RADIO
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Radiotorial Comment

SELDOM has the parable about the stone which the builders rejected becoming the head of the corner been better illustrated than by the success of short waves as used in radio transmission. Legend has it that during the building of King Solomon's temple one mis-shapen stone was thrown away by the workmen because it could not be fitted into the wall. But when the master builder came on the job he called for the discarded stone and made great trouble until it was found. He then used it as the keystone for the arch of the temple, the most essential stone in the entire structure.

When the amateurs were crowded out of the upper waveband by the requirements of the radiocasters and their listeners, they were given the short waves as a sort of a sop. Nobody else wanted these useless short waves. So the amateur took them,—and developed them.

For with characteristic industry the amateurs started to experiment. They explored this hinterland of the ether and made marvelous discoveries. Their signals with low power equipment commenced to reach undreamed of distances. Their code transmissions were heard half way around the globe so that it could not be determined from which direction their signals came. The short wave stations were found to be relatively less affected by atmospheric disturbances. They were proven to be superior in many ways to the higher powered long wave stations.

The success of these experiments then attracted the attention of commercial interests who proceeded to perfect the crude but effective equipment designed by the amateurs. Then through the earnest importunity of members of the American Radio Relay League the Navy likewise became interested and obtained marvelous results. And so today "the stone which the builders rejected, the same is become the head of the corner."

More telegraph messages can now be heard between 20 and 100 meters than between 600 and 20,000 meters. American amateurs are on speaking terms with amateurs of every country in the world. It is so common now for an American to work an Australasian, an Asiatic, a European, a South African or a South American station that such two-way communication excites no comment. Commercial interests are able to get their regular traffic through on short waves when their long wave transmitters can not get across. The Army and Navy are able to maintain constant communication between their most distant stations by means of short waves.

Perhaps the most striking recent example of their effectiveness was the ability of the Byrd and McMillan Arctic expeditions to hold radio contact with their bases whereas the *Norge*, using a more powerful long wave transmitter, was not. The full account of Byrd's polar flight as published in the American newspapers was transmitted by an amateur at Spitzbergen to an amateur in the United States, both working on short waves.

It is too soon yet to prophesy the utter abandonment of long wave equipment. It will probably continue to serve commercial needs for years to come, especially as the world's radio inter-communications will be so extensive as to require all workable frequencies. But in bearing out the truism that the index of an industry's progress is in the size of its scrap-pile, radio is progressing more rapidly than any other indudstry.

WITH the improvement of radio receivers and loudspeakers to a point where the quality of sound reproduction is almost on a par with that originally coming from the transmitting station, there is a slight lull in the development of new circuits and more attention is being devoted to the perfection of radio accessories. Foremost in this group is the battery eliminator, or socket power device, whereby power for the operation of a set is taken directly from the lighting supply lines.

As the source is generally alternating current, whereas direct current is essential to the satisfactory operation of a radio set, the process entails the use of some form of rectifier and filter circuit. The problem has been readily solved in the case of the high voltage supply of small current but is still impractical for low voltage supply of the relatively large currents necessary for heating the filaments of the larger types of vacuum tubes. While it is theoretically possible to do this efficiently, the bulky size and expense of the rectifier and filter system has prevented its commercial development.

So there have recently appeared on the market many excellent models of *B* battery eliminators, but only a few *A* battery eliminators for sets employing six or more large tubes. The demand for these devices has been enhanced by the availability of several power amplifier tubes for use with relatively high voltages in the last stage of audio frequency amplification. Because of many requests for information as to good circuits and apparatus to be utilized in *B* battery or plate current supply sets much of the present issue of RADIO is devoted to this subject.

With further regard to *A* battery eliminators two methods are gradually coming into vogue. The most immediately practical is the use of small tubes whose filaments are connected in series instead of in parallel, as in the ordinary set. The slight amount of labor involved in making this change in a set is well justified in the improved results secured. The high voltage d.c. filament supply may be either that also used for plate supply or, preferably, a separate unit constructed solely for filament supply.

Another method, not yet fully perfected, employs alternating current as a means for heating an element which is in thermal but not electrical contact with the electron emitting element or filament. Considerable effort has been expended in this direction and it is probable that the perfection of an a.c. tube will be announced at an early date.

Radio, Past, Present, and Future

Some Essential Information and Sensible Advice to Buyers of Present Day Receivers

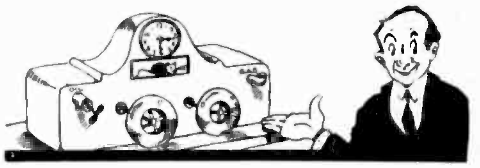
By Volney G. Mathison

"MY RADIO set don't amount to much," said Mr. Peggoty to the clerk in the local music and furniture store. "Her wires spark, her rheostats smoke, and when you turn her knobs, she makes a grindin' noise, like a sackful of gravel in a concrete-mixer. Her panel is warped up like a tough steak in a fryin'-pan, an' she blows out her tubes 'bout once a week. Sometimes, she brings us everything in town to onc't, an' sounds like three phonographs an' six Irish wash-ladies hangin' over th' back fence talkin' about Mary Ann's new shingle-bob an' how she walked home from a' automobile ride with Paddy O'Mara last week—he havin' run th' back end of a road-scraper without a light on it through his radiator—an' then again she goes on a sleepin' drunk, th' radio, not Mary Ann, an' won't make no more sound than a nigger school-boy walkin' past a graveyard at eleven o'clock at night, without no shoes on.

"Won't make no more sound than a nigger school-boy walkin' past a graveyard at eleven o'clock at night."

"Genrully, when she gets to confusin' Aunt Martha's bedtime stories with th' Laughin' Fat Man's early mornin' exercises an' the' police's list of kidnapped poodles, I shakes th' cabinet frontwards and backwards, until she comes out of her colics an' talks singly again. But when she gets a stroke of dumbness, like a brick chimbly has fell down on her, then I stands her on end an' thumps her up an' down real hard, until she starts singin' again. If all that doesn't bring her around, I know she's got to have th' repair-man with his tube-tickler, an' maybe a new *B* batt'ry or two throwed in; but these things seems to be like morphine an' castor oil—you have to keep usin' more all th' time. No, she doen't 'pear to be much of a set."

"Then, maybe you'd be interested in a new one," said the clerk in the local music and furniture store, brightening up. "Come over here and have a look at this beautiful Bewaradyne equipped with ball-bearing condensers, a single-shot lubrication-system operated from the panel, massive baseboard and five drop-



"Look at this beautiful Bewaradyne."

forged tubes enclosed in sockets of genuine armor steel ground to fit within one ten-thousandth of an inch. Regular equipment includes self-winding alarm-clock that rings automatically every thirty minutes from midnight to seven a. m., a high-voltage wife-meddling preventer, latest balloon dials, and four-wheel verniers. In the cabinet, you have a choice of a sport-model Charlemagne treasure-chest or an Egyptian Amenophis XXIV granite tomb on solid mahogany rollers. If this is a little too expensive, we have—"

Mr. Peggoty raised his hand.

"Some day, I'll be gettin' a new one, all right," he said, "but I'm lookin' for all these skinflint prices to be done away with—and I'm waitin' for all th' new things that's comin' out soon in radio."

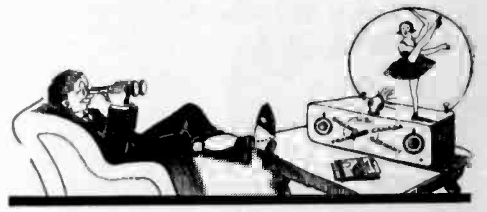
"What new things are you expecting?" inquired the clerk.

"Why, er, I dunno, exactly," replied Mr. Peggoty. "But they're a comin'. I've read all about it in th' magazine part of th' *Sunday Flub*—an' that's a place where you get reliable information, right along."

WERE it not for certain unfortunate aspects of the matter, it would be amusing to observe the number of persons who are waiting for the end of the "skinflint prices" and for the "new things that's comin' out soon in radio." Folks of all kinds, from the timid old maid who chases her tomcat around with

"Chases her tomcat around for a cat's whisker."

a pair of scissors for a whisker, to the shrewd banker with a bad-toned squawkodyne and a roll that placed end to end would make a festoon from here to the planet Mars and back, instead of buying a good broadcast receiver of the kind available on the market at the present time, are waiting month after month and year after year for some startling and revolutionary radio instrument provided with a pushbutton for ringing up Patagonia for a war-dance, and with a little movie-screen on the front, wherein they can watch a bevy of Parisian cuties flip their ankles while their jewel-bespangled leader warbles, "It's Nobody's Business if She Does,— er, Powder Her Nose." Continually, I am meeting folks with crystal sets, with antiquated one, two, and three-tube regenerative howlers, with whispering reflexes, and with no sets at all, who are putting off the purchase of a good radio until broadcast receivers shall be finally perfected. I venture the guess that about half the population of the country are foregoing the enjoyment that may be had from the present entertainment on the air, either because they buy no set at all, though financially able to do so, or because they continue to get along with some squealing claptrap that emits noises like a Chinese orchestral interpretation of the Prisoner's Song.



"Startling and revolutionizing radio."

The student of evolution is struck by the similarity between the development of living things and the development of man-made utensils and devices. Back through the dimmest ages of time the scientific investigator finds vast hordes of animals, enormous lizards, and other strange creatures that evolved through an immense series of improvements from crude and simple forms to a certain point of perfection and then either retrograded or abruptly perished because of their inadaptability to climatic and geographic changes.

Turning to radio, we observe that the earlier spark systems advanced to a point of considerable perfection, only to enter quickly upon a period of decay, owing to the introduction of continuous-wave equipment. To say that the continuous-wave wireless telegraph and telephone systems of the present moment will evolve to a certain point of perfection and then disappear before something better, would seem to be a not unlikely prediction to make, judging by history. I am inclined to believe, however, that the changes which lie immediately before us will not entail any abandonment of continuous waves, but rather a considerable modification in the lengths of waves employed in transmission. It looks as if the 500-kilowatt arc-transmitters, with their monstrous serpent-like inductances, that radiate energy on wavelengths of from 10,000 to 25,000 meters from antennas weighing hundreds of tons may be the dinosaurs of radio, which are doomed to extinction before the marvellous powers of twenty-kilowatt tubes on forty meters, using radiators less than one hundred feet high.

The earliest radio receiver, which was designed by Heinrich Hertz in 1888, consisted of an inductive loop and a

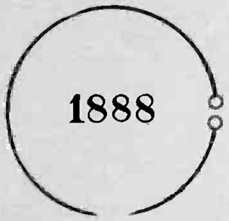


Fig. 1. The earliest radio receiver.

spark-gap, as shown in Fig. 1. The radio-frequency current set up in the loop, when the key of a nearby radiating transmitter was depressed, produced a visible glow of sparks across the gap. The range of this device was a few feet, or inches.

The next step was to introduce a detector into the loop. This consisted of two small electrodes in a glass tube with a pinch of iron and nickel filings placed between their ends, which were separated about 1/16 in. The radio-frequency current in the loop caused the filings to cohere and form a conducting bridge between the electrodes, thereby enabling a local battery current to flow,

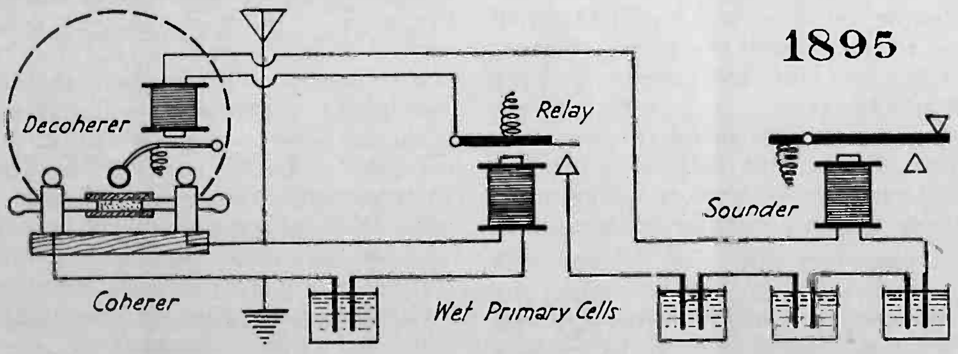


Fig. 2. The 1895 Model.

as shown in Fig. 2. The local battery current closed a relay which operated a second local battery-circuit containing a sounder and a device for jarring the detector—so as to shake loose the bridge of filings and reopen the local circuits, which otherwise would remain closed. This receiver was very sluggish and uncertain in action. An aerial and ground were soon substituted for the loop, increasing the effective range of the apparatus from a few feet to as many as twenty miles. Such crude equipment was actually installed on the battleships of several nations, and was used on the Russian fighting craft of the Russo-Japanese War. But it would have been impossible to receive radio music with this device.

A fundamentally new receiver, the prototype of the modern instrument, came into existence about twenty-eight years ago, coincidentally with the discovery of the comparatively delicate rectifying action of certain minerals. The earliest circuit using a crystal detector

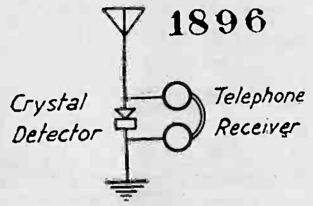


Fig. 3. Untuned Antenna with Crystal Detector.

is shown in Fig. 3. Here we have an untuned oscillating circuit — the aerial and ground,—a detector, and a device for rendering the rectified current audible, the telephone-receiver.

The next step was roughly to tune the

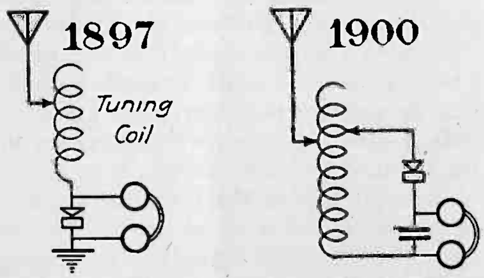
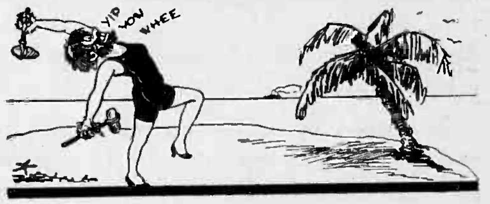


Fig. 4. Tuned Antenna with Crystal Detector.

oscillating antenna circuit by the insertion of an adjustable inductance, as shown in Fig. 4. This circuit of 1900 (about) has never been fundamentally altered to this day in either wireless telegraph or telephone work. It contains the underlying principles of the finest modern receiver in that it employs an oscillating pick-up or antenna circuit, a tuning device, and a transformer of electrical energy into sound (the telephone-receiver). The advances made since the creation of the circuit in Fig. 4 have been in the nature of a rapid series of improvements, the most nearly fundamental one being the invention, in the radio vacuum-tube, of not only a highly efficient rectifier, but also a previously unknown amplifier of both audio and radio frequency currents.

Following quickly upon the invention and partial perfection of the vacuum-tube (which device also made radio telephone transmission practicable for the first time), we experienced a period of rampant and senseless growth in a multitude of flexes and dynes, and other receivers, of which the super-regenerative was undoubtedly the most diabolical, and the single-circuit regenerative the most debased. The super-regenerative receiver is a powerful arrangement that works for from one to three minutes at intervals of about once in every four years; while the single-circuit regenerative is like a cross between a California bathing-beach beauty and a howling Fiji



"A howling Fiji cannibal."

cannibal, in that it combines the modern vacuum-tube and the modern principle of regeneration with a tuning circuit that was abandoned twenty years ago.

Out of this horde of mongrel circuits and half-designed devices, some fantastic, some the products of clever minds and some apparently the work of uninformed semi-lunatics, there have emerged two standard modern types of radio broadcast receiver, the three to six-tube instrument using tuned radio-frequency amplification, detector, and audio-frequency amplification (as represented by the neutrodyne and all other tuned radio frequency receivers), and the six to nine-tube superheterodyne, which is really a sort of fixed tuned-frequency receiver with an ingenious frequency-changer at its pick-up end.

The developments in receivers of the past two years have been almost entirely refinements on the tuned-radio-frequency instrument and on the superheterodyne —refinements represented by the straight-line-frequency condensers, vernier controls, large non-distorting audio-frequency transformers, simplified resistance-coupled amplifiers, the use of a special power-tube in the last audio-frequency stage, introduction of the cone speaker, beautification of the cabinet and panel, and the perfection of a silent *B* battery eliminator. This last item is certainly one of the most important refinements made so far.

