been completely metamorphosed. Millions of dollars worth of wonderful machinery, the best of men and the finest of materials are used in the business today. Australia was originally settled with convicts, but this is little reflection on that prosperous and well-ordered commonwealth. Things do evolute.

A B C BATTERY ELIMINATOR

(*Continued from Page* 17)

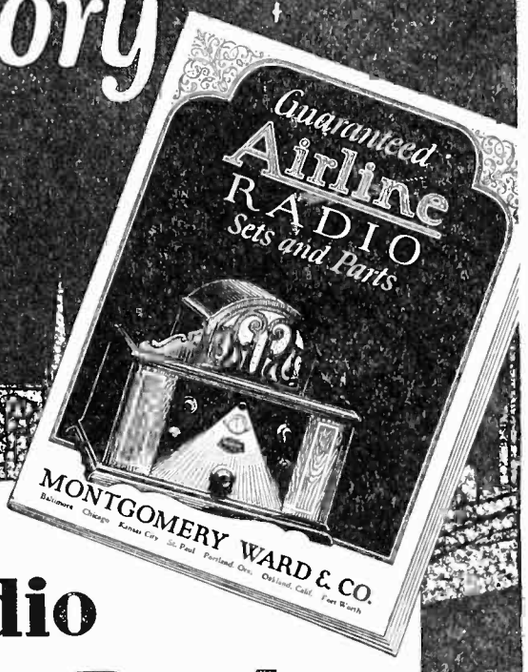
in the rectifier circuit, and the potentiometer controlling the current should again be adjusted.

The final adjustment is the detector tap, of 45 volts, which is obtained by moving the potentiometer slider nearest the filament circuit until the current flowing in the tap is approximately 1½ milliamperes. If the tube requires more than 45 volts plate, the slider may be moved nearer the positive end of the potentiometer, with a maximum of 90 volts at the positive end. If the radio set howls when making some of the voltage adjustments, the voltage may be too high for the particular circuit used, and should be lowered until the correct value is obtained. The by-pass condensers may also be insufficient to provide a low resistance path for the high frequency currents, and the amount of capacity should be increased.

It will be noted that the filter specified is similar to the one described in November RADIO, for use with the Raytheon tube. This arrangement has been found to be very satisfactory, and will give excellent service with any rectifier system. An ordinary "brute force" filter consisting of a single high inductance choke coil, and several 2 mfd. con-

(*Continued on Page* 60)

The World's Greatest Radio Story



Ward's New Radio Catalogue is Now Ready

Are you interested in seeing what is new in Radio— what is best and what has been approved?

And do you wish to know the lowest prices on tested sets, prices made without the usual "Radio profits?"

This Catalogue is a Complete Guide to Radio

Ward's is headquarters for Radio, with probably the largest retail radio department in the whole world.

This new 52 page Radio Catalogue shows everything in parts, batteries, cabinets, contains a list of stations, a radio log for recording stations. It shows the best of the new sets. One tube sets that give amazing results. Five tube sets with a single dial to turn. Think of tuning in one station after another by turning a single dial!

Every price quoted means a big saving to you. Everything offered is tested by our own Radio Experts. In fact, the best experts compiled this Catalogue for you.

Write for this 52 Page Book. It is yours free.

Our 53 year old Policy

For 53 years we have sold only quality merchandise under a Golden Rule Policy. You can rely absolutely upon the quality of everything shown in this Radio Catalogue.

ESTABLISHED 1872

Montgomery Ward & Co.

The Oldest Mail Order House is Today the Most Progressive

Baltimore Chicago Kansas City St. Paul Portland, Ore. Oakland, Calif. Ft. Worth

To Montgomery Ward & Co., Dept. 39-R

Baltimore Chicago Kansas City St. Paul Portland, Ore. Oakland, Calif. Fort Worth

(Mail this coupon to our house nearest you.)

Please mail my free copy of Montgomery Ward's New Radio Catalogue.

Name .....

Local address .....

Post office .....

State .....

RADIO EXAMINATION

(*Continued from Page 22*)

means to send Mexico and really sends Mexicg he will at once follow it with a ? ? showing that he has made a mistake. Now if you are copying every character as it is sent, you will write down the G and then have to erase it or mark over making an unsightly copy. In a commercial station you must copy messages and press correct the first time. If you are in a shore station there will not be time to do otherwise.

Notice the SOS SOS SOH. This is occasionally sent in commercial examinations. Notice also that Philadelphia is sent in two parts. It would then be copied in two parts.

The reason for insisting on copying what is sent is that if you are in the passenger service you will often receive and send messages in foreign languages and cipher. You will have no opportunity to guess.

Make all copy neat and legible, using 8 x 11 in. paper. If you scrawl unintelligibly you will be unable to make yourself understood, and may be unable to read it yourself. This is particularly so in the case of a coded test.

Anything you miss put down as an X or a dash line. This will show that at least, you heard something. Attention mark when sent will be put down as a dash line or X. If end of transmission signal is sent, put it down similarly. An ar . - . - . is put down likewise.

In a long string of ship calls the abbreviated comma (. - . -) is used between the different calls. The dollar sign, heard as - . . . - . , is unofficial. German-Spanish CH (- - - -) is used by the foreign stations very often.

Theory and Law

ALL applicants must have read the radio law before coming to take the examination. You will be asked if you have read the law before you are even allowed to make out an application. So, if you have not a copy, send to Government Printing office, Washington, D. C., for a copy of "Radio Communication Laws of the United States." This pamphlet also contains the international regulations which you are bound to respect.

A question usually asked is "what will you do when you hear an SOS"? Your best answer is that you will not open up your transmitter until the SOS vessel has sent all of its messages and the answering stations have finished all transmission relating to the distressed vessel.

This applies to all classes of vessels and stations: broadcast, amateur, ship, and shore. The important feature is that all transmission must stop except that of the stations communicating with the SOS vessel.

The amateur operator must know the

(*Continued on Page 56*)

For some—a "radio"
*For others—*Zenith!

Super-Zenith IX
Built-in Zenith loud-speaker; ample compartments for dry and storage batteries.

Super-Zeniths priced from $240 to $355.
DeLuxe Art Model Cabinets from $500 to $2,000
Other Zenith Sets $100 and $175

New Zenith De Luxe Chinese Model
Equipped with two built-in loud speakers, Bates Rotary Log, illuminated dial, single control specially constructed Zenith Radio Circuit.

Some prefer the blare of a circus band—or the friendly jangle of a hurdy-gurdy. To them it is the only music.

Those who delight in blare and jangle do not *need* a Zenith—but they will find that even such music rings truer to their ears brought in by Zenith radio.

Others go breathless at the golden notes of a lyric soprano—or the rapturous harmonies of a great symphony.

Such people—born with a love for music—should *never* content themselves with any radio instrument less fine than Zenith.

Zenith's appeal to the eye is instant—and enduring. Its clear, sweet tone is a revelation.

To see and hear one of the new Super-Zeniths for the first time is a memorable experience. Yet that experience is yours for the asking—in your own home if you so desire.

Simply telephone your nearest Zenith dealer.

Again Commander Donald B. MacMillan chose Zenith for his Arctic Expedition. When human lives may depend upon the reliability of radio performance, only one reason can explain his choice: Zenith has proved to be the best obtainable at any price.

ZENITH RADIO CORPORATION
Straus Building, Chicago

ZENITH
LONG DISTANCE RADIO

It Costs More
But It Does More!

(Continued from Page 54)

QRT and QRX signals and the commercial operator must realize that interference with SOS traffic is a punishable offense.

The theoretical part of the examinations is well covered in the various text books for the commercial operator. One of the best summaries for practical questions is E. E. Bucher's admirable little book, "How to Pass U. S. Wireless Exams."

In your diagram of a complete radio station, do not forget to put grounded protective condensers across all armatures and fields, although the books do not show this. Also put a lightning switch in the antenna circuit. Amateur theory is extremely simple and the knowledge gained from RADIO and QST is more than enough to pass such examinations.

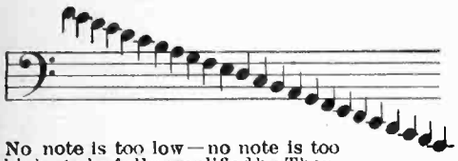
A recent addition to the commercial examinations is the substituting of questions on the broadcast transmitter for the question on the commercial transmitter. By taking a first or second class commercial examination, and asking for the radio phone questions your license will be modified to read "valid for the operation of a broadcast station." However, you will not be able to operate other classes of stations unless you have a commercial license.

By all means get an operator's license as soon as possible! The possession of even an amateur license gives you five points experience credit towards a higher class of license. If you have a station such as 6AWT, you will be easily able to argue the examining officer into giving you ten points credit. Ten points, however, is the maximum that can be given unless you have sea experience.

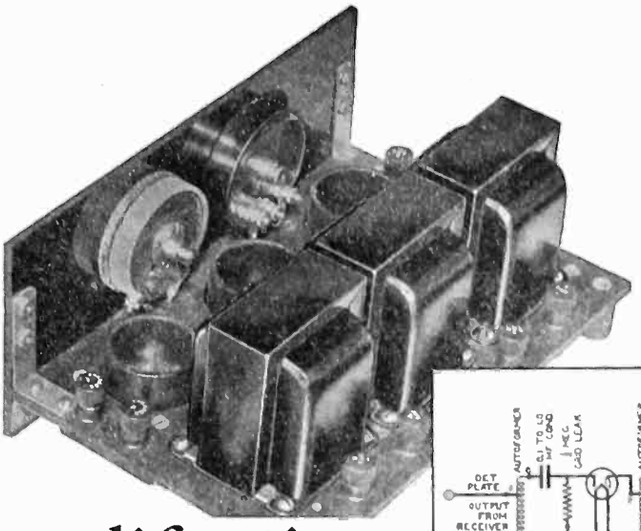
If you go up for a commercial first and fail the code, try it at 12 w.p.m. and get a second class. Or if you pass the 20 w.p.m. test but get less than 75% on the whole examination, do not refuse a second class license. Even if the license will not get you a ship job, it will give you the experience of passing a federal radio test. This experience will be valuable because the questions asked are about the same on either the second class or first class examination. And, when you go up there months later for your first class license, you will know just about what the code examination and the theory will be.

With a good breakfast, a confident feeling, and your experience, you will get the commercial first. Here's good luck.

If you are checking up your receiving distances, be sure that you take into account the curvature of the earth. The Mercator, or flat maps, are inaccurate when distances of over 100 miles are figured, unless proper allowance is made for curvature, excepting when the line runs due north and south.



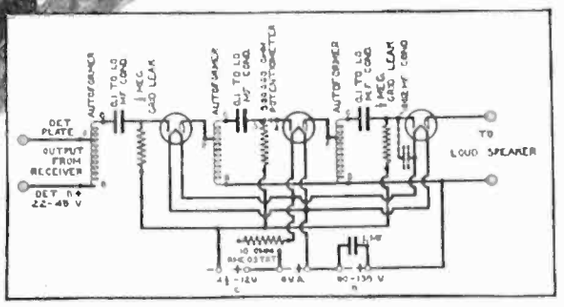
No note is too low—no note is too high—to be fully amplified by Thordarson Autoformers. Autoformers are *all frequency amplifiers*—they amplify with even magnitude ALL notes within range of the human ear. Developed, perfected and built only by Thordarson.



A Thordarson Autoformer Amplifier built in accordance with instructions and diagrams furnished with each instrument.

free!

Send for our new interesting bulletins on Autoformer amplification. They contain hook-ups and complete directions.

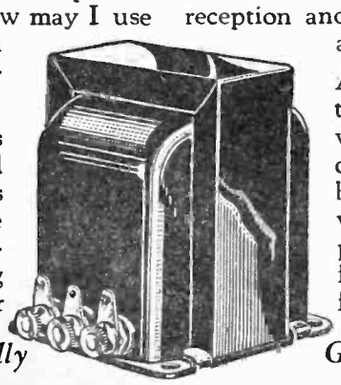


Autoformer Amplification Amazes Vast Crowds

Used at Radio World's Fair, New York City, to Amplify Programs and Announcements Broadcast by Loud Speakers Throughout the Great Halls

Tens of thousands of radio enthusiasts were completely won to Autoformer amplification during the Radio World's Fair in New York. The Thordarson Booth was besieged by fans, amazed and delighted over this latest Thordarson achievement. It was hailed on all sides as the outstanding development of the year in amplification. "What is it?" "How may I use it with my set?" Such questions were continually repeated.