The radio broadcast receiver may be said to have now reached a stage of development comparable to that of the automobile of 1912. The improvements to be looked for during the next few years are, therefore, not likely to be anything really revolutionary. There will be more and more graceful designs, better parts, better and more beautiful speakers, while the *B* eliminator will become a regular built-in feature of all the standard-grade sets, and there will be an increasing tendency to discard the outside antenna for a small ornamental loop —especially in the case of the receiver used in the large city.

Another development that may be reasonably expected within the next five years will be the reduction in size or the entire elimination of the filament-lighting battery. This last possibly may be accomplished through the separation of the electronic cathode from the heating element of the tube, which could then presumably be heated by an alternating current applied at a low voltage by means of a step-down transformer. A tube of this sort has already been produced, but it does not seem to have been much of a success—so far.

It would evidently be poppycock to say that radio receivers will not be greatly improved during the next few years; they will be, but only in the way that the automobile has been improved since 1910 or 1912. And here is where the regrettable attitude of so many of the folks who are delaying the purchase of as good a broadcast receiver as they can afford becomes most strikingly apparent. Waiting for the radio of tomorrow, they are missing the entertainment of today. What would we think of the prospective automobile buyer, the prospective phonograph buyer, and the prospective camera buyer of 1910, who would go without these things he desires until 1926, merely because he was waiting for the highly improved phonograph, auto, or kodak of today. How much motoring, how much music, how much photography would he have missed!

It is not only probable but certain that the radio set of today will be quite out of date five years hence—but what of that? Will not the purchaser have his money's worth and more out of the instrument? Even though it be necessary to replace the broadcast receiver as often as every five years (which it may not be), would it not still be an economical and a well-bought furnisher of musical entertainment? I think it would. Phonograph records purchased in such profusion as even to begin to equal the entertainment afforded by a good radio would cost about ten thousand dollars, in five years. (Incidentally, it is very interesting to note that the phonograph, despite all the improvements that are being desperately made on it, is stricken to the point of death, from a business standpoint, before the popularity and cheapness of musical entertainment broadcast by radio). Yet many folks who think nothing of getting a costly new automobile every year are disgruntled because the radio set they bought four years ago is completely out of date; they seem to imagine it is in the same class as a brick fireplace or a grandfather's clock—something to be bought once in three lifetimes.

THERE is another immense group of prospective radio buyers who seem to realize that broadcast receivers have now reached a fairly refined stage, but who are waiting for a collapse of the present-day prices, which they believe to be still inflated. It is pretty well understood that there was a lot of ruthless profiteering in radio between 1922 and 1924; hence the multitudes of little set-building shops that sprang up overnight, like a crop of toadstools, all over the country. There was so much money in building receivers, for a while, that persons with absolutely no knowledge of radio, from an engineering standpoint, but handy with a screwdriver and a soldering-iron, were able to make a good living by building one set a week in their kitchens or garages.

But those days, with their fat prices, are gone; the surest proof of this is seen in the fact that not one in a hundred of the back-yard set-builders of 1923 are building receivers today. Mass production and reduced prices have absolutely put the one-horse builder out of the running, so far as the manufacturing of the neutrodyne and the tuned-radio-frequency receiver is concerned. There are still a good many superheterodynes being constructed in small shops, and probably not a few of them will continue to be so built for a good while, for the reason that there is only one factory-built superheterodyne on the market today; and so the "bootleg" builder has no widespread competition to meet, in the case of this particular type of receiver.

I shall venture the statement, basing it upon a considerable knowledge of the costs of manufacturing, advertising, distributing, retailing, and installing broadcast receivers, that the prices of today on the standard instruments of large manufacturers will not be subject to any startling reductions during the next three years. In fact, the indications point to a general increase in prices, owing to the evident tendency to elaborate and refine.

A temporary offsetting factor is that the market has for the last two years been depressed by the immense quantities of bankrupt stocks that are lying about everywhere, all of them representing the shipwrecks of would-be radio-kings who have gone on the financial reefs. These huge job-lots of orphan broadcast-receivers are one of the aftermaths of the radio craze of 1922-1923, and most of them are being dumped at prices that entail terrific losses. I have within the last three months seen 3500 eighty-dollar six-tube receivers of unusually good quality and design being disposed of through the cut-price stores of downtown New York for as little as $24.95 apiece. The layman, with little knowledge of radio manufacturing costs, smiles cynically, shrugs his shoulders, and says that these receivers are being sold at a profit, or they would not be offered at such a low price. As a matter of fact, the bare cost of turning out these sets was $26.45, on the bench; they went to the big cut-price retail operators for $15.00 each. Also, I saw a big department store in Boston selling 10,000 five-tube receivers at $12.50 a piece that listed at $45.00 last year. These conditions are *not* going to continue; they are the publicly visible phase of the scramble of bankrupt plungers to save what they can out of their ill-advised and disastrous ventures.

Of course, there may in the future, be an occasional deluge of bankrupt sets, but such happenings will become more and more local in their effect. Also, there will be bargain sales on obsolete and abandoned models of receivers. Nevertheless, it is safe to say that during the next five years the average price of a good standard-grade five-tube tuned-frequency or neutrodyne set with a built-in *B* eliminator, and provided with a reasonably attractive cabinet, will not be less than $85.00—or from $115 to $150 complete with tubes, *A* battery, charger, and a first-class cone speaker. The finer sets enclosed in expensive cabinets, with gold and silver-plated trappings, will cost complete from $175 up; they can't be profitably turned out for much less than that.

Yet there are now, and probably will continue to be, five-tube sets on the market at prices as low as $35 or $40; they correspond in a way to the twenty-five dollar phonograph. For the many folks who can ill afford hundred dollar radios, the $35 set is incomparably better than having no radio at all. But it is poor economy to buy a cheaper radio, or, especially, a cheaper speaker than one can afford. Time and again, I have seen sixty-dollar and forty-dollar, and even twenty-dollar radio sets in homes that boast three-thousand-dollar automobiles and two-hundred-dollar washing machines. There is a million-dollar apartment house in Seattle with solid silver table service and walnut furniture that has radio music in every apartment furnished by seventy $4 speakers hooked in parallel to a good power-amplifier, which is in turn connected to a receiver that retails at $39.50. Small wonder the people in this place don't think much of radio!

Worse than this, I once met with a ten-dollar one-tube squealer and a three-dollar pair of phones with coils like peanuts and diaphragms like stove-lids ensconced amidst a magnificently-appointed private library containing thousands of expensively bound volumes. The owner of this dinky little rig was laboring under the illogical idea that the perfected radio set will shrink to the dimensions of a cigar box and a tea bell. Maybe it will—some day,—but complication and elaboration is the inevitable hallmark of the evolution of almost every human device.

(*Continued on Page* 54)

Ohm Again

By Keith LaBar

Illustrated by Louis McManus

WHEN the Engineer dropped in to call upon the Sweet Young Thing he was disappointed to find that she had gone out to the movies with the Business Man, her father, so that no one was at home but Young Bill, who was trying to build a transformer and having poor luck.

"You're just the fellow I want to see," greeted Young Bill. "Here I have built this three times and it still smokes and gets hot. I think the flux density is too high. How do you know what flux is in the iron anyway? There ought to be an Ohm's law for flux so you know what is going on."

"Well," said the Engineer, "there is. You see, it's like this. Ohm's Law simply states that the current in amperes is proportional to the voltage and inversely proportional to the resistance. With the magnetic circuit the "Current" is the magnetic flux, the "resistance" is the resistance the iron offers to the flux, called the reluctance, and the pressure tending to force the flux through the iron is the magnetomotive force, the force which induces the magnetism in the iron."

"Where does this magnetomotive force come from?" asked Young Bill.

"The practical unit is the ampere turn. Theoretically, more turns on the primary with the same current increases the magnetomotive force. But practically, more turns lower the flux, due to the voltage per turn being reduced and a number of things. All these quantities behave like the quantities in Ohm's law."

"It's simple, then, isn't it?" asked Young Bill.

"No. Here's the joker. The reluctance won't stay constant but varies with the flux, increases, in fact. Imagine a wire that changed resistance when the current varied."

"Gee, that's tough!" said Young Bill commiseratingly. "What do you do?"

"Make a chart showing the amount of flux for any value of magnetizing force. A graph for Ohm's law would be a straight line. The chart for the flux is a curve. Iron can become saturated with flux and then any increase in magnetizing force produces but a slight increase in flux. It goes like this." And the Engineer drew Fig. 1.

"But that is with a constant magnetizing force. The curve showing conditions for a changing flux, as in an alternating current transformer, is different

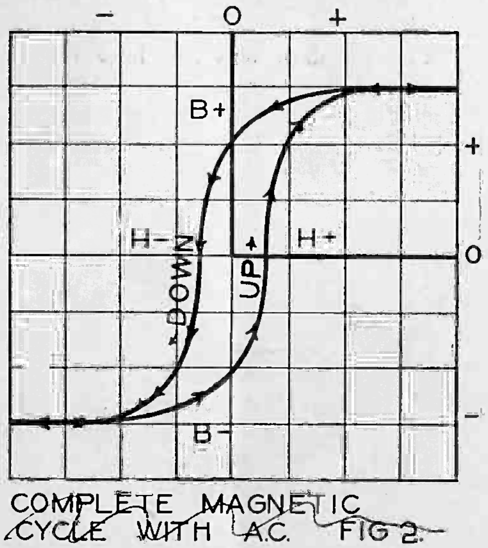


Fig. 2. Complete Magnetic Cycle with Alternating Current.

because the flux lags behind the force causing it. This is called the 'alternating magnetic characteristic.' You can see (Fig. 2) that for any given value of magnetizing force we have two values of flux, depending upon whether we are increasing the flux or decreasing it. The molecules of iron produce friction as they try to arrange themselves in position to give a field through the iron. After we have a flux and reduce the current to zero, this flux has not come back to zero; it lags behind, due to this molecular friction and we have to run the current in the opposite direction to make the flux zero.

"It might be interesting to mention that the area between the two curves, the 'rising magnetic characteristic,' and the 'falling magnetic characteristic,' is a measure of the heat lost in molecular friction in the iron. This is called the hysteresis loop and the phenomenon of the magnetism lagging behind the magnetizing force is called hysteresis. Interesting, isn't it?"

"Yes," feebly answered Young Bill, who was beginning to feel dazed.

"Now for the real low down on the transformer."

Bill brightened up.

"In our transformer we are interested in the maximum value of the flux. If the maximum current value is sufficient to run the flux up to the flat part of

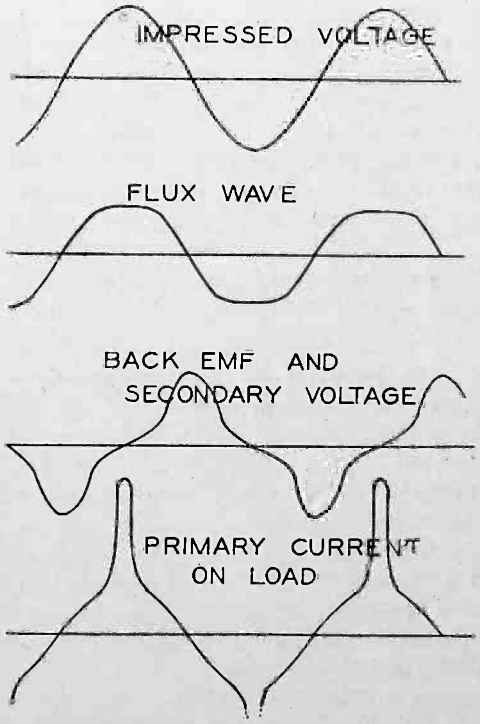


Fig. 3. Effect of Excessive Flux Density Due to Limited Number of Turns.

the curve we have an interesting state of affairs. The magnetism approaches a limit before the top of the cycle is reached. This can best be shown in a series of curves as in Fig. 3. First we have the sine curve from the supply main impressed across the transformer. This produces a wave of magnetism in the iron. The iron, however, becomes saturated before the top of the impressed wave is reached and it practically cuts the top off the wave of magnetism. This wave of flux induces a back pressure in the primary, tending to limit the flow of current. It also induces voltage in the

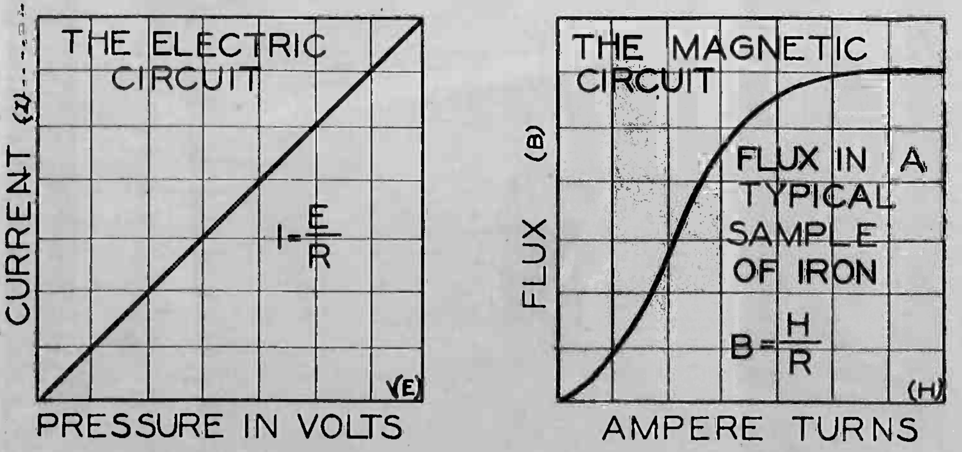


Fig. 1. Comparison of Electric and Magnetic Circuit Conditions with Constant Current.

secondary. This takes on the rather peculiar form shown."

"Think of trying to filter that," said Bill disgustedly.

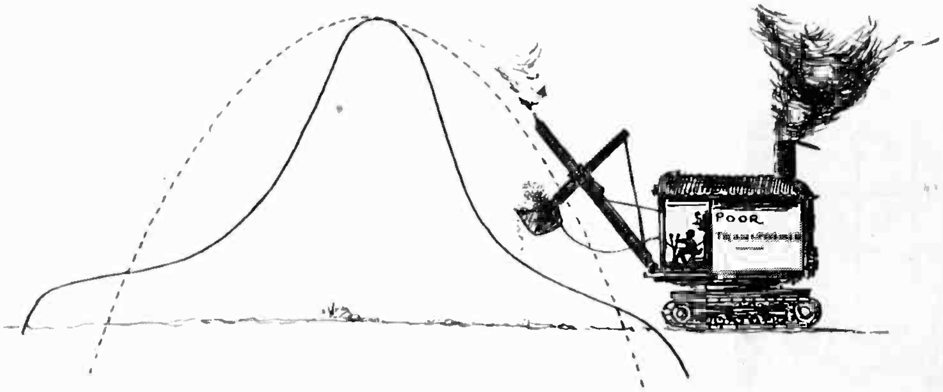
"They still try to do it," remarked the Engineer knowingly. "The primary current is interesting. It is calculated from the resultant voltage in the primary, the sine curve minus the back electromotive force, and the impedance of the circuit, and comes out looking rather peaked."

"This peak is where the primary current runs away with itself. The transformer falls down on the job of supplying back pressure to buck the supply voltage. So the current along here is limited only by the size of the wire in the primary: larger wire, more current.

"Many amateur builders have observed this and when, after winding the primary with fairly heavy wire, the insulation burns off, put on a smaller wire. This cuts down the heat loss to be sure, but the efficiency is cut, and the wave that goes into the primary still has chunks cut out of it before it comes out the secondary."

GEORG SIMON OHM

MDCCLXXXVII —— MDCCCLIV



"The Effect of a Power Transformer."

"So the principal effect in a power transformer," said Young Bill, seeking to get straight on the question, "is to cut out from the bottom of the sine wave, like a steam shovel starting to nose into a hill."

"Yes," said the Engineer," you've hit it right. Remember all this is a result of a too high flux density being used, or practically too few turns being used on the primary.

"In a battery charger or current used for lighting, it makes no difference to the battery or our eyes what the wave form is like. But when it comes to current used for *B* supply or amateur transmission by rectification it is important, for with a poor wave form we are not getting full benefit out of our expensive choke coils and condensers."