Our answer was this: As the world's oldest and largest exclusive makers of transformers, we have led for years in broadening their amplifying range. In the Autoformer we have finally developed an all-frequency amplifier—a *new* instrument capable of fully amplifying *all* notes audible to the human ear. Thus the deepest notes of the grand organ, bass viol, tuba, English horn, etc., at last are brought out as clearly as those in the middle and upper registers of the musical scale. Improved long distance reception and better volume control are further advantages.



Autoformer amplification is expressly for those who seek the finest reproduction of programs to be had. May be used with any set in place of present amplifying transformer hook-up. Autoformers are $5 each.

Unconditionally *Guaranteed*

THORDARSON

Autoformer

Trade Mark Reg.

All Frequency Amplifier

How Autoformer Amplification is praised by its users

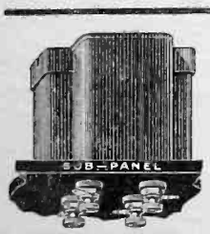
Dunkirk, N. Y., August 5, 1925.

This is to congratulate the Thordarson Co. on their achievement in producing such a perfect piece of apparatus as your Autoformer which I embodied in a new hook-up I have just completed—tuned regenerative R. F. 2 stages, soft detector and 3 Autoformers. I wish to advise that it is without parallel, exception or any comparison whatsoever, the most perfect performer I have ever seen, heard, tested or built—and I have built some pretty good ones.

Reproduction is absolutely faultless and perfect throughout the entire register—each and every note from the deepest bass to the highest treble is perfect and *uniformly* amplified. Sunday night I had Godfrey Ludlow on his 225 year old Stradivarius (from WJZ) *absolutely* perfect although it was a pretty "rotten" night. It was some treat. To-night (one of the poorest for some time) I pulled in everything east of the Rockies, that was on the air and I pulled in enough music to overcome the static to a great extent. Everything on Speaker.

She's a good D.X. getter and as for volume, has all that the windows will stand—and with all this volume does not distort any. It makes a beautiful outdoor program distributor. You can hear it plainly and perfectly for two or three blocks (at night).

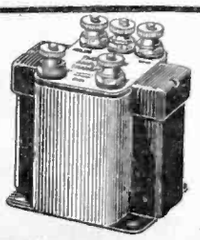
Very truly yours,
John Player.



Other Thordarson Transformers

Thordarson Super Audio Frequency Transformers are to be had in either the sub-panel or top mounting type. Sub-panel type permits neater assembly, shorter leads and concealed wiring—as in factory sets. Three ratios: 2-1, $5; 3½-1, $4; 6-1, $4.50.

Thordarson Power Amplifying Transformers, $13 the pair. Thordarson Interstage Power Amplifying Transformers, $8. All Thordarson products are unconditionally guaranteed. Shipped direct upon receipt of price, if dealer cannot supply.



THORDARSON ELECTRIC MANUFACTURING CO.

Transformer specialists since 1895

WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS

Chicago, U.S.A.

ZENITH
KENNEDY
WL
RADIODYNE
CL
Pfanstiehl
Howard
Thermiodyne
OZARKA
Deresnadyne
ADLER-ROYAL
MURDOCK
MU-RAD
Valley
LEICH
Silver-Marshall
GLOBE
ULTRADYNE
Newport
BUCKINGHAM
NUNN-LANDON
KUSTOMBILT and *many others*

Also choice of the MacMillan Arctic Expedition

use Thordarson Super Amplifying Transformers Leading set builders use more Thordarsons than all competitive transformers combined.

DX RECEIVER

(*Continued from Page* 24)

CX-220 power tubes is used in the last stage. If the power tube is employed, the *"C"* battery for the last tube is 22½ volts.

The set is quite easy to tune. Dial settings on the variable condensers are practically constant, for the tickler coil is small in diameter and has no detuning effect. To tune the set, the tickler is advanced until a "plop" is heard, indicating that the detector tube is in a state of oscillation. The detector dial is then turned until a "squeal" is heard, and set at the point where the squeal is lowest in pitch. Then the RF dial is turned to the point where the squeal is loudest. At this stage a change in pitch will be noticed, due to a slight amount of regeneration in the r.f. tube. A final simultaneous adjustment of the RF dial and the tickler will complete the tuning operation.

For local reception, it will usually be unnecessary to use the tickler. It will be found, too, that on local stations the last tube may be cut out by means of the double-pole double-throw switch, although the switch can be omitted with less wiring complications, if the constructor is a novice.

Volume may be controlled by the switch and by the rheostat on the r. f. tube. In fact, this set has given good loud-speaker reproduction of local stations with both the first and last tubes turned off. The operator will find it convenient to tune in distant stations with the headphones on three tubes and then throw the switch over for four tubes to give loud-speaker volume—with no loss in tone quality.

RADIO FOR TRAIN SIGNALS

(*Continued from Page* 18)

set which also serves to shut off the noise of the locomotive.

Due to the arcing of the pantographs overhead and the intricate mass of wiring and contacting devices aboard the locomotive, the radio telephone is not always a reliable means of communication while the train is in operation. This radio feature is at its best when the locomotive is at rest, and the machinery has been shut down. Under such favorable circumstances the radio telephone will work over a ten-mile range with excellent results.

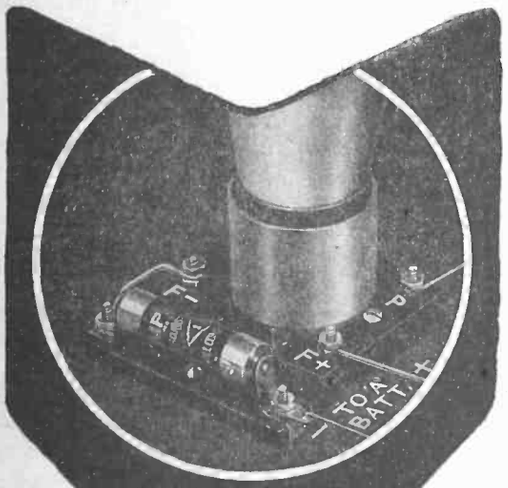
At any rate, by means of the radio telegraph alone the locomotive crews keep in constant touch with one another, using a simple code of signals. The radio telephone can be brought into play when a special condition or an emergency demands the fuller explanation that comes through the spoken word.

Phosphor bronze window screen sometimes serves as a very handy source of spring wire for small coil springs.

AMPERITE

REG. U.S. PAT. OFF.

The "SELF-ADJUSTING" Rheostat

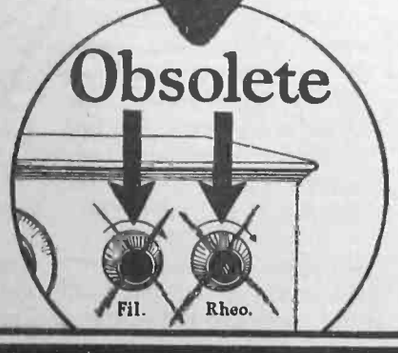


A BASIC Need in Every Circuit

BECAUSE—AMPERITE not only modernizes any set—it keeps it modern.

1—Eliminates Hand Rheostats, thereby simplifying control.
2—Permits use of the latest types of tubes or any combination of tubes.
3—Simplifies and reduces set-wiring, thereby making for greater compactness and avoids losses.
4—No moving parts, hence no grinding noises; clear and full tones.
5—Prolongs tube-life by keeping filaments at a constant temperature.
6—No filament meters needed.
7—Brings the most out of each individual tube — automatically — no guessing.
8—Makes every set-owner a master operator, no knobs to turn.

Write today for FREE Hook-Ups



Sold Everywhere
$1.10 complete with mounting (in U. S. A.)

AMPERITE is used in every popular present-day construction set. Why? Because of its many outstanding exclusive features, and because it solves the perplexing problem of tube-control—COMPLETELY and AUTOMATICALLY.

For the new tubes:

Amperite No. 112—for the UX-112 and CX-112
Amperite No. 120—for the UX-120 and CX-120

Radiall Company

Dept. R-17 **50 Franklin Street** **New York City**

Mf's of "TUNE-RITE" Straight-Line-Frequency Dial

Be sure that the set you buy or build is equipped with AMPERITE.

SINGLE CONTROL BROWNING-DRAKE

(*Continued from Page 25*)

If the dial settings of both condensers are now nearly the same, separate variable can be removed from the circuit, and C_1, the other half of the double rotor condenser, may be shunted across L_1, thus tuning both L_1 and L_2 from the same dial.

Obtain a small variable condenser such as is used for neutralizing, and try it is shunt with L_1. If at some wavelength an adjustment in this condenser increases the volume of the station being received, it is evident that some change must be made in the number of turns. As 80 turns will probably be found too great for .00035 mfd., turns should be removed until adjustments to the neutralizing condenser do not increase the signal strength, and the correct value of L_1 is now obtained. Ordinarily 75 turns will be the correct value, but if it is found that L_1 is already too small, and turns should be added to have both L_1 and L_2 in resonance at any given dial setting, it is better to remove turns from L_2 and avoid patching L_1 with unsightly soldered joints.

The size of the antenna used with the single control arrangement may affect the setting of the condenser across L_1, so that if the set is adjusted for a given antenna, and is then moved to another location, L_1 may have to be again changed unless the coupling between the antenna and secondary circuits is relatively loose. One method of loosening the coupling, in the untuned primary type, is to reduce the number of primary turns, and another is to insert a .0001 mfd. fixed condenser in series with the antenna.

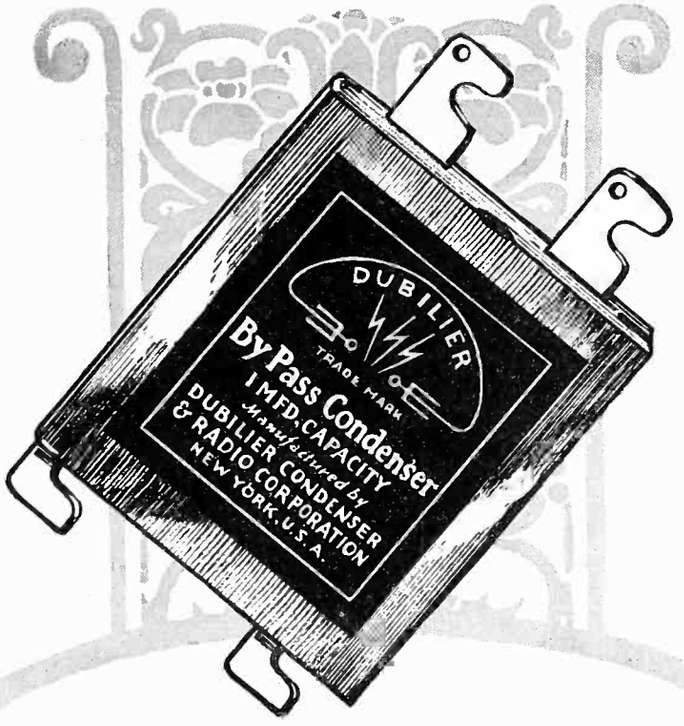
While the above changes deal particularly with the Browning-Drake circuit, there are now quite a number of other sets where the same method of single control may be applied, particularly the Neutrodyne, and those sets having two stages of tuned r. f. amplification.

A.B.C. BATTERY ELIMINATOR

(*Continued from Page 52*)

densers on each side will also serve the purpose, but it should be remembered that the better the filter, the quieter the operation of the radio set.

When connected to an 8 tube superheterodyne, the rectifier was all that could be desired, and satisfactory operation on distant stations was obtained without noise in the loud speaker, or other indication that the set was being operated entirely from the a. c. lines. Beginners in radio, however, had better take heed that while the construction of the eliminator is simple, and the alterations to the receiving set relatively few, the successful adaptation of the eliminator to an existing radio set requires a good working knowledge of the circuit of the receiver and principles of radio.



By-Pass Condenser

—*for an even flow of current and a clear flow of sound*

THE By-Pass Condenser smooths out the fluctuations of the "B" battery currents.

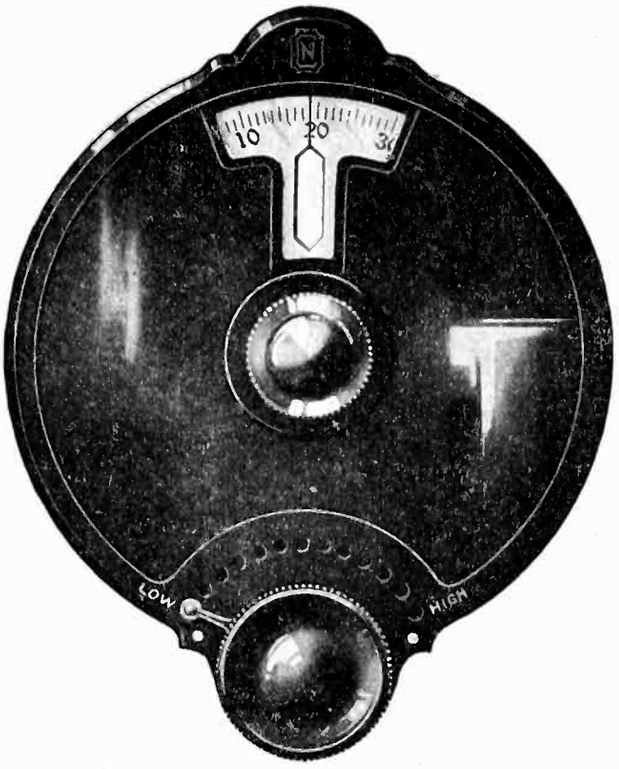
It makes the tone of any radio set greater in strength, purer, smoother. It means improved reception and *constant* quality.

Try one in your set *tonight!*

Dubilier

CONDENSER AND RADIO CORPORATION

NATIONAL



The NEW NATIONAL Type B, Variable, Velvet Vernier DIAL. (Patents pending.)

YOU
Control the Reduction Ratio!

With the *new* NATIONAL Type B, Variable, Velvet Vernier DIAL, any ratio you desire, from a minimum of 6 to 1 to a maximum of 20 to 1, is instantly obtained by shifting a small lever. It's really marvelous how it separates stations.

You'll be delighted with the difference in the tuning of your set when you replace your plain dial with this *new* NATIONAL Type B, Variable, Velvet Vernier DIAL (patents pending.)

Easily mounted on the ¼ in. shaft of any standard type of variable condenser. All you need is a screw-driver.

The mechanical principle is the same as the popular Type A, Velvet Vernier DIAL (patents pending.) It has the same velvety smoothness and the same freedom from backlash.

Price of either Type A or Type B.....$2.50

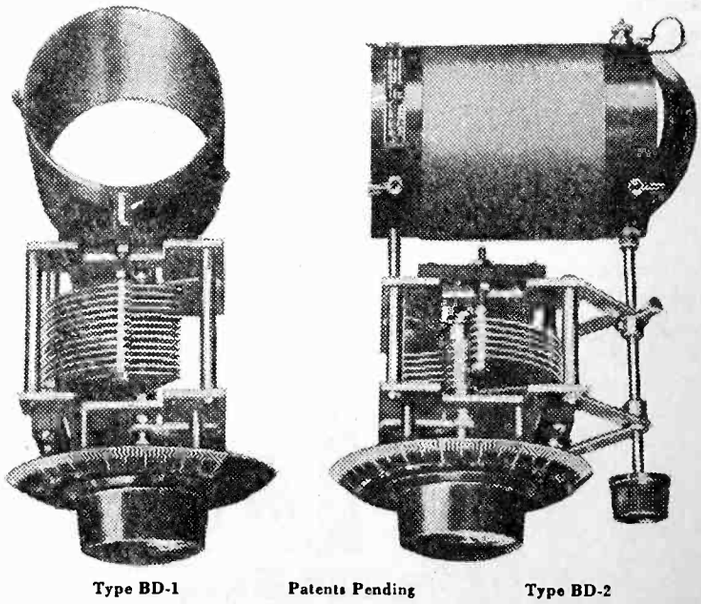
THE
NATIONAL KIT
for Amateur Set Builders

Designed for the popular circuits and hookups, the NATIONAL KIT gives amazing results to amateur set-builders. It comprises the wonderful

BROWNING-DRAKE Transformer
NATIONAL Condenser *and the*
NATIONAL *Velvet Vernier* DIAL.

Price, Complete in one package.....$22.00

The NATIONAL KIT makes a most welcome Christmas gift. Send for Bulletin 106-R.



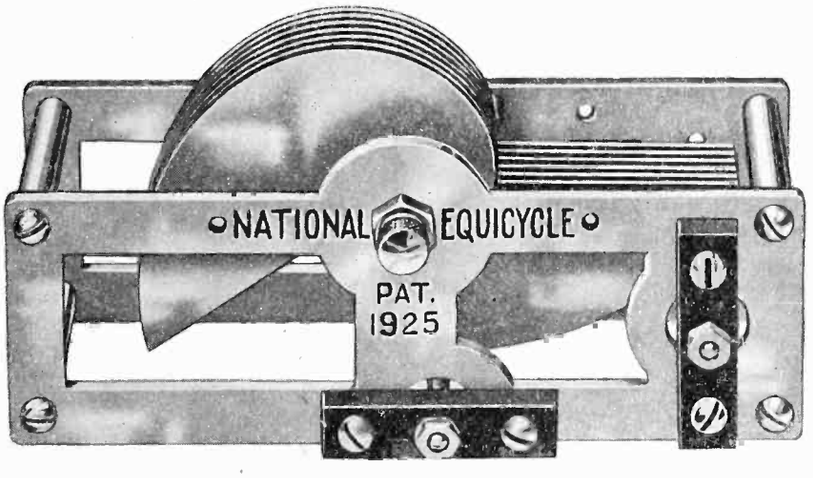
Type BD-1 **Patents Pending** **Type BD-2**

RADIO PRODUCTS

The *NEW* NATIONAL EQUICYCLE Condenser

(patents pending)

It changes a mob into an orderly procession



and lengthens the line of march!

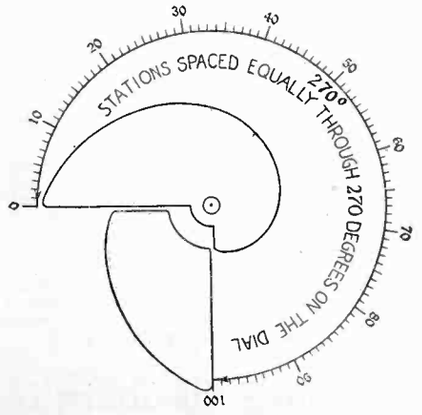
THIS *NEW* NATIONAL EQUICYCLE CONDENSER was described by Volney Hurd, Radio Editor, Christian Science Monitor, as "a distinct innovation in the capacity unit field."

It has the following features:

1—The novel shape of the plates spaces the station groups at equal intervals of 10 kilocycles (as specified by the U. S. Department of Commerce) in a true straight frequency line.

2—The useful range of rotation has been increased from 180° to 270°.

3—No gears, cams or levers are used to accomplish this result—consequently no back-lash exists and none develops with use.



4—Its greatest dimension is only 4¼ in.

5—The same electrical efficiency and mechanical ruggedness that have always characterized NATIONAL DX Condensers have been embodied in the *new* NATIONAL EQUICYCLE Condenser.

WRITE FOR BULLETIN 111-R

Get the Genuine. Insist upon NATIONAL COMPANY'S RADIO Products.
Your dealer appreciates your patronage and will gladly get them for you.

NATIONAL COMPANY, Inc.

W. A. READY, PRESIDENT

110 Brookline St. Cambridge, Mass.

TRANSMITTING TALK

(*Continued from Page* 38)

meters that choke is too large. An easy way of combining the chokes for the various frequencies is to have two sizes of choke coils in series, with the smaller first, and mounted at right angles to each other. The smaller choke will stop anything greater than about 20 meters and the larger choke will stop the wavelengths from 40 meters up. Many have found it necessary to use a choke coil in both sides of the high-voltage supply one in the negative and one in the positive lead. This need becomes most noticeable on the shorter wavelengths where a good note is desired from a motor-generator set.

The correct sizes of chokes for the different wavelength bands are: 150-200 meters—250 turns on a form from 1 to 6 in. in diameter; 75-85.7 meters—150 turns on similar form; 37.5 to 42.8 meters—100 turns ditto, and 18.7-21.4 meters—50 turns on a form with greater diameter than 2 inches.

VACUUM TUBE PROTECTION

(*Continued from Page* 33)

tained, the commercial ratings of the wires should be considered as about half their true ratings, but this is a very close margin of safety, as, especially with the small sizes, such wire may blow when least expected under a slight overload.

If a particular fuse wire is too large for certain service, and the next size smaller is too small, the larger wire may be pared down with a sharp knife, and its carrying capacity thus reduced, although this is generally a rather risky system, unless the person doing so has had considerable experience with the particular conditions of service. It will, however, serve as a good emergency scheme to obtain smaller capacity wire.

In all of these fuse schemes, it should be borne in mind that open wire, or "link" fuses, as these are called, are not approved by the Underwriters, except for open-air high tension service, on power line transformer primaries, and that the fuses described herein do not in any way replace the regular fuses that should be used for protection for the various supply circuits in a radio station. As the plate circuits of tube transmitters closely approximate the high tension transformer circuit conditions, it does not seem that there can be any great objection to their use.

In finishing wood, the popular dark brown mahogany color can be given by mixing burnt umber with a good deal of turpentine, and a trifle of linseed oil, and applying like ordinary paint. Then if this is well rubbed down, while it is still wet, and most of the color rubbed off, the resulting effect will be all that is desired. If too dark, a little raw umber can be added until the color is just right.

The common fuse plug makes a good emergency substitute for an attachment plug. Care should be taken, however, to insulate the leads, prior to using the device.

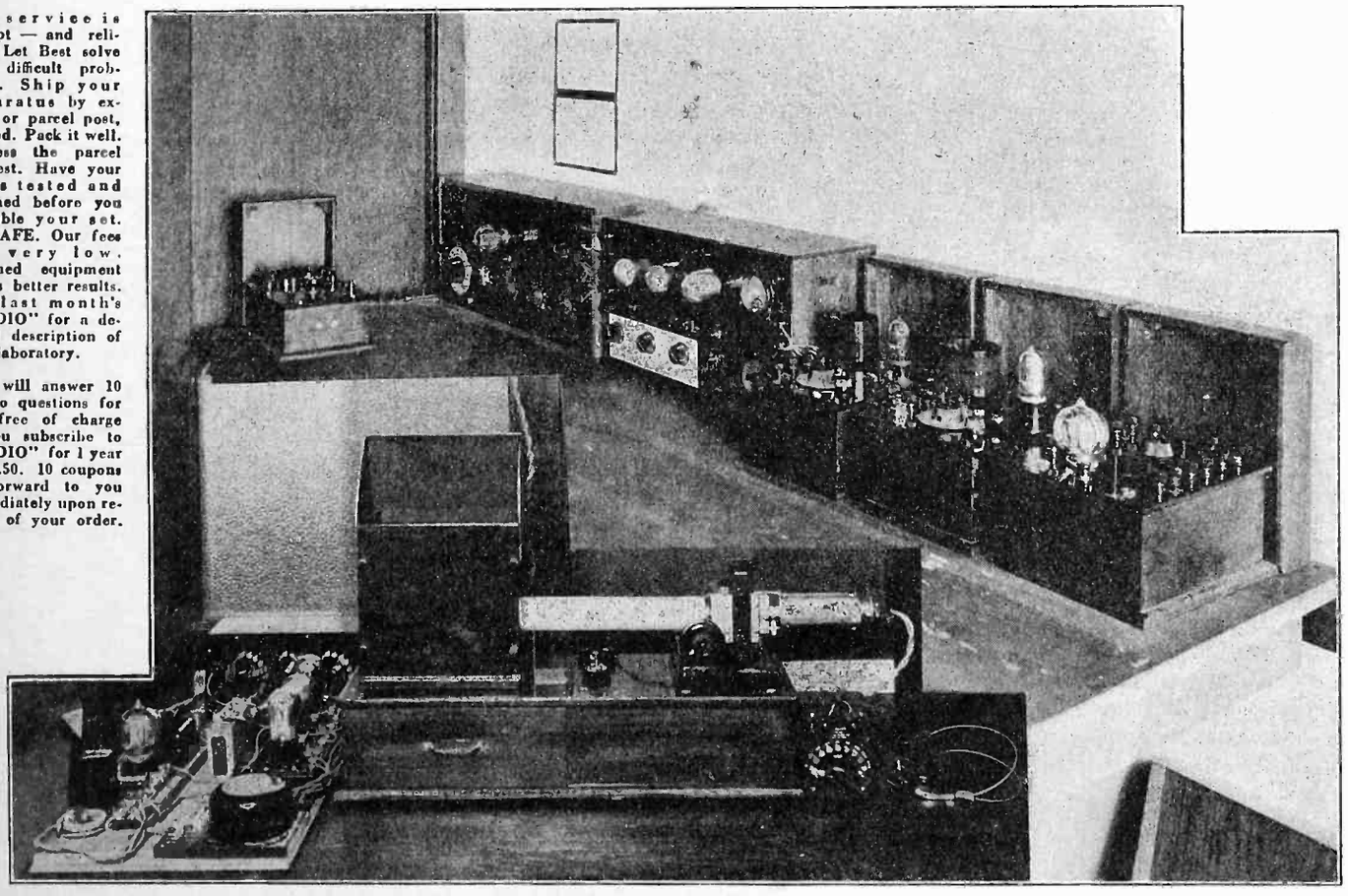
Testing and Calibration Service By Gerald M. Best

"RADIO'S" NEW LABORATORY IS *Second to None!*—

Readers of "RADIO" can now avail themselves of the testing and calibration service of our up-to-date laboratory, under the personal supervision of our technical editor, Gerald M. Best. Thousands of dollars have been invested in the most modern testing equipment, a small portion of which is shown in the illustration. Best will furnish you with test data, curves, calibration charts and a detailed report of his findings. Hundreds of our readers are already making use of this laboratory. Mail service is extended to all readers of "RADIO."