"And they are expensive," said Young Bill with a sigh. "Three six bits for a good two mike condenser. O-o-oh!"

"You may notice," said the Engineer, "that we have practically changed the frequency of the wave, although we still have sixty full waves to the second, same as before. The same effect could be produced by cutting out some of the cycles of a current of higher frequency. Usually the third harmonic makes up most of the wave, so cutting two out of three waves out of an 180 cycle current would give us our distorted wave.

"The problem was not how to take two out of three cycles from a 180 cycle current but to put the two missing ones back in and have 180 cycles current out of sixty. This would fill a want in long wave transmission where a 10 kilocycle current could be produced by a generator, and then changed to 30 kilocycles for direct connection to the antenna for transmission on a wavelength of 10,000 meters. The advantages thus gained would offset the power loss in the transformer. This was solved by the use of two transformers. One of them was worked at a high flux density and produced the distorted wave. The other was worked at a low flux density and produced the usual sine curve. Connecting the secondaries of the transformers in series, they bucked each other at appropriate times and produced the triple frequency.

"It is interesting to note that if we cut out pieces from our wave it is the same as adding one or more higher harmonics to it. Steinmetz used to worry about these a lot. Due to distortion in generators or transformers the usual commercial current is not a pure sine curve. In many of the smaller towns it is very bad. The difference is usually very slight, but even a slight difference means the presence of higher harmonics. If any of the circuits happened to be accidentally tuned to one of these higher harmonics and resonance thereby produced, dangerous voltages might be produced in circuits not designed to stand them. These transient currents have often proved the last straw to many a poor overworked insulator."

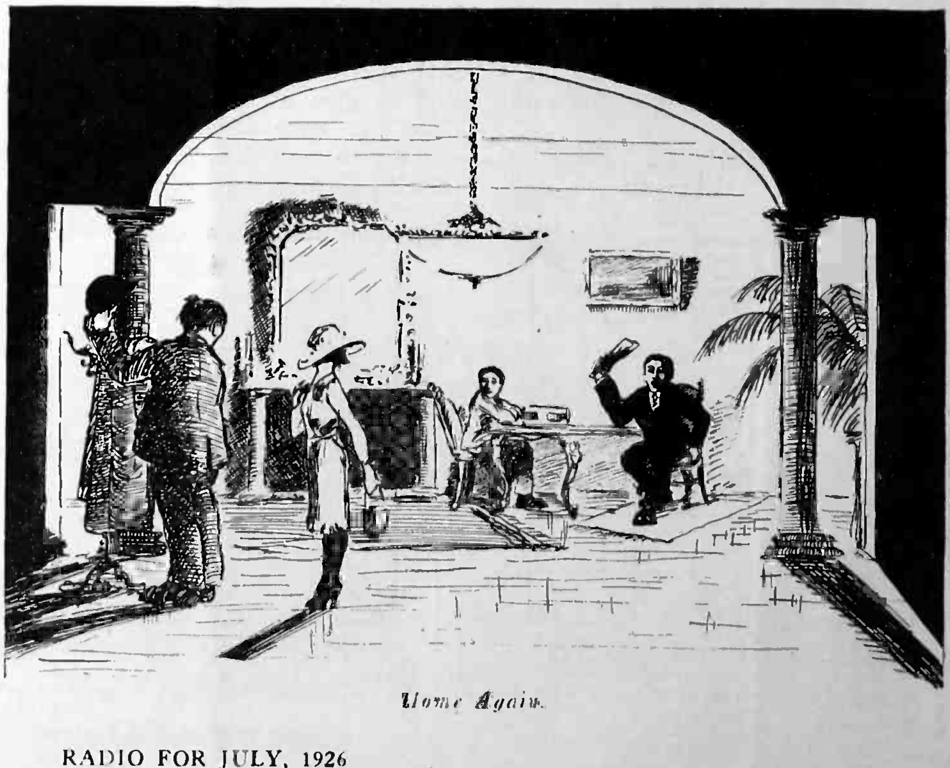
"How about the action of the amplifying transformer?" asked Young Bill.

"Very high notes are lost in the capacity of the windings. Very low notes are distorted, and as we have seen it, simply means that we lose part of the low note and obtain added emphasis on the higher harmonics, which we have too much of anyway."

"And it all started with Ohm's Law," commented Young Bill. "Great old boy, Ohm."

"Who's going to buy a home?" asked the Business Man, coming in, followed by the rest of the family. "You?"

"No, haven't asked her yet. We were talking about George Simon Ohm, discoverer of Ohm's Law."



Home Again.

How to Build a Plate Current Supply Unit

Detailed Directions for the Construction of Various Panel and Baseboard Models of Rectifier and Filter Systems

By G. M. Best

TO MEET the increasing demands for information regarding the best circuits and methods of assembly to be used in the construction of a plate current supply unit obtaining its power from the 110 volt a.c. house lighting circuits, a number of different models which have been made and tested in RADIO's laboratory are here illustrated and described. All of them deliver from 30 to 35 milliamperes at 150 volts and will meet the requirement of the UX-171, CX-371 power tube in the last stage of audio frequency amplification.

The description of the Raytheon rectifier unit by E. E. Turner in November, 1925, RADIO using the circuit shown in Fig. 1 was so complete as to require no further elaboration. But with the improved apparatus now available, particularly the compact blocks of filter condensers, the job of assembly and wiring is much simpler. Any of the makes of parts in the list of those for baseboard assembly may be used satisfactorily.

Panel Type

A MUCH neater and more convenient assembly may be made by mounting all of the apparatus on a panel as shown in Fig. 2. This can be placed vertically in the battery compartment of the average radio table so that all controls are easily accessible. Or the panel may be placed in a separate cabinet.

The parts for the panel type unit are chosen because of their small size so as to fit into a small panel. If larger parts are used the material should first be laid out on paper and the size of the panel changed to fit the particular parts used.

The schematic wiring diagram is as shown in Fig. 1. The pictorial diagram in Fig. 3 plainly indicates the actual arrangement of parts together with the connecting wires. Due to the use of a pilot lamp, to show when the rectifier is in service, the modification shown in Fig. 4 should be made, the lamp being shunted across one half of the extra 7½ volt secondary with which most power transformers are equipped. In assembling the unit,

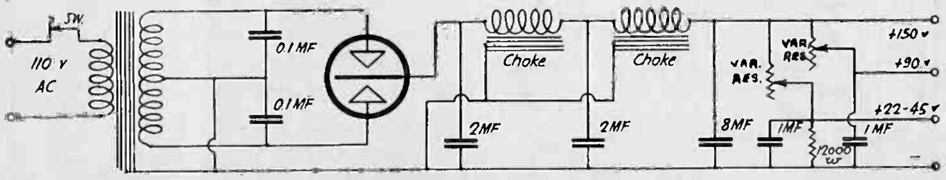


Fig. 1. Wiring Diagram for Raytheon Plate Supply Unit.

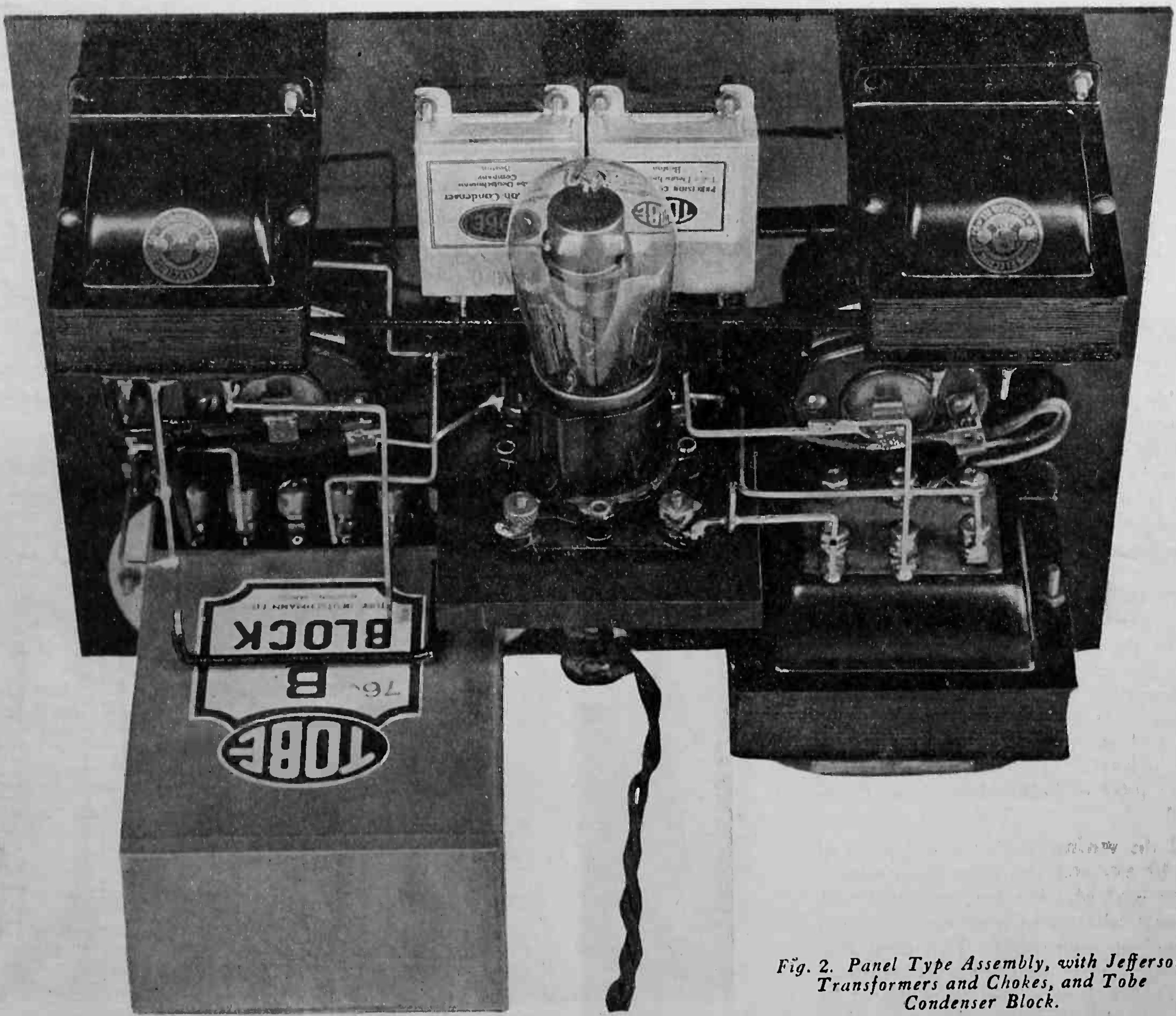


Fig. 2. Panel Type Assembly, with Jefferson Transformers and Chokes, and Tobe Condenser Block.

lay the panel face down on the table, and place the individual pieces of apparatus in the positions shown in the diagram. With a sharp instrument, mark the centers of the holes which must be drilled through the panel to hold the apparatus in place.

The variable resistance units are placed on each side of the panel, with the filament switch in the center, above which is placed the 6 volt pilot lamp. For the variable resistance, 3/8 in. holes will be required, with a 7/16 in. hole

LIST OF PARTS FOR PANEL UNIT

- 1 Power transformer—110-400 volts.
- 2 Filter chokes—20 henries or more.
- 1 Condenser block—8-2-2-1-1 mfd.
- 2 Variable resistances—10,000 to 50,000 ohms.
- 1 Filament switch.
- 1 Vacuum tube socket—Navy type base.
- 1 Raytheon tube.
- 2 .1 mfd. by-pass condensers.
- 4 Engraved binding posts—bakelite tops.
- 1 6 volt pilot lamp with socket.
- 1 Bakelite or Formica panel, 9x12x3/16 in.
- 1 Bakelite or Formica shelf 3½x3½x¼ in.
- 2 Dozen ½ in. 6-32 flat head mach. screws, with nuts.

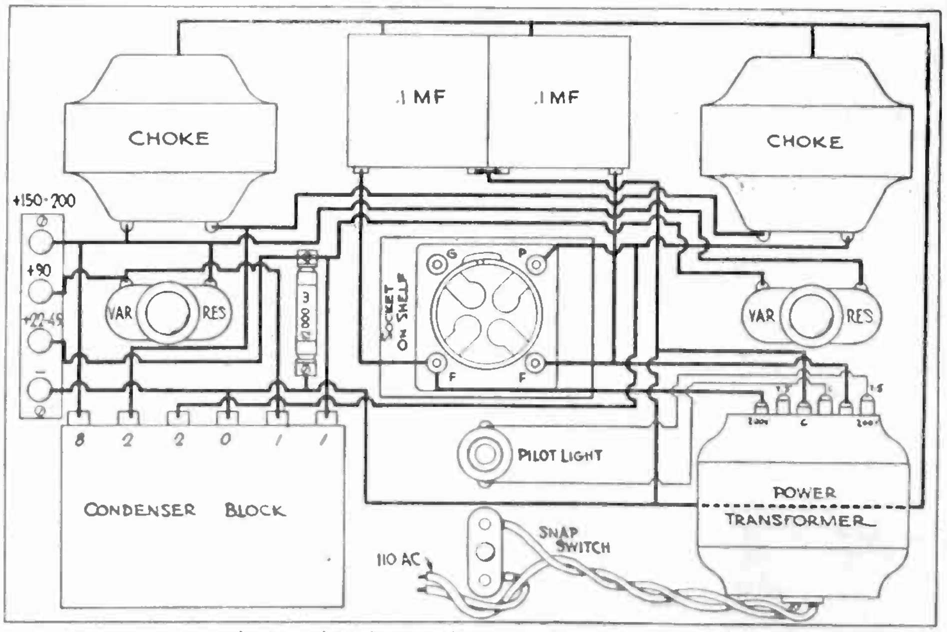


Fig. 3. Pictorial Wiring Diagram of Panel Unit.

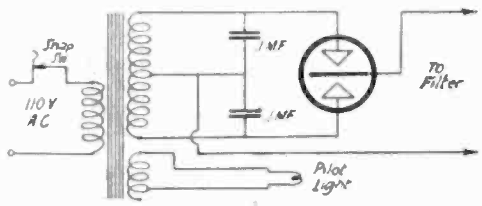


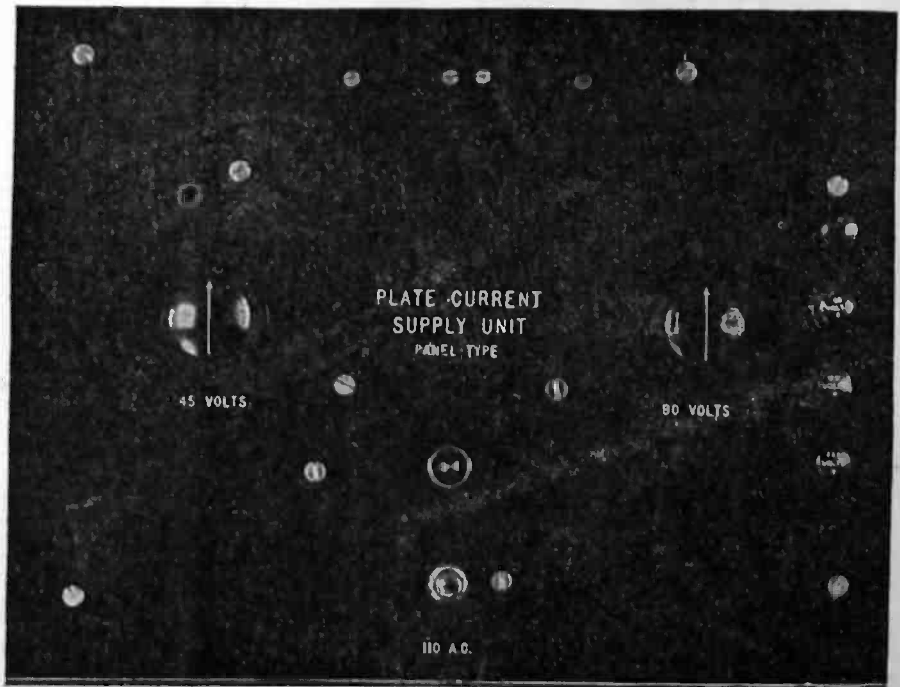
Fig. 4. Pilot Lamp Connections for Panel Unit.

for the pilot lamp. No panel drilling template is shown, as the positions for the parts mentioned above is not critical, and is best determined after the back-panel material has been properly arranged. After the holes for the mounting screws are drilled, they should be countersunk from the face of the panel, so that flat head machine screws may be used. Assemble the material on the back of the panel in the general manner of the experimental model shown in Fig. 2, mounting the tube socket shelf by drilling two holes in one edge of the shelf and tapping the holes for a 6-32 machine screw. This shelf may be made from a piece of heavy sheet brass if preferred.

All the wiring, with the exception of the 110 a.c. and the pilot lamp circuit, is done with bare bus bar, insulated with spaghetti where two wires are in danger of touching each other. It is most convenient to wire the power transformer and chokes before mounting the tube socket or shelf, making the connections to the variable resistances and output terminals last. The 110 a.c. circuit is broken by means of the snap switch, placed in series with the flexible cord with which the transformer is equipped. It is important that this switch be of the approved Fire Underwriters type, licensed for a current carrying capacity of at least 1 ampere at 110 volts. In wiring the tube socket, the filament terminals are connected to the outside windings of the power transformer high voltage secondary, and the plate terminal which is the positive d.c. connection, should be wired to the filter choke. The grid connection on the socket is not needed and may be disregarded.

After all connections are made, the wiring should be thoroughly checked, before inserting the Raytheon tube in the socket. As one of the variable resistances is placed in series with a 12000 ohm fixed resistance, a permanent load of a few milliamperes is placed across the filter, and the tube should glow a faint purple along the edge of the cylindrical plate when the power is turned on. If the plate becomes red hot in a short time, and no direct current is obtained at the output terminals, then one of the filter condensers is short circuited, and the connections to the condenser block should be removed one at a time until the short circuit is located.

A rough check of the high voltage circuit is possible by short circuiting the 150 volt positive and the negative binding posts with a piece of insulated wire which has the ends bared. If a large, snappy spark is obtained, the rectifier is properly connected, and can be wired to the receiving set. Connect the negative terminal of the plate supply unit to the negative *B* binding post on the set, and connect the positive terminals to their respective positions on the receiving set terminal strip. Adjust the variable resistances until all the resistance is in the circuit, and turn on the main switch of the rectifier. If a type 171 tube is used in the last audio stage, an effective voltage of 150, when the *C* battery is adjusted to 32 volts, can be assumed. If a smaller *C* battery is used, the power tube may take all the current from the supply unit, and it will not be possible to supply the rest of the tubes with their proper voltages. Tap the power tube



Front View of Panel Type Assembly, Showing Variable Voltage Controls.

gently, and if a ringing sound is heard in the loud-speaker, the polarity of the d.c. is correct, and it is O.K. to adjust the variable resistances.

Cut out resistances in the 90 volt resistor until a gentle tapping of the first audio tube indicates by the ringing sound that the voltage is about right. Then adjust the detector, or 45 volt resistor until the detector tube has the right voltage, and it should be possible to operate the set normally. Bring in a station on the loud-speaker, and observe whether the quality is as good as with battery supply. If the speech or music is accompanied by a rattling or scratching sound, probably the voltage on the 1st audio tube is not high enough, and should be increased. If the set is not sensitive, the voltage supply to the r.f. amplifiers, if there are such, is not high enough, or it may be too high and be causing oscillation. If a very high resistance voltmeter, having an internal resistance of 100,000 ohms or more, is available, the voltage output of the various taps can easily be measured, without error, but if an ordinary voltmeter having an internal resistance of 100 ohms per volt is used, the voltmeter may draw as much if not more current than the radio set, and the readings will be worthless.

LIST OF PARTS FOR BASEBOARD ASSEMBLIES

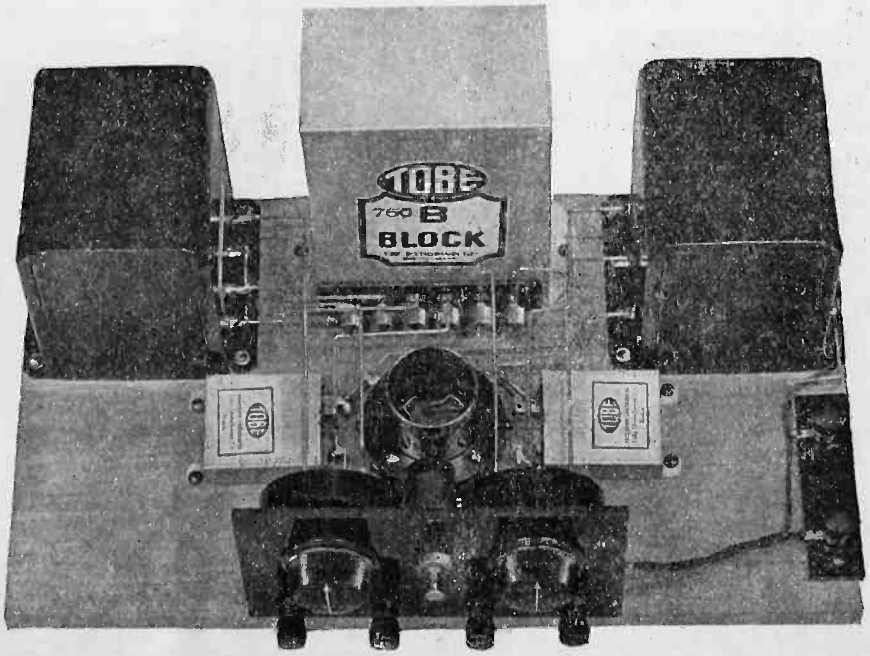
Part	Manufacturer
Step-up Transformer 110 to 400 volts.	Acme, All-American, Dongan, General Radio, Jefferson, Precise, Silver-Marshall, Thordarson.
Filter Chokes —20 henries or more.	Acme, All-American, Condenser Corp., Dongan, General Radio, Jefferson, Precise, Thordarson.
Filter and By-Pass Condensers	Aerovox, Acme, Dubilier, Electrad, Potter, Tobe-Deutschmann, Silver-Marshall.
Socket.	Any standard make—(Navy base).
Variable Resistances —10-100,000 ohms.	Bradleyohm, Centralab, Clarostat, Electrad.
Fixed Resistance—12,000 ohms.	Crescent, Electrad.
Binding Posts.	Any standard make.

Baseboard Models

FOR those who do not care to go to the expense of the bakelite panel, the baseboard models shown in the pictures will do equally as well. Fig. 5 is a pictorial diagram giving the arrangement of parts and the connecting wires. The baseboard should be of ½ in. hardwood, 8x14 in., and should be shellacked or varnished before the apparatus is mounted on it, in order to prevent warping.

For symmetry and shortness of leads, the transformer and choke are mounted at opposite ends of the board, with the condenser block in between, and the tube in the center. On each side of the tube are .1 mfd. by-pass condensers, and on a small bakelite panel are mounted the variable resistors, a.c. power switch and the d.c. output terminals. The bakelite panel is of 3/16 in. material, and is 3½x6 in. This panel places all the variable adjustments in a convenient position and provides ample room for any of the resistors now on the market. The 12,000 ohm fixed resistance is mounted on the baseboard in back of the panel, and directly in front of the rectifier tube.

The assembly using the General Radio parts is wired with bus bar wire, without insulation, since the leads are so short that they are very stiff, and there is little likelihood of their touching each other at any point. Insulated wire may be used, however, and presents a very neat appearance when all the wiring is bunched together and laced in the form of a cable after the manner of telephone switchboard wiring. The latter method is shown in the picture of the supply unit using Thordarson and Dongan transformers and chokes.



Baseboard Assembly, with General Radio Transformers and Chokes, and Tobe Condenser Block.

In view of the fact that the fixed 12,000 ohm resistor specified may not be the right value for all receiving sets, it is a good idea to install a grid leak mounting, and use a metal cartridge resistance such as the Electrad or Durham, which come in 12,000 and 25,000 ohm sizes, and are capable of carrying the current which the circuit requires.

Several manufacturers now furnish a complete set of parts, with drilled base plate, so that the job of assembling and wiring is very simple. Such an outfit is shown in Fig. 6, the output terminals being mounted on a narrow bakelite strip at one end of the baseboard, and the variable resistances are mounted vertically on the board instead of on the panel, as is done with the other models.

Where a very small space is available for installation of the current supply unit, an outfit such as the one using All-American parts is very handy. A bakelite panel is employed, and on one side is mounted the power transformer and one of the filter chokes. On the other

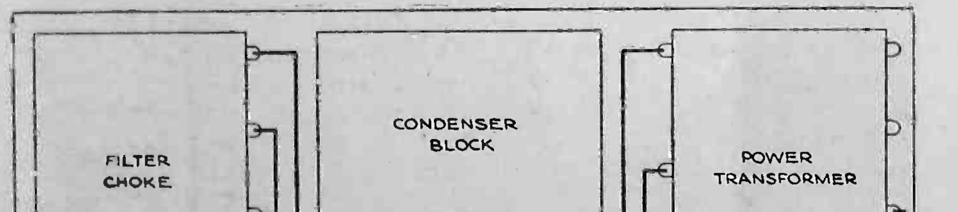
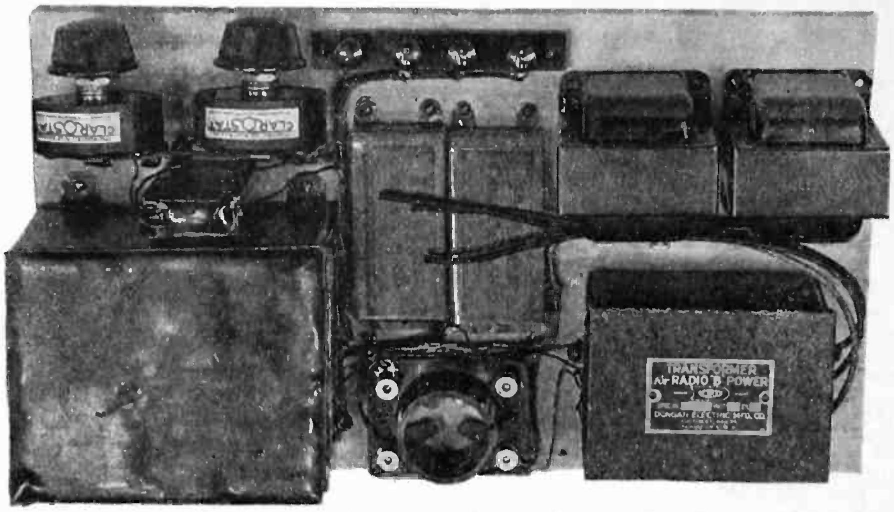


Fig. 5. Pictorial Wiring Diagram of Baseboard Model.



Another Baseboard Model, Using Cabled Insulated Wiring, With Dongan Transformer, Thordarson Chokes and Potter Condensers.

side the remaining filter choke and the filter condensers are installed, and as the transformer and chokes are quite wide, they form a firm support for the completed unit. In this set the separate filter condensers are used, as the block type condenser would take up too much space. Note how the panel supports the variable resistors, which are mounted on the under side of the panel with the knobs sticking through.

Filament Type of Rectifier

WHERE a filament type of rectifier tube, such as the UX-213, CX-313, is to be used, the circuit must be changed in accordance with Fig. 7. The two filaments of the tube are in parallel, and require a total of 2 amperes at 5 volts. Most of the power transformers available have a 7½ volt secondary, with center tap, for furnishing filament current for a power amplifier. When the winding is not needed for the latter purpose, it can be used to light the filaments of the rectifier tube, although a 1.25 ohm resistance must be inserted in one side of the secondary circuit, to reduce the effective voltage across the filaments to 5 volts. A 1.5 ohm filament rheostat will be appropriate for this resistance, and will furnish the desired adjustment.

No other changes need be made to use the filament type rectifiers, except that the socket must be wired so that the filament terminals are connected to the filament lighting secondary, as described above, and the grid and plate terminals are connected to the outside terminals of the high voltage secondary. The positive d.c. output of the rectifier is taken from one side of the common filament connection, and the negative d.c. terminal is the center tap of the high voltage secondary, as in the case with the Raytheon tube.

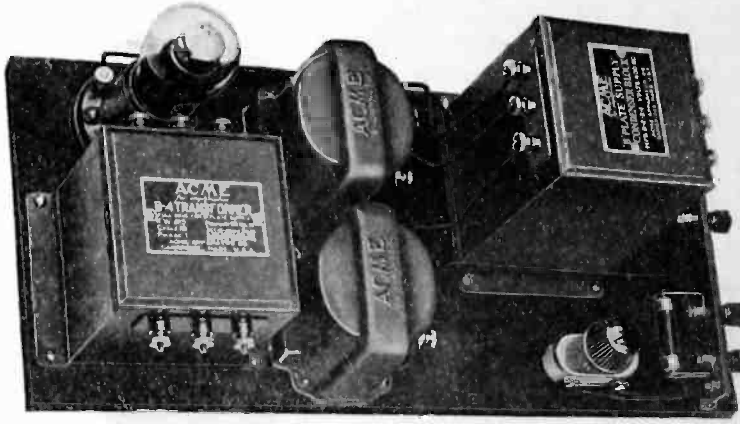


Fig. 6. Baseboard Model, Using Acme Condensers, Transformers and Chokes.

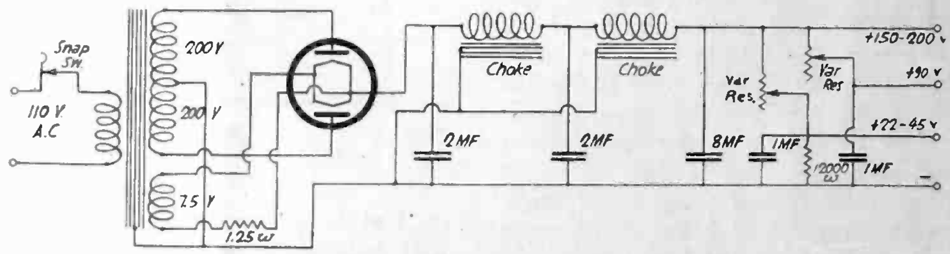
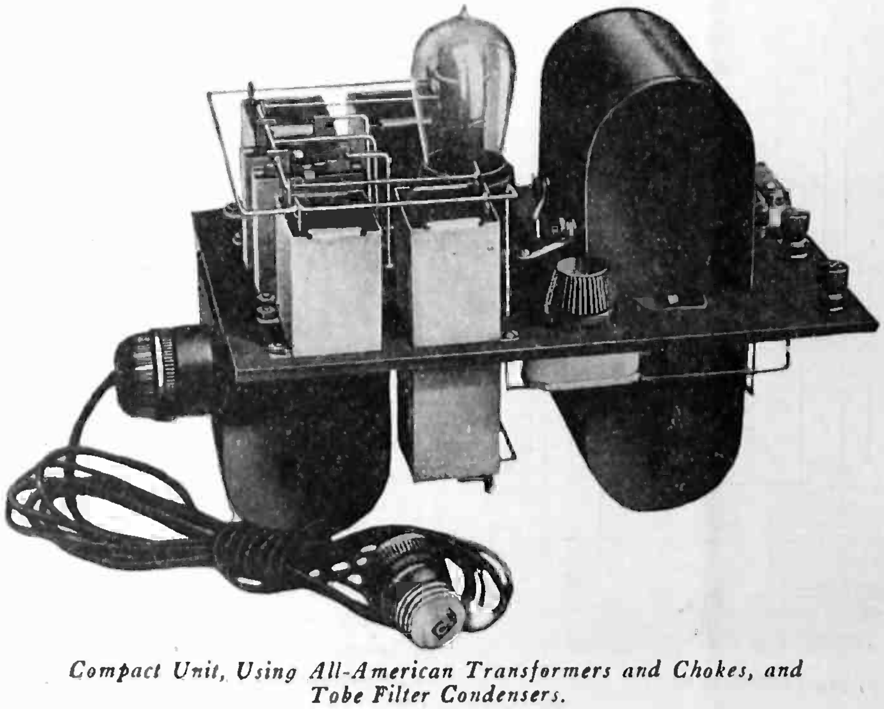


Fig. 7. Plate Supply Unit with Two Filament Rectifier Tube.

Power Amplifier

WHERE the present receiving set is not wired for a power amplifier, and it is not convenient to rewire it, a separate power amplifier incorporated with the plate current supply unit is a very useful thing. In Fig. 8 is shown the connections for a single stage power amplifier, using the UX-171, CX-371 power tube, and with a Raytheon rectifier as an integral part of the equipment. The completed power amplifier is shown in the picture, the baseboard being the same width as for the other plate supply units, but slightly longer to accommodate the power amplifier. The list of parts given herewith is for the power amplifier alone; the plate supply apparatus is the same as for the other baseboard models, and the variable resistances with shunt condensers are furnished so that the necessary *B* voltages for the receiving set may be had.