The service is prompt — and reliable. Let Best solve your difficult problems. Ship your apparatus by express or parcel post, insured. Pack it well. Address the parcel to Best. Have your parts tested and matched before you assemble your set. Be SAFE. Our fees are very low. Matched equipment brings better results. See last month's "RADIO" for a detailed description of this laboratory.

Best will answer 10 radio questions for you free of charge if you subscribe to "RADIO" for 1 year at $2.50. 10 coupons go forward to you immediately upon receipt of your order.



A Corner in "RADIO'S" Calibration Laboratory

NOTE THESE REASONABLE PRICES—

WAVEMETERS: $1.00 for first two coils, $.35 for each additional coil; $.50 extra for each curve. For buzzer type the calibration covers 100-3000 meters; for vacuum tube type 25-25,000 meters; tube type to be accompanied by actual tube and statement of filament, plate and grid voltage to be used and anticipated range of each coil.

VARIABLE CONDENSERS: $1.00 for capacity curve drawn from ten tested points, including maximum and minimum.

FIXED CONDENSERS: $.25 each for calibration at either radio or audio frequency as specified.

GRID LEAKS: $.25 each for d. c. resistance.

INDUCTANCES: Fixed or variable; $.50 each up to 100 millihenries; $.75 from 100 millihenries to 1 henry; $1.00 above 1 henry.

I. F. TRANSFORMERS: $2.00 for matching with specified tuned transformer; $1.00 for frequency characteristic curve.

A. F. TRANSFORMERS: $1.00 for curve of frequency characteristic from 60 to 5000 cycles; $.50 for impedance or inductance measurement at any desired frequency.

VACUUM TUBES: $.50 for measurement of amplification constant at any one audio frequency.

All equipment should be securely packed in wooden box with screwed lid so as to be usable for return shipment. Fees do not include return express or insured parcel post charges, which should be added. Stamps not accepted in payment.

ADDRESS ALL COMMUNICATIONS TO CALIBRATION LABORATORY

"RADIO" - PACIFIC BLDG. - SAN FRANCISCO, CAL.

TWO CHRISTMAS EVES

(*Continued from Page 21*)

"No. No more. Guess I'm getting old, son; I don't sleep well lately." He was serious now. "So business is taking up radio at last," he murmured, more to himself than to me. "That means it'll soon be used just like the telephone. I knew it would come!"

"Maybe you knew it would come, but I didn't," I confessed, proud to acknowledge old Dan as my teacher. "Old heads are best, Dan: to me the spark was a 'thing of beauty and a joy forever,'—when you told me it was doomed I wouldn't believe you. I'm sure glad now, that I changed my mind."

At last I managed to get out; "This is the first decent job and the first decent salary I've ever had, and I owe it to you, Dan. Thanks."

"If I've helped—you know I'm glad, Jimmy. There was a pretty good man lived once, about two thousand years ago, who believed in helping." He laughed softly as he settled back in his chair, remembering the times when he helped me with my boyish "ham" problems. "You were a funny kid. I'll always remember the first time you came aboard and looked at my bum set, as though it was a cross between the circus and Heaven. You said you wanted to ask a question: you wanted to know how I grounded the set when we were out on the Lake where there wasn't any ground."

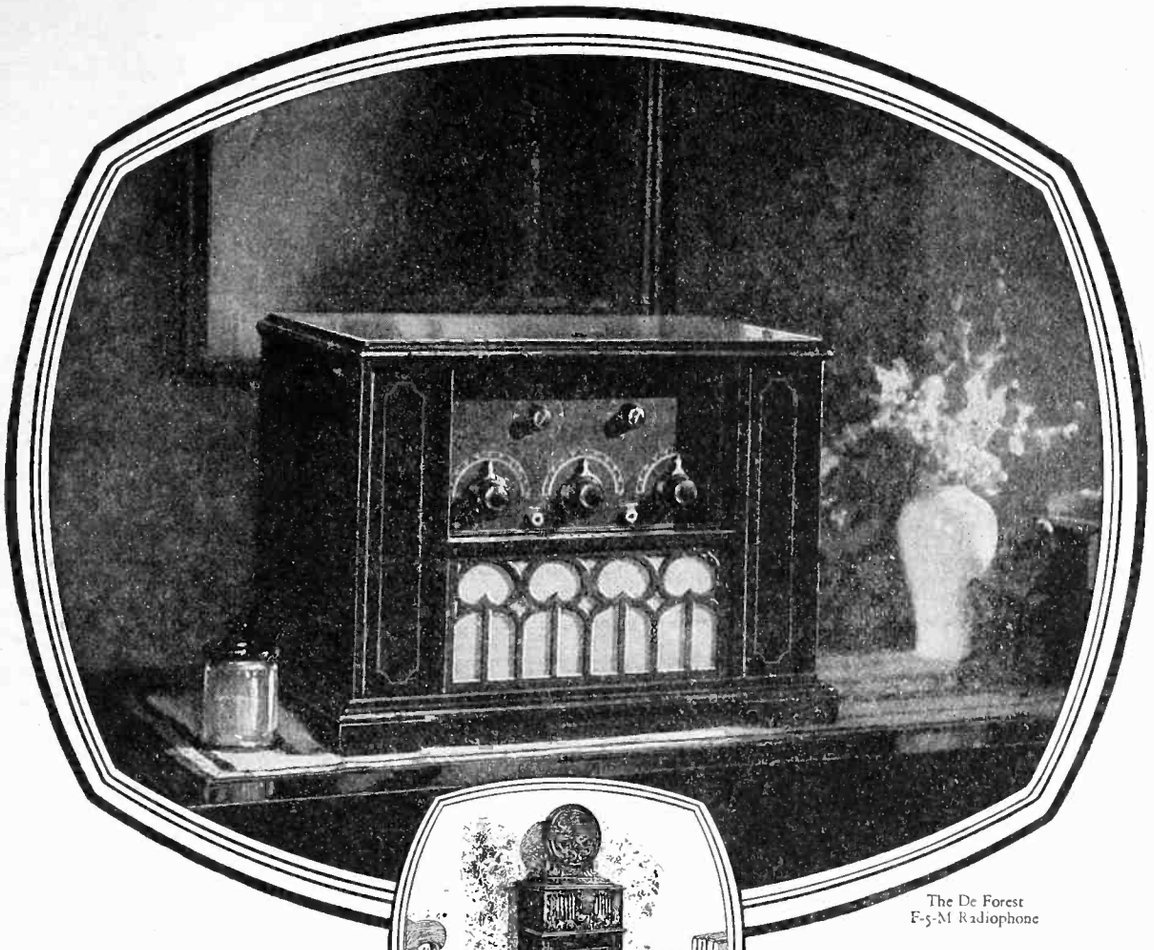
"I was only eleven," I grinned, sort of embarrassed. "That was in 1910 when I was just putting up my first aerial. I don't know how I ever got up nerve enough to come aboard without permission. You had an iron pyrites detector that I thought was wonderful."

Content with each other's company and with the warmth from the oil stove—incidentally, due to Dan's tinkering that stove was the one oil stove I have known, without an odor like that of the annual picnic of the combined Amalgamated Glue and Limburger Cheese Unions—we sat silently for a while, then. The intense cold forced some of itself through the ancient wood of the radio shack's walls, just enough to intensify the comfort of the heat, and it was so quiet outside that we heard—or fancied we heard—the soft drifting touch of the snow falling on the roof. The old boards popped and cracked from the icy cold.

Suddenly the front legs of Dan's chair, coming to the floor with a thump, signified that he had heard something interesting. "C. W., Jimmy," he shouted at me, busying himself with the dials of his receiving set.

I had been working with C.W. every day for a week; it was nothing for me to get excited about. I watched Dan, instead of taking one of the 'phones, and tried not to notice how tired and old

(*Continued on Page 68*)



The De Forest
F-5-M Radiophone

The De Forest W-5 which sets a new epoch in cabinet artistry and tone reception.

DE FOREST

The Greatest Name in Radio

A Peerless Value from the Master Scientist of Radio

SELDOM are the finer things of life introduced at popular prices. The cost of originating the new usually prohibits low price.

But here is a notable exception—the De Forest F-5-M Radiophone, a masterpiece in performance, quality and dignified beauty, from the master mind of radio science.

Everything about this marvelous set is exceptional. The circuit is new—and ingenious. Known as the De Forest Balanced Circuit, it gives to radio tone the rich realism of life. Low and soft tones that usually die away in a misty blur are reproduced distinctly and musically. Very high tones that seem to climb into the infinite and flutter away like white butterflies against a blue summer sky are borne to your ear with a clearness and sweetness new to radio devotees. Individual parts in quartette and choral harmony are intensified—something new in reception.

This self-same circuit also contributes economy to operation. It reduces the drain on batteries, thereby lengthening "B" battery life and the interval of recharging or replacing "A" batteries.

Refreshing, also, is the manner in which this new circuit tunes in stations . . . without scraping and whistling.

New power qualities, distance mastery, station separation and volume are added by other newly devised mechanisms. And art intervenes to add the final touch . . . grace and symmetry in cabinet design, the tone reproducer in-built and out of sight, "B" batteries housed in a compartment within the cabinet.

Yet the price is only $110! (*Western prices slightly higher.*) See and hear the F-5-M at your nearest Authorized De Forest Dealer's.

Price range of De Forest Radiophones—$85 to $450.

DE FOREST RADIO COMPANY
Jersey City, N. J.

For better reception and longer tube life always buy De Forest Audions. There's a special one for each socket. De Forest invented the radio tube—there can be none finer. $3.00

(*Continued from Page 66*)

he looked, and how his skin, that looked like wrinkled leather against the whiteness of his hair, was changing. Finally he beckoned me to take half of his "Baldies," and I heard the then unusual note of a low-powered C.W. I came in just in time to get the last few letters before he stopped sending.

"That's an airplane," Dan said excitedly. "Must be a private one, or he'd have used a call. Unlicensed, the nervy devil! Just said 'Qst 2000 feet above city; how do you get me? A-i-r.'"

"By gosh, that's young Marshall," I guessed. "I heard one of the fellows at the store say that his dad had bought him a plane. And I know that the Old Man would never have put in a radiocast set if his son hadn't interested him in it. Did you notice the bum fist?"

"Well, he's crazy, to go flying around in this kind of weather," Dan muttered. "If he should get caught in some of this wind and dumped into the Lake he'd be frozen stiff in a few hours."