(*Continued on Page* 48)



Compact Unit, Using All-American Transformers and Chokes, and Tobe Filter Condensers.

An All-Around Short Wave Receiver

Adaptable to Reception of Either Code or Radiocast Programs

By Lloyd Jacquet, 2 OZ

AS AN antidote to the radio listener tired of the same old programs from the same old stations, the short waves provide a field replete with thrills. The knowledge of the code is not essential for short wave reception, because there are quite a few stations sending interesting programs. But of course, the full pleasure of this new field can be best discovered by the listener who takes the trouble to learn the dots and dashes.

Details of a short wave receiver, with a wavelength range from 10 to about 110 meters are given in this article. A list of parts is provided, with full working instructions, and the result is a standard receiver, which amateurs everywhere are using with remarkable results.

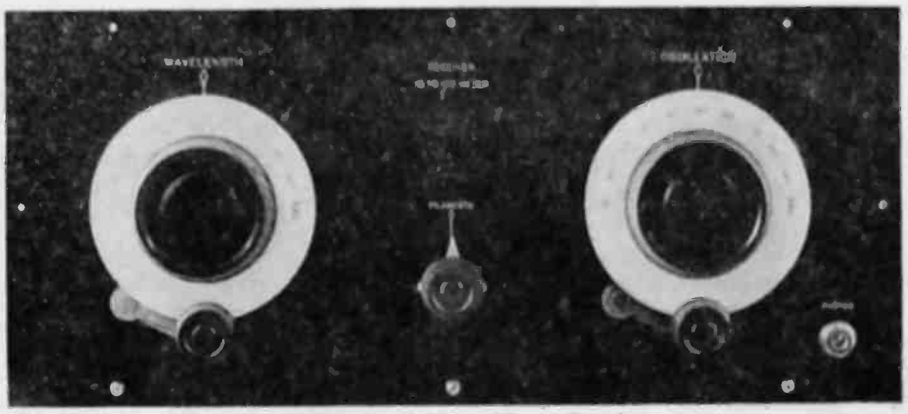
This short wave receiver is, in a way, a universal receiver. With the layout suggested, either the Reinartz, or the capacity-feedback circuits can be used. By means of properly designed coils, the wavelength range can be extended to higher waves.

The set is built around the panel. Either hard rubber or bakelite may be used. As the only "live" connection on this panel is the phone jack, we need not fear current leakage in any case. On this panel will be located the wavelength, or tuning condenser control, to the left, the rheostat in the middle, and the regeneration, or oscillation control to the right. The tuning is really reduced to the turning of these two controls.

A phone jack connection is provided in the lower right hand side of the panel. In addition, eight holes are drilled ½ in. from the edge, at regular intervals along the sides, for fastening the panel to the baseboard, and to the cabinet, if such is desired. The distance between condenser shaft centers is 8¾ in. The rheostat is located in the center, and 2 in. from the lower edge.

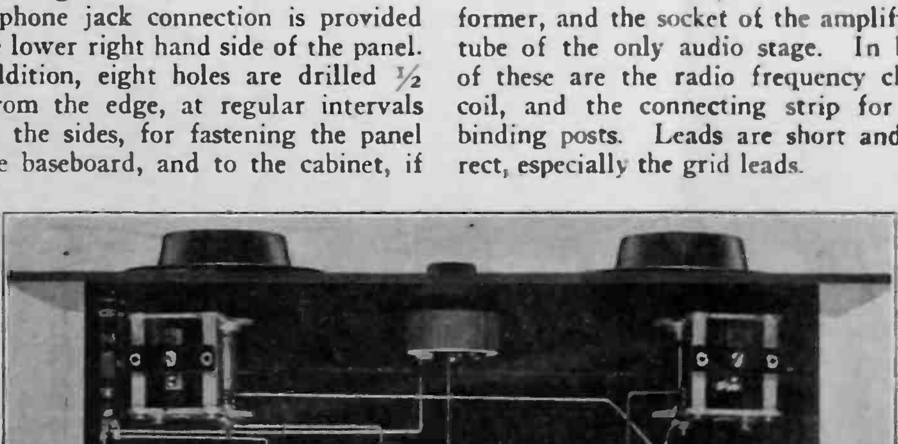
LIST OF PARTS

- 1 Filament control, or single circuit jack.
- 1 7x16x3/16 in. panel.
- 1 10x16x½ in baseboard.
- 2 0.0001 mfd. variable (straight line capacity) condensers.
- 2 Sockets.
- 1 Rheostat.
- 2 Vernier dials.
- 1 Audio transformer (6:1).
- 1 Set low loss coils.
- 1 0.00025 mfd. fixed condenser.
- 1 5 meg. grid leak.
- 1 Set binding posts.
- Bus wire, screws, solder, few ounces No. 30 DCC wire and support for R. F. Choke.



Panel View of Short Wave Receiver.

Study the layout of the apparatus on the baseboard, which has been given special attention. To the extreme left is the small coil rack, then, the sockets of the detector tube, the audio transformer, and the socket of the amplifying tube of the only audio stage. In back of these are the radio frequency choke coil, and the connecting strip for the binding posts. Leads are short and direct, especially the grid leads.



Baseboard Layout with Wiring Details.

By following the picture, which shows the wiring plainly, the builder will have no difficulty in connecting. Bussbar is used for all of the connections, except those of the coil, which must maintain a certain degree of flexibility. Otherwise, everything is quite rigid. No special precautions need be taken for the wiring, except that every joint must be a perfect one. You simply cannot afford to have a loose wire, or a poor connection in a short wave receiver.

The construction of the coil rack is simple. It consists of two pieces of bakelite or hard rubber drilled to fit two glass rods ¼ in. thick, and 5½ in. long. These rods may be purchased cheaply in a drug store, cut, and ground on ends. They fit loosely in their holes, so that they can be removed to change the coils.

As to the coils. So much has been said lately about all types of coils, that the average man well be lost in a maze of technicalities as to distributed capacity, inductance, radio frequency resistance, and other things. Actually, the Lorenz coils seem to be no worse than the single layer solenoids. They can be built by the amateur with patience, very easily. If they are properly designed, ruggedly wound, and the right kind and size wire employed, they certainly do work.

In the coils used for this set, No. 16 double cotton covered wire was used. In order not to soil too easily, chocolate covered wire was used instead of the conventional white covering. In the constant changing over from one to the other, coils soil very quickly. Data are given in the table for the winding of the coils. A form with 15 pegs, mounted in a circle having a diameter 3⅛ in. was used.

From a viewpoint of time and energy expended, it is much more satisfactory to purchase an entire set of coils, instead of winding them by hand. The factory ground, and the results in reception of signals will be determined only by trial in each individual case. In general, a standard fixed condenser of .006 or .01 mfd. capacity connected in series with the usual ground lead will prove more satisfactory, as it offers a path for the radio currents to ground as usual, while insulating the 110 volt supply.

Should the eliminator fail to function when first connected to a receiver, rectification may be started by lifting the electrodes out of the solution, then slowly lowering them into it. This reduces the active surface contact with the solution and allows a film to be built up quickly on the aluminum elements. Should this procedure fail, a 40 watt lamp may be connected directly across the output terminals of the eliminator until all aluminum electrodes can be seen to be gassing freely. Once the film is built up, no further trouble will be experienced.

In time, the solution will turn a dark brown color, but this in no way affects its operation and does not indicate impurities in the solution. Impurities will become apparent by the formation of a black film on the surface of the aluminum, and should such formation occur, it is only necessary to wash the electrodes. However, if reasonable care has been taken in making up the rectifier cells no such procedure should be found necessary.

When in correct operation the aluminum electrodes will show a slight sparkling quite visible in a darkened room, and possibly noticeable in the light. By raising and lowering the electrodes in the solution the sparkling is increased and diminished, the proper depth being at the point where only a dull blue glow with no isolated bright spots is shown on each aluminum. In general this point will be found to be between ½ and 1 inch, but is not critical, in fact may be disregarded except in the interests of efficiency. When successful operation is assured a small quantity of neutral oil or ordinary kerosene may be spread over the surface of the solution in each cell to prevent evaporation and the outfit will require no further attention.

For the high voltage outfit two more condensers of 4 mfd. capacity are necessary and the wiring is somewhat different. The rectifier cells are built up in the same manner as has been set forth, but are all connected in series as in the diagram of Fig. 5. The two added condensers are connected in series directly across the four rectifier cells and the 110 volt leads brought to the middle point of the two condensers and to the mid point on the rectifiers. The theory of action in this connection has been given by Clinton Osborne in March, 1926 RADIO, while the actual output curve using values as shown in Fig. 5 is given in Fig. 6. One cell only may be used on each side, but the voltage output will be considerably lessened and the efficiency low as there will be large amounts of reverse current. In this as well as in all other forms of aluminum-lead rectifiers it is best to use at least one cell for each 50 volts of potential. Thus in the high voltage outfit two cells should be used on each side, there being approximately 200

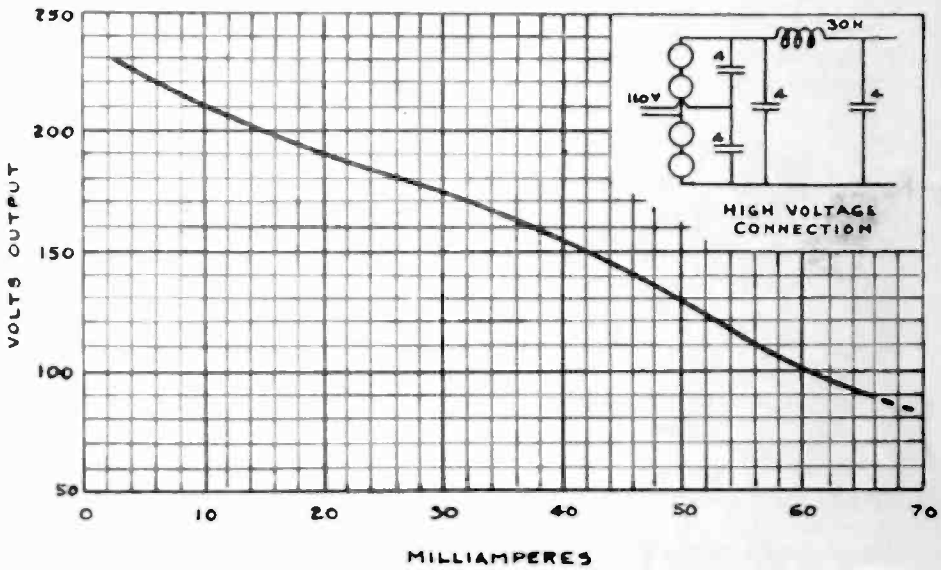


Fig. 6. Current-Voltage Curve of 200 Volt Eliminator.

volts across the four cells in the one illustrated.

Arrangements for various voltage taps can be made in accordance with standard practice used on any eliminator and detailed repetition will not be given. On the 100 volt outfit a detector tap may be obtained through a 50,000 ohm resistance, the Allen-Bradley being recommended. Variable detector voltage is of course preferable, and may be supplied by a Clarostat. For the 200 volt outfit two Clarostats may be used for two intermediate voltages. All intermediate voltage taps should be supplied with individual condensers of 1 mfd., connected to the negative terminal of the eliminator, in Fig. 5.

By using larger values of condenser at *a*, *b* and *c*, and immersing the electrodes deeper in the solution the output of the 200 volt eliminator may be greatly in-

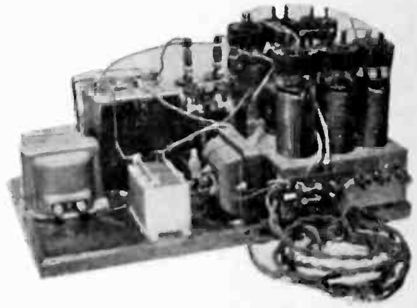


Fig. 7. Complete Electrolytic Rectifier with "A" Battery.

creased, and by so doing it should be entirely possible to adapt it to Mr. Best's *A B C* eliminator circuit in place of the Raytheon tube and transformers.

Fig. 7 illustrates a built up high voltage outfit in conjunction with complete 6 volt *A* battery supply. The trickle charger of the *A* battery is also of the electrolytic type, being a standard Willard colloid cell and a Wayne 50 watt bell ringing transformer. This transformer has taps for voltages of 8, 16, and 24; giving charging rates through the rectifier of 20 mils, 200 mils and 550 mils respectively. The complete outfit requires no attention other than the addition of distilled water every few months. The drain on the house meter is practically negligible.

The surprising feature of the two eliminators described is the small amount of filter necessary for the suppression of undesirable hum. If due care is taken in the preparation of the rectifier cells and the receiver is insulated from the ground for low frequency, no troubles should be experienced in operation.

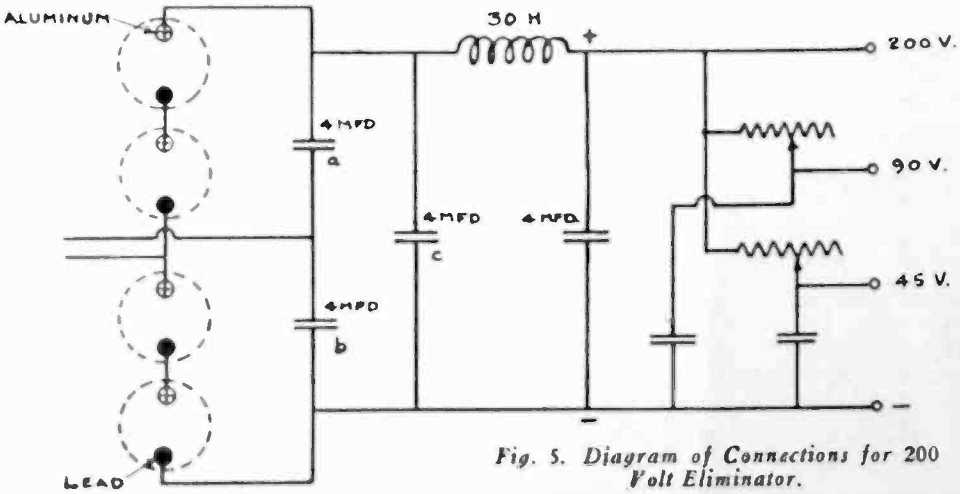
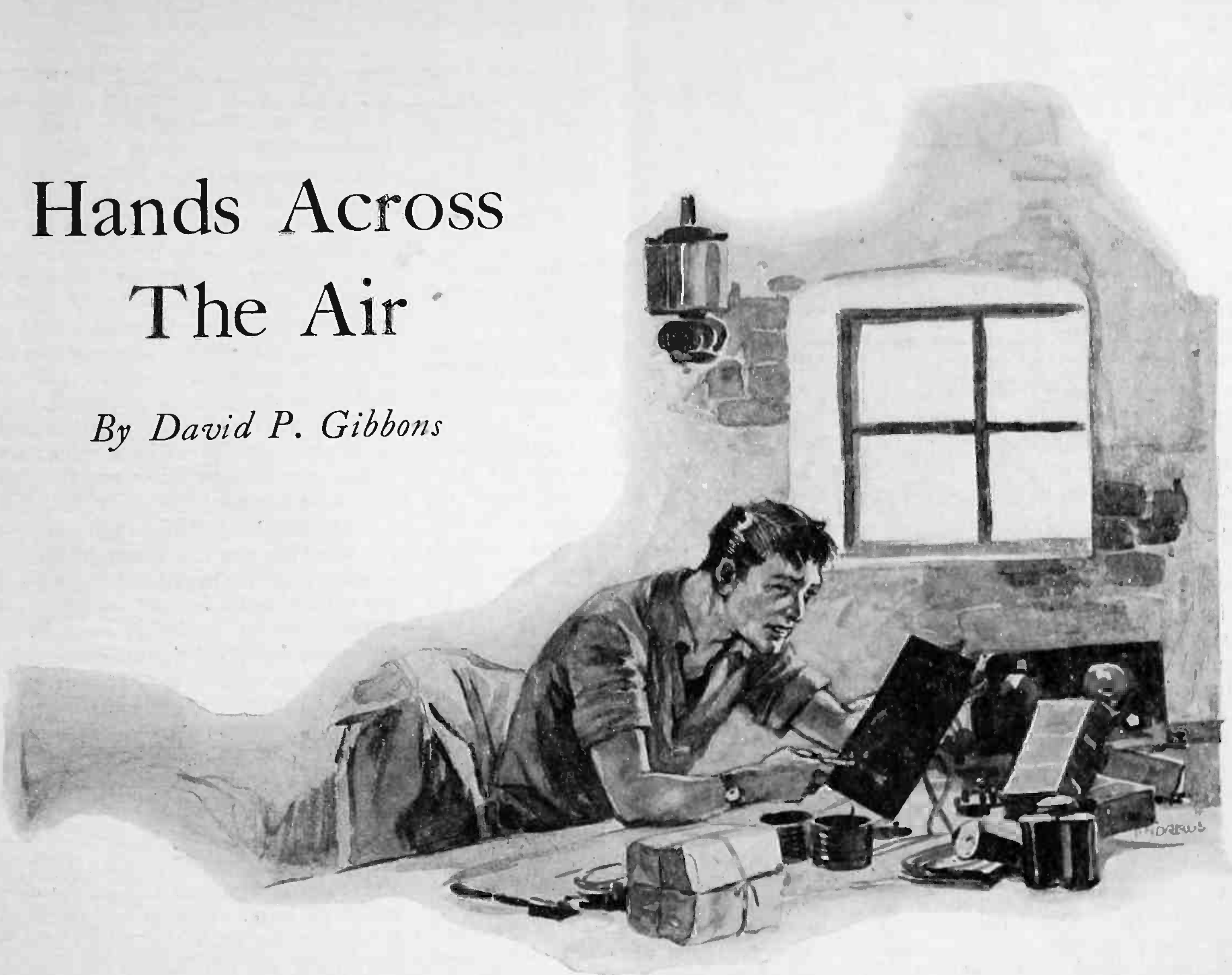


Fig. 5. Diagram of Connections for 200 Volt Eliminator.

Hands Across The Air

By David P. Gibbons



"For two hours he worked feverishly."

JUPITER himself, as the inventor of static, could hardly have been more suspicious and incredulous than was Mr. Walter Bellis, general manager of the Mammoth Radio Corporation at San Francisco, as he listened to Jim O'Dwyer's claims for his new static stopper. Bellis had known O'Dwyer as a capable radio operator who had inherited a fortune about a year before and had resigned his job as a brass-pounder so as to perfect some new radio devices in his laboratory.

Several of these had been successful, but the fiasco of his most ambitious one, a radio-operated hand, was still the butt of many a joke. Its operation had depended upon the modulation of a continuous carrier wave by means of a series of pre-determined supersonic frequencies. At the receiving end these were first filtered and the proper ones selected, while the others were rejected, so as to operate various mechanical devices by means of delicate relays.

As demonstrated at the radio show it had consisted of a mechanical hand which could be grasped at the transmitter and caused to duplicate any form of secret grip to a similar hand located at the receiver. During the first five days of the show these demonstrations caused such widespread publicity that the other exhibitors were hopelessly eclipsed. Thousands of visitors had transmitted the "grips" of various secret societies across the auditorium to brother members holding the receiving hand, and the delicate apparatus functioned perfectly. As a final convincing demonstration on the closing night of the show it was determined to have the High Grand Muckymuck of a well known fraternal order transmit the hand-clasp of brotherhood to another Top Lofty Potentate in Los Angeles and a special duplicate receiving set and hand had been dispatched to the white spot of America and installed in the studio of KFI.

When the announcer at KFI informed the expectant multitude that all was in readiness at his end, O'Dwyer conducted the Grand High to the platform where the transmitting set had been placed, and briefly explained the process and action of the apparatus.

His Nobs who had donned for the momentous occasion his full regalia grasped the extended artificial hand as O'Dwyer threw the switch which put the apparatus in commission. The strained silence was broken by a terrific growl of static from the loudspeaker overhead and at the same moment the air was rent by an astonished yell from the Grand Mucky himself, who casting his dignity to the winds was executing an Indian war dance on the platform while his right hand was still firmly gripped in the relentless grasp of the mechanical fingers, the spasmodic twitchings of which became more violent and the vise-like pressure increased in proportion to the louder and deeper roar of the static.

Before O'Dwyer recovered sufficiently from his amazement to throw the switch again the outraged Imperial Kluck was bordering on apoplexy while the audience was in hysterics and the erstwhile gloomy exhibitors went into paroxysms of delight.

Even Jupiter giggled.

Mr. Bellis had read the embellished reports in the next day's papers and the remembrance caused him to accept with a good-sized grain of salt the startling claims which the young gentlemen before him so confidently advanced.

"Yes, I know, Mr. Bellis," he was saying smilingly, "You are thinking that because that last demonstration of mine was a kind of a flat tire that there's nothing much to this. As a matter of fact though I could right now repeat that same test successfully without the slightest danger of having any atmospheric disturbances interfere in the least. I'm aware of how incredible it must sound to you, but I have actually discovered a method of completely removing static from all radio reception.

Mr. Bellis smiled politely and said:

"How about some practical proof?"

"Any kind of a test you say," agreed

O'Dwyer readily, "When, where and how makes no difference to me."

"We have several of our own sets in various models in the sales department on the next floor," answered Mr. Bellis, "and if you like you might try out your device on them. I'll be glad to listen, but of course this is entirely unofficial."

"I'll be back in half an hour," O'Dwyer said as he took his hat and his departure simultaneously.

The series of tests carried out that afternoon impressed Mr. Bellis sufficiently to cause him to request the young inventor to give a more thorough demonstration by taking his device and several receiving sets of various makes on a trip to Mexico and Central America where the static makes its home and headquarters all the year round. He was to be accompanied by a representative of the Mammoth Corporation. Mr. Bellis entered into a written agreement with O'Dwyer which stipulated that should the results of the trip prove the entire reliability and efficiency of the invention, the Mammoth would pay to the inventor a quarter of a million dollars for the sole patent rights and an additional royalty of two per cent on every "Stopper" sold.

O'Dwyer was jubilant and immediately set about arranging the details of the trip southward to deal a death-blow to the most useless and irritating pest that ever rasped the tempers of an otherwise mild and good-natured populace.

But while he was busy the following day securing accommodations for himself and his prospective companion, as yet unappointed, a conference was being held in the inconspicuous quarters of a shady radio concern which by devious underground channels had learned of O'Dwyer's startling invention and of his early departure to Central America to make a final test. It troubled their democratic sense of equality that this young man, who already had an ample share of the world's goods, should be in danger of being overwhelmed by any further accumulation of filthy lucre. From such a risk they determined to save him at all costs.

Their earnest and vehement deliberations were marked by constant and fervent appeals by the four members present to various deities and divinities, but it was remarkable that not one of them appealed at any time to the divinity most interested. Nobody interjected a single "By Jove!" into the discussion, although Jupiter from his invisible seat on lofty Mount Olympus favored the gathering with an interested and approving smile.

The final result of this conference was boiled down and pithily expressed by the tough-looking leader:

"Here's the dope, then, fellahs," he said. "Manuel here is the boy for this job. He knows radio lingo pretty good. Worked at a station in Spain during the big scrap and handled some delicate stuff from POZ that didn't hurt his bankroll any. He knows these spigotty countries down here and he's on to all the gentle methods of persuasion that a spig can work on beloved gringo to get something he wants. He's got the front and we'll give him the backing. Here's how we'll do it."

He lowered his voice and his companions, including the highly-commended Senor Manuel Malagua, hitched their chairs closer and listened with a concentration and unanimity that explained the success which usually crowned their crooked but profitable deals.

A WEEK later when the motorship *City of Berkeley* glided out from Mazatlan Harbor and passed below the lighthouse, perched on the huge 800 foot rock at the entrance, on its way towards Manzanillo, two of its passengers sat at a table in the smoking-room and regarded each other speculatively. Mr. Dennis O'Dwyer, inventor of the "Static Stopper" and Senor Manuel Malagua, President of the Central American Radio Syndicate and special representative of the Mammoth Radio Corporation, were vainly endeavoring to maintain the friendliness and politeness which their present relationship demanded.

For five days O'Dwyer had been trying to escape a growing suspicion that this dark-skinned voluble Latin-American was not quite the public-spirited business man that Mr. Bellis had represented him when making them acquainted. He had been given to understand that the Central American Radio Syndicate had been formed entirely for the purpose of introducing the benefits and delights of radio to the poor but worthy peons in the vast territory that lies between Tia Juana and "The Big Ditch."

That this enormous field was immensely valuable potentially O'Dwyer realized and it was not remarkable that a company should be willing to invest a large sum in any device which would make this value concrete. The fact, however, that the Syndicate was confident enough to make a deposit of $10,000 with the Mammoth Corporation for exclusive rights to his Static Stopper in their territory before the invention had been tried out commercially was rather remarkable. His suspicions were not decreased by the persistent endeavors of Malagua to obtain some information as to the principle on which his device operated.

Two days later the *City of Berkeley* anchored a mile off-shore from Acapulco within hailing distance of her sister ship, the *City of Alameda,* just in from the south. The two departing passengers were swung out over the side in a chair attached to a rope running through a block on the cargo boom and were lowered into the heaving rowboat alongside. Their baggage followed promptly, including the cases containing the various sets, and on reaching the flimsy-looking dock that extended precariously through the pounding surf, they were hoisted ashore in a similar manner.

They inspected the primitive accommodations of the one so-called hotel and proceeded to unpack the apparatus for the evening test. As the Spanish-speaking member of the party Manuel was detailed to convince the doubting landlady that an aerial across the roof would not cause any immediate violent commotion of nature, and with the more than willing aid of the entire junior male population he soon had a fair two-wire aerial about 40 feet above the ground, with a lead-in and ground connection that would have passed inspection anywhere.

Meanwhile O'Dwyer had unpacked the receiving sets and arranged them on a couple of borrowed tables, stacking the empty cases in one corner of the room. One of the larger cases he left unopened and piled the others carelessly on top of it, remarking to himself, "Sure glad I thought of sticking in a duplicate Stopper with that other junk in the quite probable event that brother Malagua tries any funny business with this one we are using."

His suspicions of Manuel's unbrotherly intentions, however, did not prevent him from accepting a cup of the coffee which the latter had suggested in view of a late session with the receivers. He had drunk this unpalatable beverage before, and he believed that if this mixture of black sirupy coffee extract and hot water were offered as coffee anywhere along Ellis or Powell Streets the police reserves would have to be called out to quell the ensuing riot.

He made a remark to this effect to the solicitous Manuel and with a grimace gulped down the bitter cupful. Five minutes later he threw himself heavily on the bed and immediately dropped off into that pleasant land that knoweth not of static or bloopers or run-down batteries.

Way up aloft on Mount Olympus Jupiter roared and playfully kicked a couple of sleeping volcanoes into activity.

O'Dwyer awoke slowly and painfully about noon of the following day and with the help of some wicked native poison antidote (called *tequila*) managed to collect his badly scattered wits. He was not greatly surprised to learn that the oily Manuel had reached the *City of Alameda* a few minutes before that vessel had picked up her anchor and got under way on the run up the coast to San Francisco, nor to find that the departing Senor had added injury to insult by absconding with the highly prized Static Stopper.

The *City of Berkeley* had left at daylight that morning on her way to the Canal, and by slow degrees, due partly to his having to resort almost entirely to

(*Continued on Page 56*)

Voltage Versus Power Amplification

A Quantitative Analysis of Resistance, Impedance and Transformer Coupling of Vacuum Tubes

By J. E. Anderson

THE recent popularity of the power tube for use in the last stage of audio frequency amplification has occasioned some confusion in the minds of radio users. They have learned to regard a vacuum tube as essentially a voltage amplifier and find it difficult to adjust their ideas to the concept of power amplification.

This confusion is cleared by the knowledge that every tube is a power amplifier, but in the ordinary tube the voltage component of the power is amplified much more than the current component. Power is equal to the product of voltage and current; $P=EI$, watts equal volts times amperes. According to Ohm's Law amperes equal volts divided by ohms; $I=E/R$. Upon substituting this value of current in the power equation, $P=E^2/R$. So the power varies as the square of the voltage. Thus if V is amplified tenfold, then P is amplified a hundredfold.

The fundamental characteristic of a vacuum tube, no matter what kind of coupling may be used between two tubes, is to amplify the voltage more than the current. Every coupling device is a voltage amplifier or a voltage "losser." But power is always associated with its voltage amplification.

The usual distinction between what have become known as voltage and as power amplifiers is in the method of coupling. Thus all direct coupled circuits, such as those employing resistances or choke coils, are considered as voltage amplifiers, while those employing transformers are power amplifiers. This classification is somewhat artificial but it serves a useful purpose. If the coupling is such as to transfer the greatest proportion of the voltage in the plate circuit of a tube to the grid circuit of the next tube, we have voltage amplification. If the coupling is such as to transfer the greatest power from the plate circuit of a tube to the primary of a coupling transformer or to the windings of a loud speaker or other power driven device, we have power amplification.

But another heretofore less used distinction exists in the inherent characteristics of the tubes, most of which are designed primarily as voltage amplifiers, but in some of which a greater current amplification takes place coincidentally with the voltage amplification so as to give greater power amplification. So a real power amplifier tube is a current amplifier and usually has less voltage amplification than a voltage amplifier. The present treatment is concerned only with a study of the effects of different kinds of coupling.

LET us first consider resistance coupling for obtaining voltage amplification. This is the simplest form of coupling and it is very popular now because of its inherent non-distorting qualities. Let the input voltage to the tube be E and let the amplification factor of that tube be μ. The effective voltage in the plate circuit of the tube is then $E\mu$.

Now suppose that the plate ac output resistance is R_p ohms and that the resistance of the coupler is Z ohms, a pure resistance. R_p and Z are both in series with the voltage $E\mu$. Hence the current in the plate circuit is $E\mu/(R_p+Z)$. Therefore the voltage across Z is $E\mu Z/(R_p+Z)$, and this is the input voltage to the second tube. The amplification of this resistance coupled stage is $\mu Z/(R_p+Z)$, or $Z/(R_p+Z)$ for each unit in the amplification factor of the tube. This is a measure of the amplification and it may be denoted by the letter m.

If we divide both the numerator and the denominator of the expression for m by Z and denote the ratio R_p/Z by x, we get that $m=1/(1+x)$. The amplification, then, for each unit in μ depends only on the ratio of the plate ac resistance of the tube to the coupling resistance. The smaller this ratio is, that is, the smaller x is, the larger is the amplification. The smallest x can be is zero, when the amplification is unity, that is, then the entire voltage in the plate of the tube is transferred to the grid circuit of the next tube. That is the ideal limit in this type of voltage amplification. The larger x is the smaller is the amplification, a condition to be avoided.

Now x may be made small in one of two ways. The plate output resistance R_p may be made small or the coupling resistance may be made large. The first choice is not available for practical reasons, for, ordinarily, as the plate resistance is reduced so is also the amplification factor of the tube, and nothing is gained in amplification. It is better to use a tube with a high μ even if it has a high plate output resistance. The alternative of making x small, that is, by making Z large, is available, however.