The next day while I was working on the roof at Marshall's, Mr. Marshall himself dropped in to see what progress we were making, and I verified the fact that it had been his son in the plane. "My boy goes to school up at St. John's," the grim old financier told me proudly, yet I detected a worried note in his voice. "He's down—for the holidays, and I bought him this hydroplane to go along with his racing car. He's interested in this radio—has one on the plane, in fact. He'll amount to something some day."

That came close to a confession that so far the boy hadn't amounted to much, but I didn't hint at the fact. "I've never met him, Mr. Marshall," I said, having no idea at the time that I was going to meet him in the very near future. "By the way," I continued, changing the subject, "I read of a new phonograph reproducer that is being put out in New York for radiocast stations. It's rather expensive. Do you mind if I write to New York for one of them?"

"Write, nothing! Jump on a train as soon as you get time and go to New York and bring one home. I want only the best in this station, and don't worry about the expense."

Lord, why didn't someone say that to me when I was playing the little game of rebuilding condensers and having masts fall down on my head, called Being An Amateur!

Anyway, about three o'clock in the afternoon who should drop in but Dan, weaned away from his loved radio shack by his interest in me. He was followed a few minutes later by a young fellow, eighteen or nineteen years old, dressed in million-dollar clothes and with a cigaret hanging from his lips—a visit not unusual, for lots of people, thanks to the newspapers, had been coming up to

(*Continued on Page 70*)

(*Continued from Page 68*)

see how the station was getting along. Remember, there were no huge factory-built installations then: I was practically building the outfit right there on the roof, with the aid of some blueprints and what knowledge of theory I had got from Dan's advice.

"Dan, this is a good chance for me to see how the set sounds over the air," I said. "How'll it be if I run down to the boat and listen in on your set, while you work this one for me? I've never heard how she sounds over the air."

"Nope, Jimmy. You can't teach an old dog new tricks!"

"Oh, can't you?" I shouted. "Well, it seems to me that the old dog taught the young one some new tricks, in this case."

"No, I told you to go *learn* the new tricks; I didn't teach 'em to you, Jimmy."

"But, Dan, I've got her wired so that one switch controls the whole shooting-match. Look here—you just throw this and talk, and throw it back to turn everything off." I thought that would fetch him. I was right. We figured the time it would take me to get to the *S. S. Moper,* and I left. In a short time I heard Dan's voice; listening on the *Moper's* set which Dan had come to think of as his.

If I heard that modulation today I'd shriek and go around shooting innocent bystanders with a knife, but then I thought it was fine. I could understand what Dan said, and in 1921 that was more than sufficient. "Hello, *S. S. Moper,* Hello *S. S. Moper.* How's this? How — do — you — get — me? Hello-o-o —"

Suddenly Dan's voice stopped, and I heard the echoing sound of footsteps in the uncarpeted room on the roof of Marshall's store, followed by the distant sound of two voices arguing. For a few minutes after that I could get nothing but the hum of the generator. The silence was beginning to worry me when Dan came in and said, "A little trouble here. Can't tell you over the air, Jimmy; it isn't the set, though. Better come right away." I heard the hum die as he pulled the switch.

Anxious, I rushed back to the roof. Dan had sounded sick at heart. Suddenly the freezing winter seemed crueller. The holiday red and green that hung everywhere was a bit less joyous, a bit more artificial, as though people's hearts were not behind the decorations.

I found out soon enough what had happened. The young fellow whom I had seen enter the station, just after Dan, had become excited as soon as he watched Dan talk into the microphone, and had demanded to be allowed to do the same. Dan had refused, and after the argument I had heard over the air, he had tried to take the microphone out

(*Continued on Page 72*)

FADA Radio

Tune up your toes-Lopez is on the air!

ROLL back the rugs! Roll back the years! It's time for stepping out—when FADA RADIO lures Lopez into your home!

But unless your Radio is up to the FADA RADIO Standard of Reception—even the marvel-music of Lopez may sound like a Hurdy-Gurdy. To get perfect clearness, perfect tone-shading, satisfactory volume—you can depend on FADA RADIO—daily more widely recognized as the criterion for all radio performance.

And the ease with which you can tune in and out with FADA RADIO makes any evening's program one strictly of your own choosing, whether the desired stations are close at hand or scattered over the continent.

Strong Statements—Let's Prove Them! Of course, the best way to judge FADA RADIO Reception is to hear it in your home. The nearest Fada Authorized Dealer will be glad to demonstrate one on trial, free of obligation. Most of them will arrange convenient terms of payment if desired.

And remember, when you own one, FADA RADIO Service guarantees the maintenance of the Fada Standard of Reception.

There is a Fada Radio model for every purse—all 5-tube Neutrodyne sets for dry cell or storage battery tubes, from $85 to Art Cabinet models up to $300. Illustrated is the Console at $275.

F. A. D. ANDREA, INC.

CHICAGO NEW YORK SAN FRANCISCO

FADA RADIO, LTD.—TORONTO FADA RADIO, LTD.—LONDON

Manufacturers of TUNED RADIO FREQUENCY *receivers using the highly efficient* NEUTRODYNE *principle*

Send to F. A. D. ANDREA, Inc., 1581 Jerome Avenue, New York, for book B, "FADA RADIO—the Standard of Reception"

(*Continued from Page 70*)

of the older man's hand. He had some friends who would be listening in, he said, and he wanted them to hear his voice over the air. Naturally Dan had refused, both because he suspected the boy had no license and because he didn't think I wanted anyone to touch the set. Finally the boy, in a rage, shouted that he was Mr. Marshall's son, and sneeringly promised Dan that he'd pay for his insolence and for what he had done.

Dan was sick with worry, and so was I. But we couldn't do anything but wait. The next day Dan was called on the carpet and fired.

That evening Dan and I had dinner together—a dinner which Dan didn't touch, and which we ate without either of us speaking a word. When we were through, Dan broke the silence:

"Jimmy, you think I'm crazy to love that job on the old *Moper*—and my set so much, don't you? I'll tell you why—"

And he told me his story:

"Jimmy, I've drifted for twenty years, trying to forget something that happened. I—when I was just a little older than you are now, I was married—to the most wonderful woman in the world, and—I had two sons. Two baby sons. Five years of happiness. Then—and it was Christmas Eve—it seems like Fate that all this has happened now, with Christmas Eve the night after tomorrow night, Jimmy—it happened." His voice was hoarse, now. "It happened."

"I came home from work, Christmas Eve, with my pockets stuffed with candy and a few extra things I had decided to buy for presents at the very last moment. I was thinking of the welcome I'd get at home, with my wife's face shining in the glow from the lighted tree, and of the excitement and mystery of preparation for Christmas Day. I was planning how I'd play with—my boys, and then as I turned the corner where our house had been, there was no house; only a square, black patch against the white, cold snow, with icicles already forming on the smoking black timbers, where the engines, too late, had tried to put out the fire."

He stopped, and it was a long time before he went on, with the heart-ache of twenty years of loneliness dragging every word that came from his lips: "There was no little wife, Jimmy boy, and there were no little boys. They were all gone—burned—and we never even learned how the fire started. I suppose it was from the Christmas tree.

"I drifted, starting that same night. I went to sea. After a year or two the sea herself, with her greatness, brought me to my senses. I realized that I had been out of my head for months on end, that I was slowly going mad. Then I fought it. 'Dan,' I would tell my-

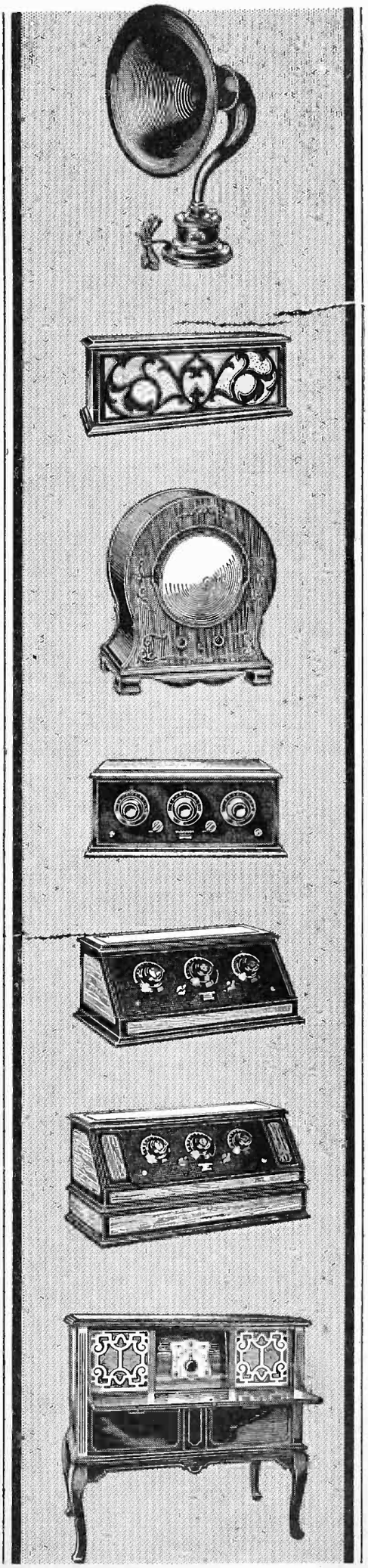
(*Continued on Page 74*)

Where great radio inventions were first produced

ALL the leading authorities in radio know of the famous Thompson laboratories, for during the past 16 years over 116 different types of radio apparatus have been designed and manufactured by Thompson; many of the important problems of radio were solved by Thompson engineers.

Out of the Thompson plant came many of the intricate devices used by sailors on the seas, soldiers on the field of battle, and by radio operators in aeroplanes and submarines. The radio direction-finder, the sonic depth indicator, the light-weight aeroplane transmitter, etc., etc., have added to Thompson renown.

This bulwark of scientific and practical radio experience stands back of Thompson products today. It is your assurance that in design, manufacture and performance, Thompson Radio will meet your most critical expectations. Thompson Receivers are priced from $125 to $360. Thompson and Thompson-Fuller Speakers, $28 and $35. All prices slightly higher west of the Rocky Mountains and in Canada. Sold by the better dealers everywhere. R. E. Thompson Manufacturing Company, 30 Church Street, New York City.



THOMPSON RADIO

LICENSED BY INDEPENDENT RADIO MANUFACTURERS, INC. NEUTRODYNE REG. U.S. PAT. OFF. REG. U.S. PAT. OFF. DAT MARCH 27, 1923 AND APRIL 1, 1924 HAZELTINE DATS NOS 1450 080 AND 1482 220 OTHER PATENTS PENDING R.E. THOMPSON MFG. CO. 30 CHURCH ST. N.Y.C.

BUILT BY MAKERS OF ARMY AND NAVY RADIO APPARATUS USED BY LEADING NATIONS

(*Continued from Page 72*)

self, forcing myself to listen—'Mary won't have any more respect for you—it won't show that you love her, if you spend the rest of your days in an insane asylum. Mary wouldn't want her husband to be an idiot. Buck out, Dan. Get interested in something that will take your mind off it all, keep you from brooding!' I was a common sailor on a tramp freighter going to Australia at the time. I never even remembered starting the voyage. I went to the skipper and asked him for a book. He gave me one on electricity. I learned it by heart. Not interested in the book, I forced myself to memorize page after page. When we docked I had a big pay check coming; I had never gone ashore, never spent a cent. I spent all my pay for books. One of them mentioned wireless telegraphy. I really began to get interested.

"When I quit the sea and drifted to Chicago, the first wireless sets were being installed on the boats on the Lakes. I got a license and a job. Radio gradually came to fill the place in my heart those others used to hold, I suppose—now that I look back on it. There—there are two things in the world I love: boys, because of my own sons, and my old set on the *Moper.*"

"Every man has to have something to love," I said, blowing my nose. "Even that old ——— Marshall loves something. His store and his son."

"And that's why I don't blame him, Jimmy. He's choosing between hurting my feelings and hurting his boy's feelings—and he's choosing in favor of his son, just as I'd do. What Mr. Marshall doesn't realize, of course, is—that set on the *Moper,* it's like a son to *me,* Jimmy."

I planned to leave for New York the next night. One night on the way, a day in New York to get the stuff I needed, and a night to return. Coming back to Chicago, spending Christmas Eve on the train, would get me into Chicago in time for Christmas day, in the morning. Before I went I bearded the lion in its mahogany private office, and talked to Mr. Marshall. I almost lost my own job. In vain I pleaded, as a last resort, that Dan had only been obeying a Governmental statute forbidding those without commercial licenses to operate a commercial installation.