It is interesting to see graphically how the value of m varies with different values of x. This graph is shown in A of Fig. 1. It starts with a value of unity for x equals zero and then gradually decreases as x increases. When x is unity, that is, when R_p and Z are equal, the value of m is .5, which means that only one-half of the voltage in the plate circuit is transferred to the grid of the next tube. This is the point where the coupling resistance matches the tube impedance. A voltage amplifier should be operated with such a value of Z that x is smaller than unity so that more than .5 of the total plate voltage is passed

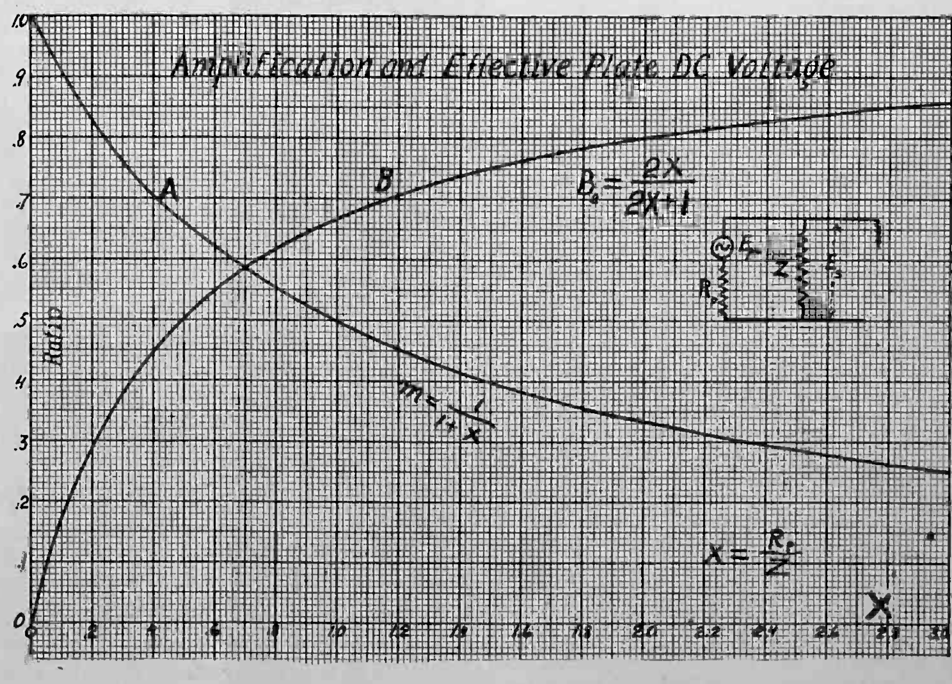


Fig. 1. Curves for Determining Proper "B" Battery Voltage in Amplifiers.

on to the next grid. As will be seen, when the value of x is .2 the value of m is .83. This is the case when the coupling resistance is 100,000 ohms and the plate impedance of the tube is 20,000 ohms, a common case. If this tube has an amplification constant of 8 when its plate impedance is 20,000 ohms, then the amplification will be 8X.83=6.64 times. When x has the value .1 the amplification ratio m is .905, which makes the voltage amplification 8X.905=7.25, assuming that the μ of the tube has not changed.

A practical limitation to diminishing the value of x by increasing Z is the voltage drop in the coupling resistance. This reduces the effective dc plate voltage on the tube and thereby changes both the μ of the tube and its plate output ac resistance. The only part of the B battery voltage which is effective on the tube is that which is dropped in the plate dc resistance. That part which is dropped in the coupling resistance is wasted in a sense. The plate dc resistance is larger than the ac resistance, approximately twice as large.

On the assumption that it is exactly twice as great, the ratio of the effective plate voltage to the total applied B battery voltage is given by $2x/(2x+1)$, in which x is still the ratio of the ac plate resistance to the coupling resistance. This expression has been plotted in B, Fig. 1. As will be seen from the curves, when the value of x is unity then two-thirds of the applied B battery voltage is effective on the plate, while the amplification ratio is .5. Also when the value of x is .5, B is .5 effective, but the amplification ratio is two-thirds. The two curves cross at x=.7, when the amplification ratio and the effective voltage ratios are .585.

The curves of Fig. 1 may be used in determining the correct B battery voltage to be applied under given conditions. Suppose a certain amplifier tube has a plate output resistance, or impedance, of 20,000 ohms and an amplification factor of 8 when the effective plate voltage is 45 volts. Suppose we wish to use a coupling resistance of 100,000 ohms with this tube. What should the applied voltage be in order that the effective value be 45 volts. The value of x is .2 and from B we see that for this value of x the effective voltage is only .285 of the applied. Then 45=.285B, where B is the B battery voltage required, which is 157.8 volts. The amplification ratio is .83 and the voltage amplification is 8X.83=6.64 times. A failure to realize that in resistance coupled amplifiers the effective plate voltage is only a small fraction of the applied B battery voltage has led to much distortion from overloading, and consequently too much condemnation of this type of amplification.

The small value of the effective plate voltage for a given applied B battery voltage is the main disadvantage of resistance coupling. But if high μ tubes are employed the disadvantage is not so serious. Suppose we have a μ 20 tube which has a plate ac resistance of 40,000 ohms and that we use a coupling resistance of 100,000 ohms. Then the effective B is .45B, according to B, Fig. 1. Thus the required B for an effective value of 45 is only 100 volts. The amplification is 20X.7=14 times, according to Curve A.

The situation is much more favorable for choke coil coupling. Suppose that the coupling impedance Z is composed of a high inductance with fairly low resistance, instead of a pure resistance. Z will then be large for all the essential frequencies in the scale, and consequently x will be small. In fact it will be very near zero for all the essential frequencies in the scale. That means that the amplification ratio will be near unity, and that nearly the whole of the μ of the tube is transmitted to the grid of the next tube. The high value of Z is obtained mainly through the inductance. The resistance is comparatively low. Hence the dc voltage drop in the resistance of the choke coil winding will be small, and the effective value of the plate voltage will not differ greatly from the applied value. Suppose that the dc resistance of the choke coil is 15,000 ohms. This value will make x in the formula equal to 2.66 when the plate impedance of the tube is 40,000 ohms. This makes the effective value of the plate voltage equal to .842B. The particular choke coil used had an impedance of 5.5 million ohms at 1000 cycles, making the x for this value equal to .00728, and the amplification ratio .993. At 100 cycles the ratio is about .931. While x varies greatly over the tone scale, the amplification ratio varies but slightly. Hence we get good amplification for all the essential frequencies without the necessity of using excessively high B battery voltages.

In order that we may more clearly see the differences between resistance and choke coil coupled amplification, the curves in Fig. 2 have been plotted to show the amplification as a function of frequency. For abscissas are used the logarithm to the base 2 of the frequency rather than the frequency itself. This is done so that the octaves will be equally spaced and so as to give the proper weight to the musical intervals. The locations of the various C's on the scale are marked, assuming that middle C has a frequency of 256 cycles per second.

Curve A is the amplification curve for a choke coil having an inductance of 875 henrys and a dc resistance of 15,000 ohms. This curve runs from unit frequency up to 8,192 cycles per second. The amplification per unit μ starts with nearly .45 for unit frequency and gradually increases to unity for infinite frequency. The amplification for the very lowest frequencies are mostly due to the dc resistance of the choke coil, and for the higher frequencies to the inductance of the choke. At unit frequency, .216 is due to inductance and about .223 to resistance. At 4 cycles per second, that is, at $\text{Log}_2 4=2$, the effect of resistance begins to be negligible. The lowest audible frequency may be taken as 16 cycles, that is, C^{IV}, where $\text{Log}_2 16=4$. At this point the amplification is .815; at middle C it is .988; and at C^{III} it is .998.

Curve A does not appear to be very uniform over the essential frequency scale, since the amplification varies from .815 to .998 of the maximum. But this variation is wholly inappreciable to our sense of intensity variation. Furthermore, the error is partly compensated for by a selective tuner which emphasizes the low frequencies and suppresses the high.

As a direct comparison between choke

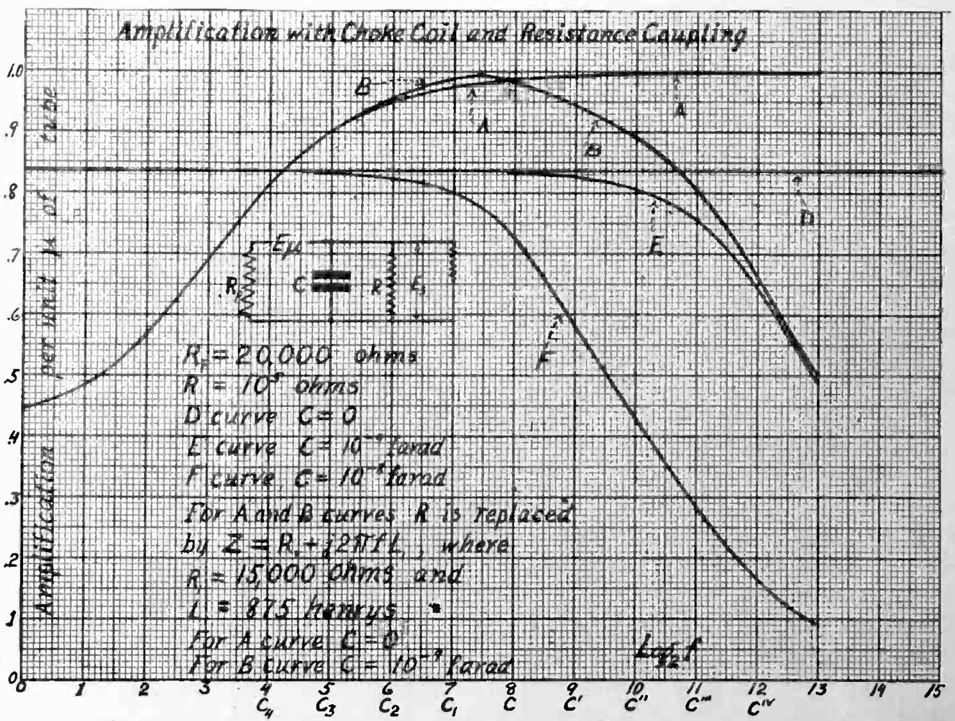


Fig. 2. Variation of Amplification with Frequency in Resistance and Impedance Coupled Amplifiers.

coil and resistance coupling, Curve *D*, has been plotted. This is based on the same plate impedance, namely 20,000 ohms, and a coupling resistance of 100,000 ohms. Curve *D* is a straight line parallel with the axis of frequency, and runs at a distance .833 up. Since the curve is a straight line parallel with the axis, the amplification is the same for all frequencies from zero upward. Curves *A* and *D* cross at 18.4. For all higher frequencies this particular choke coil gives higher amplification than the resistance, and for all lower the resistance gives the higher amplification.

Curves *A* and *D*, presume that there is no distributed capacity in the winding of the choke, and that there is no by-pass condenser across either the coupling resistance or the coupling choke. Of course distributed capacity cannot be avoided in a choke coil, and it very frequently happens that it is necessary to put a by-pass condenser across either the coupling resistance or across the choke, usually for the purpose of aiding regeneration in the detector. What effect will capacity across the coupling impedance have on the amplification? Is the effect, if any, negligible for the capacities usually recommended? Let us see.

First assume that there is a total capacity of .001 microfarad across the 875 henry choke coil. This of course alters the coupling impedance. For all the low frequencies the impedance is practically unaffected, for the higher frequencies the impedance is greatly reduced, for frequencies near the resonant frequency of the coil and condenser the impedance is increased. Since *Z* in our formula for amplification varies in a different manner from that for resistance and inductance alone, it follows that our *x*, and consequently the amplification, will vary differently. The amplification curve in this case is given by *B*, Fig. 2. As will be seen *B* follows *A* up to $\text{Log}_2 f=5.4$, or $f=42.4$ cycles, where *B* rises above *A*. It reaches a maximum at $\text{Log}_2 f=7.47$, or $f=177$. At $\text{Log}_2 f=7.87$, or $f=233$, it again crosses *A*, and from then on the decrease in amplification is rapid. The rise of *B* above *A* is due to parallel resonance of the by-pass condenser and the inductance of the choke. The impedance at resonance is so large that the amplification is practically unity. The decrease in the amplification for the higher frequencies is due to the by-pass effect of the condenser, and as will be observed the decrease in the amplification is quite serious. In the three octaves between $\text{Log}_2 f=10$ to $\text{Log}_2 f=13$ the decrease in amplification is from .89 to .50. Even this enormous difference may be inappreciable to an untrained ear, but when to this distortion is added the similar distortion in a selective tuner, almost any ear can tell that something is missing. Few may know just what is missing, but the thing does not sound quite as it should. It is an interesting experiment to put a condenser across a choke or other device of similar nature and actually hear the difference.

What happens in a resistance coupled amplifier when a condenser is put across the resistance? First take a .001 mfd. condenser and put across the 100,000 coupling resistance already used. Without the condenser we got *D* for the amplification characteristic. With the .001 mfd. condenser we get *E*. As will be seen, this curve begins to deviate from *D* to an appreciable extent at middle *C*. In three octaves the amplification has decreased from .833 to .755, and in two more octaves it has decreased to .488. This is far from non-distorting. Now suppose we increase the by-pass condenser to .01 mfd., that is, make it just ten times as great as it was before. The amplification curve now becomes *F*. This starts to deviate appreciably from *D* at C_3, or 32 cycles per second. At C_1, or at 128 cycles, the descent becomes rapid, and it is not checked until the frequency is 4,096. Even above that frequency it keeps on going down. In the nine octaves between $\text{Log}_2 f=4$ and $\text{Log}_2 f=13$, the amplification decreases from .833 to .090, and the greatest variation occurs in the most important range of the frequency scale. A by-pass condenser of this magnitude is therefore out of the question. Yet it is not infrequent that a condenser of half that magnitude, namely .005 mfd., is recommended. Obviously, that also is much too large. Curves *B*, *E* and *F* show the importance of using the smallest by-pass condenser possible, which will accomplish the desired result.

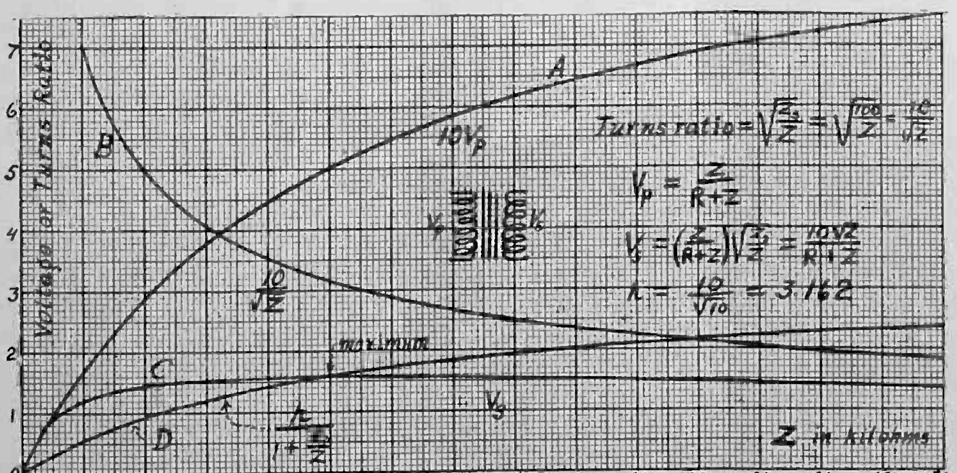


Fig. 3. Curves Showing Necessity for High Primary Impedance in Transformer Coupling.

THERE remains transformer coupled amplification. This has been called power amplification regardless of whether or not there has been any attempt made to match the impedance of the primary with that of the plate circuit of the tube. It has also been stated in authoritative sources that these two impedances should be matched and that the tube should be operated as a power amplifier in order to get the greatest voltage gain per stage. This is here questioned, at least as regards radiocast reception.

The reasoning used in arriving at the matching condition is familiar, but bears repeating. Suppose R_p is the plate output impedance, Z the impedance of the primary of the transformer, $E\mu$ the effective voltage in the plate circuit, and Z_s the impedance of the secondary winding. Then the current in the primary circuit is $E\mu$ divided by R_p+Z, and the primary voltage E_p is $E\mu Z/(R_p+Z)$. The secondary voltage is obtained by multiplying the primary voltage by $\sqrt{Z_s/Z}$, the effective turns ratio of the transformer. Hence the secondary voltage is $E\mu\sqrt{ZZ_s}/(R_p+Z)$. To obtain the greatest amplification this should be made as large as possible.

Now it is argued that since the input impedance to the second grid is very large, it is desirable to make the secondary impedance as large as possible. Then make it as large as it can be made practically, and regard it as a constant. The variable factor in the above expression for secondary voltage then becomes $\sqrt{Z}/(R_p+Z)$. This factor has a maximum value when Z is equal to R_p, a fact which may easily be verified by differentiation. Hence to get the greatest voltage gain with transformer amplification, with the secondary impedance constant, the primary impedance should be made equal to the output impedance of the tube. This is also the condition for getting the maximum power out of the tube. Hence the conclusion that tubes should be operated as power amplifiers when transformer coupling is used in order to get the greatest step-up per stage.