"He insulted Robert," was all Mr. Marshall would say. "I allow no one to do that. I will do absolutely nothing about the matter. The man is discharged, and he will not be rehired."

"But Mr. Marshall," I made a final attempt. "He's an old man. He couldn't get another job even if he could stand one, away from radio. Honestly, Mr. Marshall, if he has to get a job as night watchman or dishwasher some

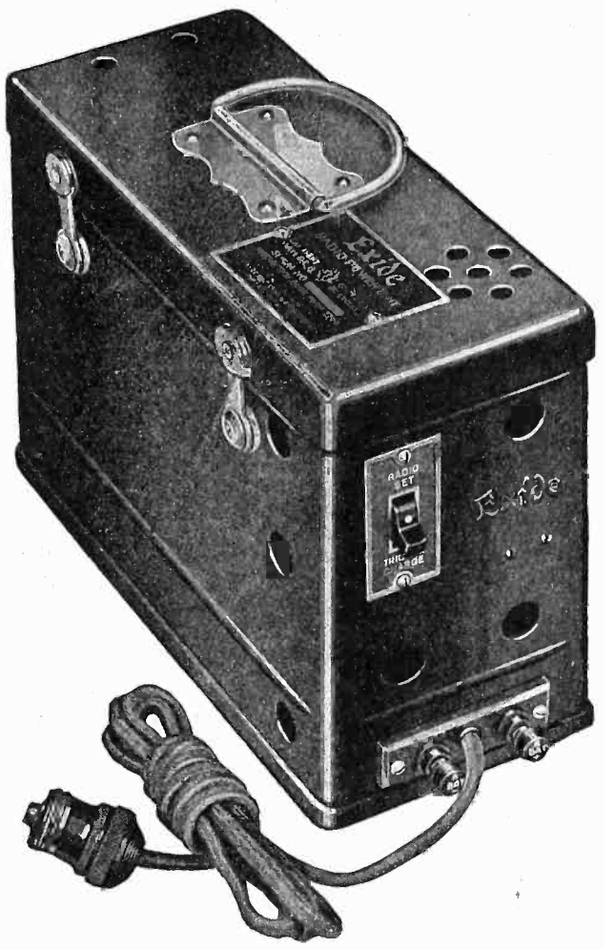
(*Continued on Page 76*)

6-VOLT "A" BATTERY
Here is the rugged, good-looking Exide 6-volt "A" Battery. One-piece case.

2-VOLT "A" BATTERY
Compact Exide for low-voltage tubes. Also made in 4-volt size.

24-VOLT "B" BATTERY
In glass cells, 6000 milliampere hour capacity. Also in 48-volt size.

RECTIFIER
Exide Rectifier for economical recharging of "B" Battery from your own house current.



THE EXIDE RADIO POWER UNIT
(Combination "A" battery and charger)

This unit is kept connected to your electric light socket as well as to the radio set. Raise the small switch on the end and the receiving set is ready for use; lower it and the battery is automatically placed on charge. Finished in rich mahogany color, the Exide Radio Power Unit is furnished in two sizes — one, for sets using 4-volt tubes; the other for sets using 6-volt tubes; retailing at $28 and $38 respectively — slightly higher west of the Rockies.

Range far and near with your radio set

BRINGING in the distant stations, selecting the choice numbers from local programs — in short, getting the most enjoyment from your radio set — is largely a matter of proper current supply.

All the distance, volume, and clearness that an ample, uniform supply of current gives to radio reception are yours when current is supplied by Exide Radio Batteries. There are Exide "A" and "B" storage batteries for every requirement, and a rectifier for recharging "B" storage batteries.

See the complete line at any Exide Dealer's or at your favorite radio store.

Exide
RADIO BATTERIES

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia
Exide Batteries of Canada, Limited, 153 Dufferin Street, Toronto

FOR BETTER RADIO RECEPTION, USE STORAGE BATTERIES

(*Continued from Page 74*)

place, he'll kill himself—or die of heart break. He loves that job on that *Moper,* and that radio set."

"Old? All the more reason for getting rid of him," Mr. Marshall smiled. "The boat he worked on is getting too old, too; I'm going to junk her in a short time; we no longer need her, with railroad rates getting cheaper and cheaper. I should have scrapped her before now, and the radio operator she does not need along with her!"

Without seeing Dan again, I caught the flyer that night for New York.

* * * *

CHRISTMAS Eve, Robert Marshall attended a hilarious party at a girl friend's. With his girl, he went out on the porch to look at the sky, where black clouds were racing across the cold white moon before a fifty-mile gale. That same wind was playing havoc on the Lake, where it drove snow and sleet across the water and blinded the shipping worse than any fog could have done. "What a glorious night," the girl exclaimed rapturously. "How powerful it is! Just think, if we could fly up there into that seething blackness."

Five minutes later young Marshall was in his racer, headed for the hangar on the Lake, where he kept his plane. He was alone. At the last moment the girl refused to go with him. Sliding down the driveway at the wheel of the roaring car, he turned and shouted back to the awed group left behind on the porch that he'd call them by radio from the air when he got up, knowing that there was a receiving set in the house and that one of the boys could read code. Christmas Eve, Old Dan sat in his warm little radio cabin for the last time. Wearing the familiar 'phones, he stared at the glowing lights of the tubes, hardly able to realize that no more would they bring things out of the air to him. His two battered, thin suitcases lay near the door. Dan was unable to believe that he himself had packed them. Why should he pack suitcases? He had no place to go—. So these were the last few hours on the *Moper!* His gnarled, brown hands twisted the dials slowly. 200 to 800—back slowly to 200. On this last night he wanted to hear all that was in the air; he wanted to store away in his memory all the familiar calls and tones, so that he might keep them in his heart forever.

Suddenly Dan jumped. The whistling note of a C.W.—and a note that he had heard before, at that. When had he heard it? He thought of me and of my story about young Marshall's new hydroplane, and his face became grim. Could the fool be flying on a night like this?—when the Lake was wrapped in the worst storm in twenty years? His keen ears, trained to note and remember

particular notes, told him that it was really Marshall's son, up in the roaring storm.

"AIR," came the throaty whistle. "Had hard time getting up. Wonderful up here. Am heading over Lake 100 mph. Will circle and pass over house at 1000 feet."

Dan wondered to whom the message was directed, not knowing that Robert Marshall was trying to reach his friends at the party. Robert himself had no idea that the icy wind had torn the words from his lips when he shouted back to the people on the porch, so that it was impossible for them to hear what he said. They were not listening for him, though they rather expected him to pass over the house. Dan wondered also at the extreme jerkiness of the boy's fist, till he happened to think that the boy was sending with one hand and guiding a steeply bucking and heavy plane with the other and with his feet—then, in spite of his human dislike for the boy, he admired his nerve. The code started again, wavered, began once more—and became one long dash, like a wail, which cut off suddenly. Then came SOS, wildly, hurriedly—followed by silence.

Dan leaped to his feet, sensing instantly what had happened. He saw a clumsy hydroplane flung by the wind and turned upside down to fall heavily into the icy water, while a game, white-faced boy tried to send a distress call even as the plane fell. The black water, driven by the fierce wind, was pitching with large waves that would break a plane to pieces in short order.

Beads of sweat stood on Dan's brow. What could he do? Evidently no one else had heard the C.W. Instinctively he threw the master switch of the *Moper's* transmitter, but without result. There was no power; not with the boat tied to her moorings. He sat down again. Mr. Marshall's son! Let the little snob drown! Why save him just because Mr. Marshall loved him? Had Mr. Marshall worried about saving Dan's job for him, merely because he loved it?

Well, there'd be death this Christmas Eve, as there had been on a Christmas Eve years ago. Still—the time of Good Will to Men, wasn't it? Oh, God! He rose and started for the door, but returned to his battered chair beside the oil stove and began the fight over again. He asked himself what he could do? There was a speed-boat tied up at the next wharf, but how was he, an old man, to start it and guide it out into the freezing hell that was Lake Michigan? It was certain death. That would help nobody—making two deaths instead of one. There was no one else around to run the speed-boat, though. He rose again, sighed, and straightened.

Then Dan galvanized into action. Hatless and without a coat, he threw

open the door, climbed to the wharf, and ran till he saw a taxicab. Gasping from his long run, he fell into it and asked chokingly for Marshall's Department Store. Arrived, he found the street doors locked. He kicked his way through the plate glass panels, felt the splintering stuff bite into his leg, dashed into an elevator and took a chance on running it, so that he might more quickly reach the roof. The elevators were running, and by a miracle he reached the roof safely, though he had never touched the control of an elevator before. He had to return to the top floor to get a chair with which to smash in the door of the broadcasting room, which was locked. He snapped on the electric light, and saw that the power was on; the set that I had built lay before him.

Pausing just the fraction of a second as he remembered Mr. Marshall, he threw the switch and glanced at the tubes to see if they were burning—the faces of the meters were unfamiliar to him, except that of the antenna ammeter. He knew that thousands of amateurs would be listening at that time of night—would be eager to tune in the unusual sound of a voice over the air. To them he spoke. "A hydroplane piloted by Robert Marshall of this city has just fallen into the Lake, between five and ten miles from shore, near here. Please do everything available to help. All boats out." This was the broadcast which resulted in the great numbers of private and police power boats which turned out, all up and down the Lake shore. From the results, every amateur must have known ten people who owned fast launches,—and they were amateurs who called the police and fire departments, too.

Dan rushed down again to his taxi, wincing as the pain of his gashed leg bit in, and leaped to the ice-glazed running board. There he clung, holding down the horn for free passage, while the driver raced his cab through the streets of Chicago to the dock at full speed. They stopped at the wharf where the slim white speed-boat was tied.

"I can't start it," Dan gasped, shivering with the cold.

"I work as a speed-boat mechanic every summer," the young fellow driving taxi volunteered. "Let me do it, boss."

Together they warmed up the frozen motor and broke through the yards of ice which separated them from open water. Where the ice was thin the boat could cut its own way. They headed out into the Lake, describing great arcs that took them ever farther and farther from the shore, and fighting every inch of the way against winds bearing knife-edges of sleet, and against waves that the light racing boat had never been built to withstand.

Just as the plane, with its floats leaking, was beginning to sink, they found

him. Dan and the boy collapsed and had to be brought home in the bottom of the boat. The taxi driver lasted till shore was reached; he was the driest and most heavily dressed of the three.

Christmas Day I had dinner at the hospital with the three of them. And—oh, yes, Mr. Marshall was there too, and annoyed us by blowing his nose tearfully every few minutes. He paid the bill for our dinner, which was brought in divisions by six different caterers. His son Robert explained that he had acted as he had because of being expelled from St. John's for refusing to tell the name of a room-mate who had cheated. He had been angry with all the world, the day he and Dan had their little encounter. He had gone up in the storm because he felt that if he were killed it would relieve his dad from the disgrace of his expulsion from school. What a kid!

SEVERAL years have gone by, now, and Marshall's radiocast outfit is a huge thing that would make my little set that I built look like an accident. Gone are the days of soup-strainer modulation and canned music. A salaried man operates the set; I am in charge of the Studio, if you please.

Down in the Radio Department, a white-haired, kindly man sells radio sets to boys. He has no other customers; other clerks take care of all the grown-ups. Dan has the two things he loves in life—radio and boys, together. Occasionally, when I ask him, he comes up on the roof and tells stories of his adventures at sea to listening youngsters. Or else he tells bed-time stories to the little folk.

They call him "Uncle Dan."

TRANSMITTING CIRCUITS

(*Continued from Page* 28)

It will be observed that in this circuit, the plate energy is supplied through a *shunted power feed circuit* in contrast with the *series feed circuit* heretofore employed. The inductance L_1 is one of low intrinsic capacity and for circuits operating at 200 meter wavelengths, it may consist of a 200-turn lattice wound coil of the character used in receiving apparatus.

Unless properly built, home-made "a.c. current supply" devices are liable to be dangerous. In most cases the current is supplied to the distribution system at 2200 and 4400 volts pressure, or even in some few cases up to as high as 11,000 volts, and if it should happen that there was defective insulation in the step-down pole transformer, there might be some portion of this impressed on the low voltage system, and as the usual current supply set made at home is not any too well insulated, serious results might take place.

ULTRA-SELECTIVE CRYSTAL SET

(*Continued from Page* 14)

has no electrical connection with either set of plates, and the Remler condenser fills this requirement very nicely. That is the reason that it has been chosen.

A baseboard is not needed if the set builder never intends to make more than a crystal set out of it. However, for one tube and more, a baseboard is needed and later trouble will be avoided if the binding post strip is mounted as shown.

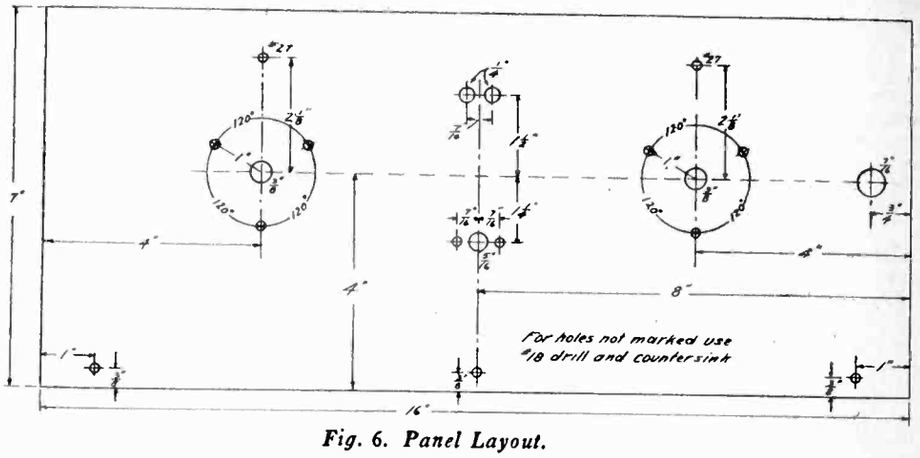


Fig. 6. Panel Layout.

A great deal of the efficiency of Circuit No. "O" depends upon the choice of a good crystal detector. The detector shown in the picture is a Lincoln but as this detector may not be available everywhere, the builder may substitute any similar type. It is best to have a detector with a semi-permanent adjustment, which is at the same time easily accessible to change when needed. A "fixed" detector is not recommended. For the crystal, use a good piece of galena, either mounted or unmounted, or an A-1 Crystal.

The parts are wired up as per the diagram in Fig. 3. Use No. 14, round, bus bar and solder all joints. Spaghetti may be used where there is danger of two wires crossing and forming a short circuit in the set. Aside from insulating against short circuits, spaghetti neither adds to nor detracts from the efficiency of the set and can be very conveniently left out. The writer does not recommend rosin core solder unless the set builder is an expert mechanic. Quite frequently the rosin will stick two wires together and at the same time form a thin insulating film between them which will hinder the passage of the current and many hours can easily be wasted in looking for one of these rosin joints. It is best to use the solid wire solder and a good grade of non-acid soldering paste. Use a great deal of care in soldering to the jack terminals, because if the soldering paste runs into the insulation on the jack, it will ruin it as well as make the set very noisy. It is best to tin the extreme ends of the jack terminals, whether or not they are already tinned, using as little flux as possible, then tin the wire and use no flux whatever when joining the two.

The operation of the crystal set is simple. To begin with put the antenna clip on about the second tap from the bottom, and turn the coupling coil so that the coupling is a maximum. Adjust the crystal until static or some noise is heard that indicates that a sensitive point has been found. Then turn both dials until a station is tuned in. If there is interference with any other station, loosen the coupling, and, if necessary, drop the antenna clip to a lower tap. The position of the antenna tap is in no way an indication of the amount of energy being used in the set or of the strength of the signal that will be heard, and very frequently the strongest signals will be received with the loosest antenna coupling. This crystal set is selective enough so that a large antenna can be used to get good signal strength.

The results that may be expected will, of course, vary greatly with the locality, with the individual operator, and also with the care with which the set has been built. The writer is going to risk a laugh from the old timers by stating in plain print that this set will operate a sensitive loud speaker on nearby powerful stations under good conditions. The loud speaker operation, of course, will not compare with that of the tube sets, but it will be loud enough to be heard distinctly all over a medium-sized room when everyone in the room keeps quiet. The set will not receive further than the local stations except under extraordinary conditions, under which it might be possible to get 300 or 400 miles on earphones. Earphones are recommended as standard equipment for this set, regardless of its capabilities of operating a loud speaker.

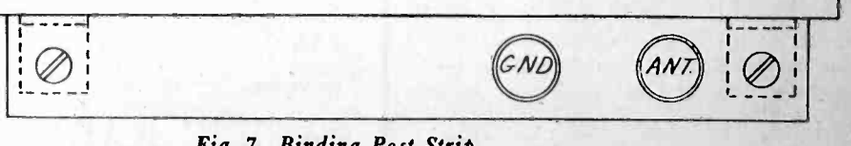


Fig. 7. Binding Post Strip.

PACIFIC CONVENTION

(*Continued from Page* 39)

6BUR, on the Heaviside Layer and Skip Distance Theory by Dr. L. Hoyt Taylor, U. S. Naval Laboratories, Bellevue, D. C. The paper was illustrated by black-board diagrams in explanation of the theory, the paper being the one given by Dr. Taylor at the last national convention in Chicago.

Prof. Strem was next on the program, giving a lecture on picture and map or diagram transmission. This lecture was also highly interesting and educational, being made more so by an exhibit of the apparatus used in the experiments. Prof. Strem's experiments do not follow those brought forward by the Jenkins method, as they were originated before Mr. Jenkins's idea was published. The lecture was illustrated by board diagrams of the circuits used. The principle is based on the use of the potassium hydride cell for transmission, and an ordinary camera film for reception. It is interesting to note that practically all of the apparatus used was made of various odds and ends that may be found in the average amateur's station. Great credit is due Prof. Strem for his efforts, and the convention was highly favored by his kindness in giving the lecture.

The crowning events of the convention, the speeches, lectures, and other activities, were brought to a glorious climax on the night of the 3rd, when two stunts were put on (and pulled off) and the banquet was held, being full of "pep" and enthusiasm as such banquets usually are. Just before the banquet, the stunt sponsored by the Radio Club of Los Angeles was staged in the lobby of the hotel. It was in the form of a very dignified (?) initiation, and the "goat" was selected by "phoney" ballot. The name of the "order" was "The Royal Order for the Elimination of Cranial Vacuum," and the unlucky individual taking the initiation was first given a physical examination and put through the "First Stage of Radio Frequency Amplification" with the "Battle of Electrons." The candidate being too curious, did not bite on the next step of "Through the Ammeter," so the spark coil was not used. The "Plate Voltage Test" was given next, with the aid of a "swatter" and a .38 caliber revolver. The initiation was interrupted by the entrance of a Santa Ana motorcycle officer, who arrested the candidate for a traffic violation. The candidate being blindfolded, did not know that he was addressing an officer, and a few "wise cracks" were indiscreetly made. When the blindfold was removed,—well, as we said before, "you should have been there!" After the "goat" was led out by the officer, an explanation was made. Motorcycle Officer Janes, of the Santa Ana Police Department was introduced to the "gang." He had kindly consented to assist in the stunt, which he did with huge success. He is an ardent "fan" and a friend of the Santa Ana "gang."

After an excellent dinner was disposed of by the method of eating, the San Francisco Radio Club presented an unusually fine stunt; a marionette show. An improvised stage was constructed in one corner of the banquet hall and entertainment was provided that was surely F. B. The marionettes were cleverly manipulated and skillfully handled, accompanied by harmonica music and well spoken roles.

Later in the evening, Lieutenant Schnell said that he was coming back to southern California some day to live. Following this, he was presented by a trio of reminders of his cruise by Myron Hexter, 6CNL. These were a small battleship, a toy elephant and a South Sea island girl doll. Hexter accompanied the presentation with an ap-

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present style of d. c. filament tubes appears to be destined to popularity for some time to come.

The hardest set of questions of all to answer are those in regard to interference being picked up from man-made static, and on this subject several books could be written. Most of the causes have already been treated at various times, and of the cures, the safest is to locate the trouble at its source, and either cure it yourself or put up such a howl of protest that the offending party cures the trouble in self defense.

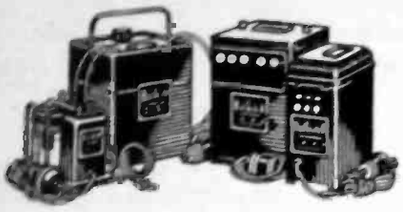
To the best of our knowledge, there is not a single device on the market which will absolutely eliminate static, power line hum or insulator leakage troubles, street car static, or any of the thousand and one noises that infest the antennas of all city radio fans and not a few rural ones. Twisting your antenna into odd shapes and making other changes in your antenna system will not cure the trouble if it is coming into your set directly from the power wiring in the wall back of the apparatus, and the various static or noise eliminating devices usually cut down on the signals to the same degree that they mitigate the noise, so "what's the use?"

Don't be misled, either, by trick antennas which claim to do everything but eliminate your *A* battery, as they are really most ordinary in performance and extraordinarily expensive, considering the market price of good antenna wire of recognized merit. If you have reason to suspect that your antenna is not as good as it might be, take a trip up on the roof with your soldering iron or blow torch, and thoroughly solder all joints in the wire, particularly the point where the leadin is connected to the main antenna. More signals have been lost in that particular point, due to corroded and dirty wire junctions, than in any other part of the radio circuit, and perhaps when you act on the suggestion, you will find that your little old set isn't so bad, after all, even though your expectations were greater, and you had to call in the Question Man to hunt bugs for you.

In wiring up a composite radio set, a short piece of interior cable, such as is used in telephone work, makes a very fine system of conductors. Such cable ends can be obtained from the telephone company's office for a reasonable sum, in most cases, in lengths which are too short for use for their work.

When drilling or turning aluminum, it should be lubricated with kerosene (coal oil) to prevent tearing, and trouble.

The rubber tubing such as is used for some forms of artificial flowers makes a good insulator for short bare leads, where needed.



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DAMPING

(*Continued from Page* 30)

In the transmission and reception of speech in radiotelephony it is not desirable that the damping be very low. As has been pointed out before in these columns, faithful speech reproduction requires that a band of speech frequencies from 100 to 10,000 cycles be reproduced, since these are the extreme limits of speech frequencies. This means that the resonance curve of both the transmitter and the receiver must be sufficiently broadly tuned that the current effect in both is essentially uniform over a band of frequencies 10,000 cycles wide. If the resonance curve is sharper, then the higher speech frequencies will be discriminated against and speech will sound drummy and not be faithfully reproduced.

Thus suppose that the transmitter wavelength is 600 meters, corresponding to a frequency of 500,000 cycles per second, and assume that the resonance curve is as shown in Fig. 11, corresponding to a very sharply tuned transmitter. The current is a maximum at the tuned frequency of 500,000 cycles, but begins to fall off exceedingly sharply at 497,000 cycles and 503,000 cycles. Hence speech frequencies above 3000 cycles will be chopped off or not transmitted effectively. The transmitter has too low damping. If the damping were increased so that its resonance curve were broadened to appear as in Fig. 12 speech will be transmitted faithfully. For it will be seen that the current effect between 500,000 cycles and 510,000 cycles is very uniform, hence all frequencies up to 10,000 cycles will be uniformly transmitted. It is apparent, therefore that too small damping, or too sharply tuned transmitters, is to be avoided in radio telephone circuits.

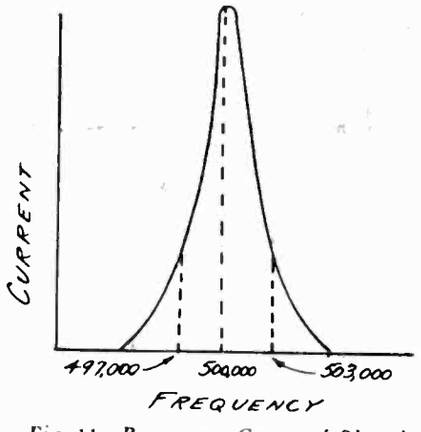

Fig. 11. Resonance Curve of Sharply Tuned Transmitter.

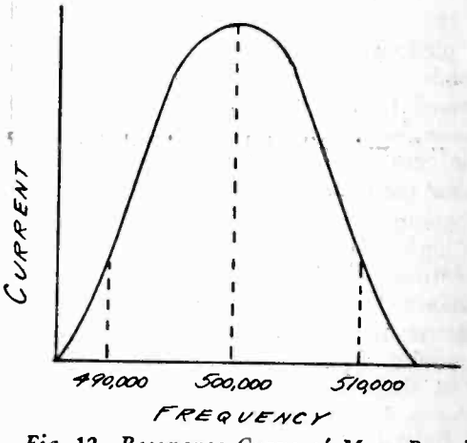

Fig. 12. Resonance Curve of More Broadly Tuned Transmitter.

The same thing holds good for receiving circuits. A receiver which is too sharply tuned will likewise discriminate against the higher frequencies of speech. The superheterodyne circuit is an interesting example of this. The incoming signal which is carried at radio frequencies is converted to an intermediate frequency of the order of 40,000 cycles. The amplifier of the superheterodyne set is designed to amplify frequencies around this intermediate frequency exclusively, and it is for this reason that high amplification and selectivity are secured. Now if sharply tuned air core transformers and filters were used in each step of the amplifier, very little other than the intermediate frequency, 40,000 cycles, would be amplifiied, for the resonance curve of the amplifier would be so sharp that practically everything other than 40,000 cycles would be cut off. However, by the use of iron cored transformers for the amplifier sufficient damping and losses in the iron are introduced to broaden out the resonance curve of the intermediate frequency amplifier, so that its amplification extends out far enough to include the highest speech frequencies.

The above illustrates the use of the idea of damping in electrical circuit design. Consider now such important devices as the radiocasting microphone and the loud speaker. It was illustrated above how important for faithful transmission and reproduction of speech it is to have transmitting circuits and receiving sets properly damped. The best transmitting and receiving sets are useless unless the speech is initially faithfully converted into electricity by the microphone. If the microphone distorts, the distortion is transmitted on throughout the whole system.

All microphones in practical use are constructed so that some part of it vibrates, and this vibrating member causes changes in the electrical circuit. Thus in the carbon microphone, a light metal diaphragm is the vibrating member. The sound impinges on it, the diaphragm moves or vibrates in unison with the impressed sound, it thereby compresses a mass of carbon granules or globules. thus altering the resistance of the circuit and causing a varying current, which is amplified. If speech is to be reproduced faithfully by the microphone the diaphragm will have to respond equally when sounds of various frequencies are impressed on it. Now every body has a natural period of vibration of its own at which it vibrates most readily and

most strongly. If any particular object is struck it will give out a sound characteristic of this period, its resonance period. The diaphragm of a microphone likewise has a period of vibration of its own. Whenever it is actuated it will have a tendency to vibrate at this period. Also if it is actuated by a number of different sounds, one of which corresponds to its natural period, it will naturally vibrate more strongly at this natural resonance period than at any other period. In other words its natural frequency will predominate and sounds will not be uniformly reproduced by the microphone diaphragm.

To reduce the distortion which is thus introduced by resonance of the diaphragm, recourse is had to the idea of damping. If the motion of the diaphragm of a microphone be plotted against voice frequency in the same way that a resonance curve is plotted for a tuned radio circuit, it is observed that the diaphragm of the average desk stand telephone microphone moves most at around the frequency of 800 cycles. This is obviously its resonance period. It responds but weakly at frequencies far removed from 800 cycles. Such a microphone, while suitable for ordinary telephone conversation, is obviously unsuitable for radiocasting. The 800 cycle sounds would be horribly exaggerated and the higher voice frequencies would be lost entirely. The distortion due to the resonance, however, can be cured by damping the diaphragm, that is to say, by interposing enough resistance to its motion so that the resonance peak at 800 cycles is flattened out. By increasing the friction against which the diaphragm moves and introducing a resistance against which the diaphragm moves the motion of the diaphragm can be limited and its resonance peak be reduced. Thus in the case of the radio microphone the diaphragm is limited in its motion on either side by a button of carbon granules, secondly it is rigidly clamped around the edge so that it cannot move so freely, and finally the motion of the diaphragm is damped by means of a stiff film of air which the diaphragm must move against. The microphone is so constructed that behind the diaphragm is a film of air about 1/1000th of an inch thick which opposes considerable resistance to the motion of the diaphragm, and very effectively suppresses any resonance peaks which it may have. In this way by the proper use of damping high quality microphones are constructed.

A similar problem presents itself in the design of loud speakers. The average loud speaker is essentially an ordinary telephone receiver coupled to a horn of some description. The telephone diaphragm itself has resonance periods of vibration which are very difficult to eliminate entirely, and the horn has natural periods of its own. The re-

sult is that the loud speaker consists largely of a series of resonance peaks. Clamping the receiver diaphragm has some effect towards increasing the damping on its motion, and the addition of a horn imposes a load on the diaphragm which likewise dampens its peaks. In the case of the horn the best way to eliminate the peaks is to construct the horn of material which vibrates the least, which is the reason for getting away from metal horns and going to wood, papier mache, composition rubber horns. But at best the horn has peaks which are very difficult to get rid of. For this reason the horn type of loud speaker is probably doomed to go the way of the spark set. The cone type of loud speaker seems to be its successor, and here the vibrating material is a paper cone driven by a light magnetic armature. The magnetic armature driving the paper cone has resonance periods of vibration of its own, but these can be damped out by loading with it with non-vibratory material like tape or rubber. Paper cones have been made with only one or two prominent natural periods of vibration which by proper design might be shifted to a part of the audio frequency scale where they do least damage.

As a final illustration of the use of the idea of damping in engineering design we may consider the design of radio studios. The heavy drapes, carpets, and furniture are not put there purely for ornamental or decorative purposes, but play a very significant part in the correct performance of the studio. The speech and musical sounds which originate in the studio are intended for the microphone. Once these sounds have acted on the microphone and been transmitted to the amplifier they might best cease existing altogether. However in an ordinary room with bare walls and hard floor, the sounds, after acting on the microphone, will continue travelling until they strike walls, ceiling and floor. In fact they will do this even before reaching the microphone. When sound strikes a hard surface it is reflected. As a result the microphone will be acted upon by the direct sound from the source and numerous reflected sounds, giving rise to echoes, which reach the microphone at different times and the net result is a horrible jumbling of sounds. To avoid this it is necessary to design the studio so that any sounds reaching the walls, ceiling floor, in fact any part of the room, will be immediately damped down to zero intensity at the surface which it happens to strike, so that the surface will not reflect the sound. It has been found by experience and research that certain types of materials are extremely good absorbers of sounds, for example certain types of felt, monk's cloth, in fact any soft materials

(*Continued on Page* 90)

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placed in a room will help absorb sound and so deaden or damp the room acoustically. For this reason the ceilings are generally covered with sound absorbing material, the floors with carpeting, and the walls heavily draped.

It is, however, extremely important also that these materials absorb all sound frequencies to about the same extent. If the material absorbs only low frequencies then the higher sound frequencies will be reflected and we will still have trouble. Certain companies have therefore set themselves the task of making materials which will have the same absorption for all sound frequencies.

STRAIGHT LINE CONDENSERS

(*Continued from Page* 32)

area A of opposition is formed. This area varies with the position of the sliding plate. It can readily be seen that $A = d^2/2$ where d is the distance which the sliding plate has moved. Here as elsewhere the capacity depends directly upon area A; namely $C = k\,d^2$. This is the simplest form of sliding plate condenser. There are variations on the market but the basic principles are the same, namely a motion of rotation is

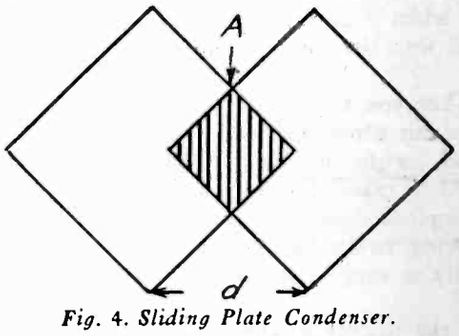

Fig. 4. Sliding Plate Condenser.

converted to one of translation and one square moves diagonally into the other. The diagonal feature is essential because if the plates are placed merely end to end we will not have a straight line condenser. Practical condensers consist, of course, not of single plates, but of a series of them. The principle remains the same.

Having considered the types of straight line condensers we may now enumerate the advantages which they hold over the old circular type. First and foremost we have the advantage of an even distribution of wavelengths instead of a bunching together at the lower end of the condenser scale. This permits greater selectivity in this region as well as ease in manipulating the tuning process. Another advantage of the straight line condenser is this: It allows a much lower zero capacity. As is well known any circular plate condenser or any variable condenser for that matter, when placed at zero degrees does not have a zero capacity for the reason that there remains a definite capacity due to the proximity of the edges of the fixed and movable plates. Thus the real

equation of capacity for a circular plate condenser is $C = C_0 + k\Theta$ where C_0 is the irreducible zero capacity, k is some constant and Θ is the setting angle.

The value of C_0 for a straight line condenser can be made smaller because the shape of plates is such that at zero setting only a part of the opposing plate edges are near to one another.

Recently manufacturers have produced condensers giving straight line curves for frequency instead of wavelength settings. As frequency varies inversely as the square root of capacity, whereas wavelength varies directly, it is evident that the plates should be of such a form that the intermeshed area will correspond to $f = K/\sqrt{C}$. This is also a logarithmic spiral which can be calculated mathematically. The advantage of this type of condenser is that all stations from 545 to 1500 kilocycles appear at 10 kilocycle intervals on the dial.

A quite satisfactory insulating paper can be made by coating both sides of ordinary manila paper with shellac, and then drying in a warm room.

Glass rods or tubes may be used as supports for inductance coils, and the like, when it is not desired to introduce metal into the radio frequency fields.

When you are all out of solder, small joints can often be "soldered" by using tinfoil, with the usual fluxes. Care should be taken, however, to get enough foil melted down to complete the job, as owing to its lack of thickness there usually is very little metal present.

If the tips of a telephone cord break off, or are lost, a short piece of about No. 12 bare copper wire can be substituted. Then if the tinsel ends are bound firmly to this with small copper wire, a quite satisfactory job will result.

In an emergency, almost any kind of insulation can be removed from a wire by pounding the latter with a hammer, after laying it on some hard, and preferably metallic surface.

WATER COOLED 5 WATTER

(Continued from Page 33)

After thoroughly cleaning the brass of the tube about ¼ in. from where it meets the glass bulb, slip the can on the tube and press it to as close a fit around the tube base as possible. Stuff rags into the can so as to hold the tube firmly an equal distance from the walls of the can. The tube must be in as far as possible, leaving only enough of the brass of the base inside the can to hold firmly and keep the solder from touching the glass, as this would crack the glass and if too far down on the base, the tube will not fit in the socket.

Use plenty of flux and carefully solder the tube to the can. This can be readily done in the usual manner with a small copper, care being taken to do a good job so there will be no leaks. The tube must be heated slowly until the glass is just too hot to touch but not hot enough to soften the cement in the tube base before soldering, otherwise the glass will crack from the heat of the soldering.

When this is done and while the tube is still hot, stand it in an upright position and pour hot melted paraffin into the can to a depth of about ¼ in. This is to fill the pores in the cement which holds the glass shell to the brass base. If it is desired to use oil as a cooling agent this treatment must be done with thin orange shellac, applied while the tube is cold and dried by slight warming. The assembly may be clearly seen from the picture.

When cool, fill the can with oil or water, as the case may be and the tube is ready for operation.

It will be noted that when water is used the tube capacity is increased more than when oil is used, but this is offset when it is further noted that the tube will not get as hot as when water is used as is the case with oil.

The note is steadied and heating troubles are at an end with this arrangement. Slight overloading will not be noticed in the way of wobbly signals and overheating, as is the trouble when tubes are worked in air.

It is not necessary to empty the liquid out when leaving the set, except that the can will rust in spots unless an exceptionally well "tinned" can is used. A jacket made of copper or brass or any non-rusting material, that can be well soldered, will greatly improve the whole job.

The tube is kept warm during listening periods, minimizing the customary heating-up "slide" and operates satisfactorily on waves down to 3 meters.

Rainwater, or melted snow will serve to refill evaporated storage cells, just as well as distilled water. Care should be taken, however, only to gather such water in absolutely clean vessels.