Anybody who understands the differential calculus has checked the above argument and has concluded that it is correct. And it is, for the very limited case imposed by the conditions. Just what happens when Z is varied and Z_s is held constant? As the Z is increased the primary voltage is increased. This would tend to increase the secondary voltage. But as Z is increased the transformer ratio is reduced, and this tends to decrease the secondary voltage. Of course, decreasing Z has the opposite effect, increasing the transformer ratio and decreasing the primary voltage. Curve *A*, Fig. 3, shows graphically how the primary voltage varies with Z. This curve does not give the actual primary voltage but any ordinate is directly proportional to it for any value of Z. Curve *B* gives the turns ratio of the transformer as Z is varied. These curves are based on the assumption that the plate impedance of the tube is 10,000 ohms and that the constant impedance of the secondary of the transformer is 100,000 ohms. Curve *C* gives a measure, V_s, of the secondary voltage for different values of Z. This curve has a maximum at $Z=R_p=10{,}000$.

Under the condition, then, of constant secondary impedance, the amplification is greatest when the primary matches the tube from which it gets its exciting current. But when is the secondary impedance constant? It is when we are dealing with a single frequency; and therefore we can only match the tube and the primary at one frequency. But we have no means for doing this; for, fortunately, available transformers do not have taps on the primary nor any other means of varying the impedance. Hence we are limited to selecting a transformer which we think matches the tube we use at some desired frequency.

In any practical transformer neither the impedance of the secondary nor that of the primary remains constant. Each is very nearly proportional to the frequency. Deviations from this proportionality are due to resistance and capacity in the windings. Since the impedance of each winding is directly proportional to the frequency, the effective ratio of turns remains constant.

How will the amplification vary when the effective ratio of turns is constant? This is easily found by substituting the constant $\sqrt{Z_s/Z}=r$ in the expression for the secondary voltage already given. The result may be expressed $r/(1+x)$, where x is the ratio of R_p/Z. This, it will be observed, is the amplification per unit μ obtained for direct coupling, multiplied by the constant ratio of turns. This expression has no maximum for any finite frequency, but increases from zero up to the value r. Hence the larger the value of Z, the greater will be the amplification. Therefore if we wish a high amplification we should choose a transformer with as high primary impedance as possible, that is, high as compared with R_p, and we should not match impedances.

In Curve *C*, Fig. 3, is shown the amplification curve of a transformer having a constant ratio of turns equal to 3.162, and connected to a tube having an output impedance of 10,000 ohms. This curve gives the amplification per unit μ of the tube as a function of the primary impedance, and since the impedance is directly proportional to the frequency, it gives the amplification as a function of frequency for any one transformer as well as for different transformers of varying primary impedance, the ratio of turns remaining constant no matter whether the value of Z *is* changed by varying the frequency or the turns. The *D* curve crosses the *C* curve at $Z=10{,}000$ ohms, where *C* is maximum, because the values were so chosen.

Thus to get the highest amplification with transformers, the primary impedance should be considerably higher than that required for matching the impedance of the tube. There are two other main reasons why the primary impedance should be high. First, the higher the primary impedance is, the more nearly is the dynamic characteristic of the tube a straight line, and consequently the signal will be relatively freer from harmonics. Second, the higher the primary impedance is, the less will the amplification vary over a given frequency range, and hence the less will be the sound intensity distortion.

There are, of course, practical limitations to increasing the primary impedance, keeping the effective turns ratio constant. They are: cost of transformer, bulk of the instrument, and finally the distributed capacity of the windings. The tendency now is to make transformers bulky, and costly, and satisfactorily good. If proper care is taken to reduce as much as possible the distributed capacity, transformers may be made in which the capacity does not produce any serious effects. A little capacity in the windings will even help to prevent too great amplification at the higher audio frequencies, which necessarily results if the inductance is pure.

It will be interesting to see how Curve *D*, Fig. 3, looks when plotted against frequency, or rather against Log $_2f$. Curve *A*, Fig. 4, is this curve. Here the inductance of the primary is 25 henrys, the resistance of the primary winding is 1,300 ohms (at zero f), R_p is 10,000 ohms, r is 3.162. The curve has been plotted over the nine octaves between $f=16$ and $f=8{,}192$ cycles per second. The curve rises rapidly from .85 at $f=16$ to 2.55 at $f=256$ and to 3.15 at $f=8{,}192$. It tends to flatten out at the higher frequencies.

Curve *A* does not look very good in view of this wide variation, but nevertheless it is a typical amplification curve for a transformer of the better class. No transformer curve published is carried as low as 16 cycles, most of them stopping near 100 cycles per second. Suppose we start the curve at 128 cycles, or at Log $_2f=7$. Here the amplification is 2.15. Most transformer curves published do not go above 4000 cycles. At 4,096, or Log $_2f=12$, Curve *A* shows an amplification of 3.1 times. It is a pretty good transformer that shows no greater variation over this range. One reason the curve does not look so well is that it has been plotted on a logarithmic scale. Other curves are usually plotted on a frequency scale, which "plays up" the flat portion of the curve by stretching it out, and at the same time minimizes the curved portion by crowding it together, or by throwing most of it away.

Now what effect does the distributed capacity of the windings or that of a bypass condenser have on the amplification? This is answered for one case by Curve *B*, Fig. 4, which is taken under exactly the same conditions as Curve *A*, except that a .001 mfd. condenser has been connected across the primary of the transformer. *B* begins to rise above *A* appreciably at middle *C* and it reaches a maximum at nearly C^{11}, or more exactly

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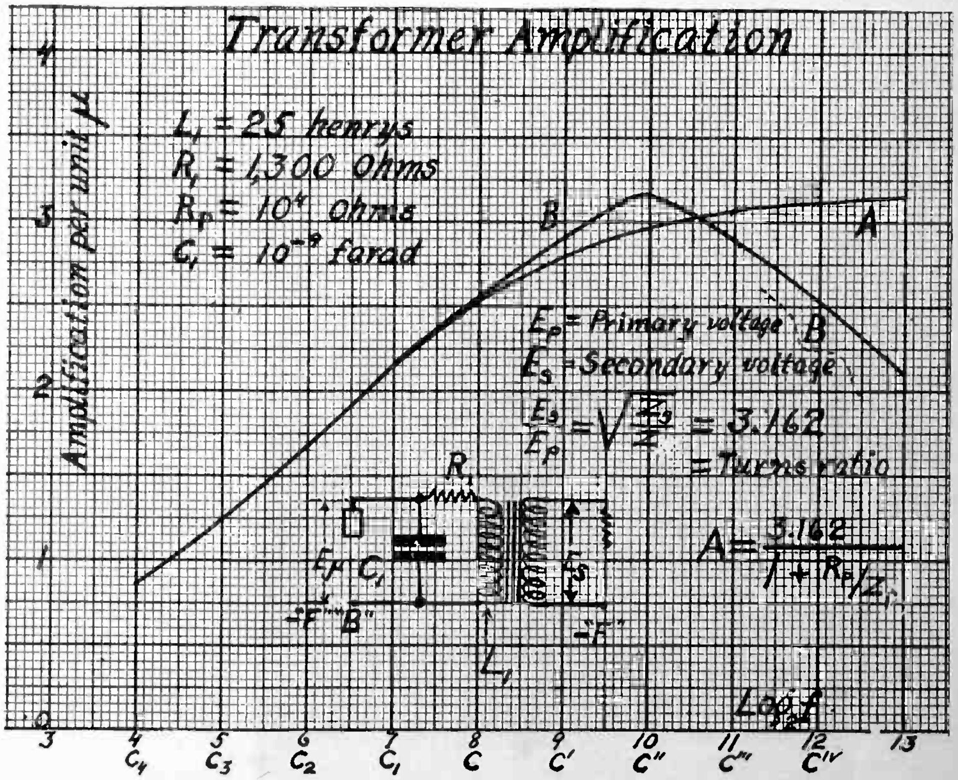


Fig. 4. Variation of Amplification with Frequency in Transformer Coupling.

An All-Wave Duplex Receiver

Covering All Wavelengths From 20 to 20,000 Meters by Means of Three Units

By Mickey Doran

THIS receiver was designed primarily for use aboard ship where the only contact with the shore world for long periods of time is by radio. A more or less constant watch is required on the ship's 600 meter wave along with periodic reception of long wave press news, radiocast programs, and short wave amateur and broadcast work.

These receiving requirements were originally met by means of several receivers scattered about the desk along with a maze of external wiring, separate antennas, headsets and other complications. Shifting from one wave band to another or cutting out the various receivers when the spark transmitter was operated was quite a job and on the whole the receiving plant was not satisfactory from the viewpoint of the operator.

The present receiver was developed after a year or more of experimenting and it is believed to be about the last word in ship sets. Arctic expeditions, ships and other isolated groups might find the answer to their problems in a similar rig. The entire assembly, containing four distinct receivers occupies less space than a standard Navy type ship's receiver. Each unit measures 7x12x10 inches. See Fig. 1.

All wavelengths are covered from 20 to 20,000 meters, including amateur and radiocast short wave bands, regular radiocast bands, commercial ship bands, and commercial and Navy long wave bands.

The four receivers in the assembly are so designed that two sets can be used simultaneously on the same antenna without the tuning of one affecting the other. Phones or loud-speaker can be used alternately on either receiver, or if straight phone reception is desired, the separate phones of the headset can each be connected to any one receiver.

For head-phone work, a one-stage transformer coupled amplifier in the B.C.L. set gives ample volume. A two-stage resistance coupled amplifier follows this when the loud-speaker is used. One or two stages of transformer coupled amplification are available at will for phone work.

The various circuits chosen are sufficiently selective for use aboard ship and might even be used ashore, although some modification might be necessary for use near local transmitters. The operation of cutting in or out any one receiver or amplifier or any two receivers can be done instantly by throwing the proper antenna and filament switches. The output through phones or loud-speaker is likewise instantly available. There are no rheostats to adjust, no leads to pull off or put on and no plugs and jacks to monkey with.

Ordinarily, the 600 meter watch is maintained with the MED. wave set, using phones. When wanted, the B.C.L. set is cut in for broadcast programs with the loud-speaker, or one or both phones of the headset are cut in on it temporarily while tuning. When copying press on the LONG wave set, or amateur signals on the SHORT wave set, the 600 meter watch is transferred to the B.C.L. set. The following duplex combinations are possible:

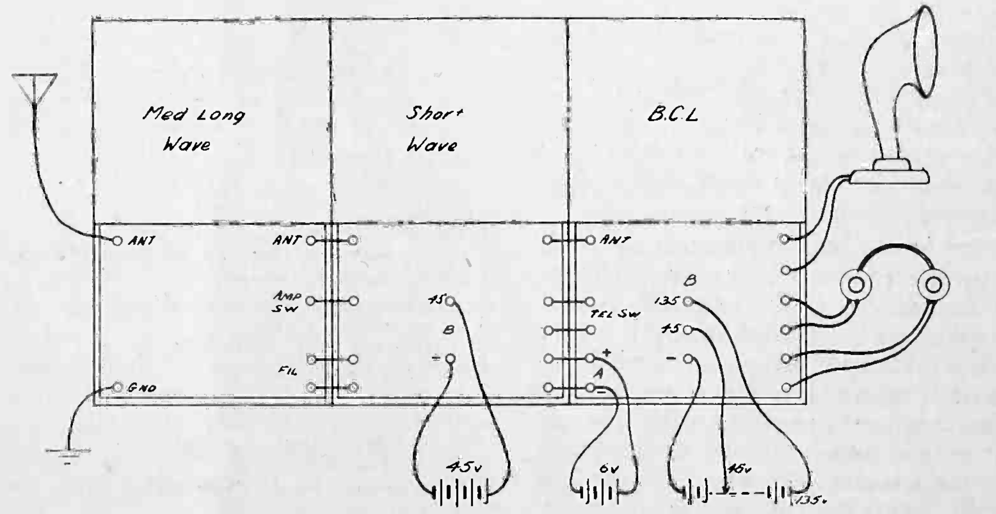


Fig. 2. Rear Panel Arrangement of Three Units.

Receiver	*Wave Band*	*Output*
BCL Med. WV	Broadcast 600 meters	Horn, One or both phones. Phones with 1 or 2 stage amplifier.
Long WV BCL	Press waves 600 meters	One or both phones with 1 or 2 stage amplifier. One phone or horn.
Short WV BCL	Amateur bands 600 meters	One or both phones with 1 or 2 stage amplifier. One phone or Horn.

When not necessary to maintain the 600 meter watch, other combinations are possible.

If any new or better circuit is found, only the one of the three units affected need be changed. There is no necessity for tearing down the entire set; simply remove the rear connections and pull out the unit to be changed.

The antenna must be large. At least 200 ft. long and 50 ft. or more high is recommended. A shorter antenna will reduce signal strength, especially on the MED. and LONG wave sets.

The B. C. L. set uses a standard Browning-Drake circuit, followed by one transformer and two resistance coupled stages of audio amplification. The phone and horn control switches are located on the panel of this unit. The Browning-Drake circuit is used because the regeneration control permits the reception of CW signals on 600

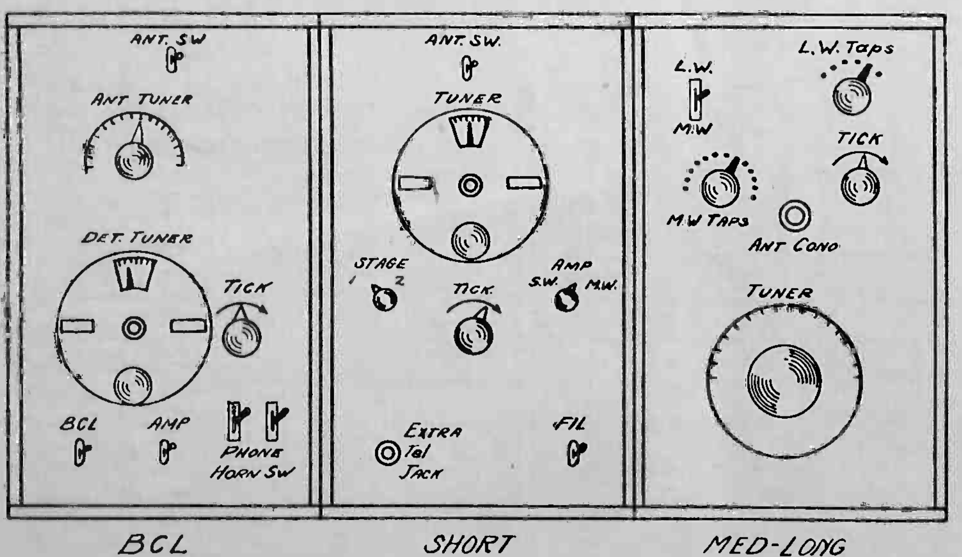


Fig. 1. Front Panel Arrangement of Complete Receiver.

Arresting Stray R. F. Currents

By A. J. Anderson

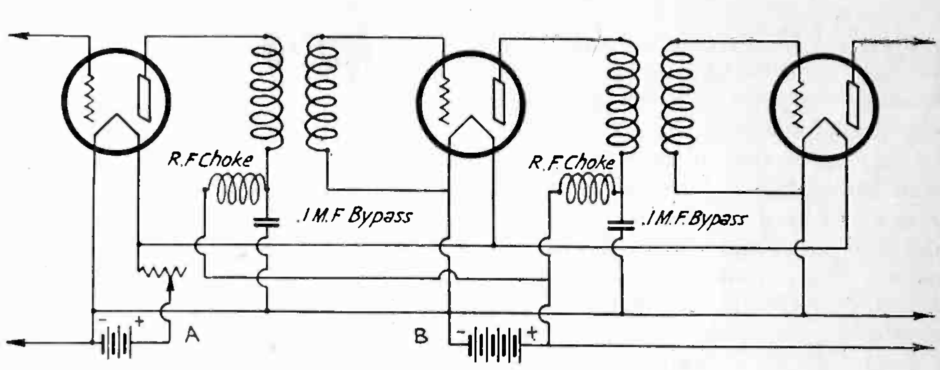


Fig. 3. Choke in "B" Battery Lead.

DUE to the great improvement in quality of tone reproduction which results from keeping stray radio frequency currents out of the audio frequency circuits, any effort to accomplish this result is well justified. One of the simplest and best methods is to insert a radio frequency choke coil in such parts of the circuit as are liable to this trouble.

These choke coils should be small in size so as to minimize the magnetic field and should have low distributed capacity to prevent their acting as by-pass condensers for the radio frequency energy. A coil that will meet these two requirements and whose inductance is about right for the average circuit can be made by helically winding 2000 turns of No. 36 enamel wire on a ¾ in. bakelite tube 1¼ in. long with 1/32 in. wall. This will allow 15 turns to the "pie" and give an inductance of about 85 millihenries.

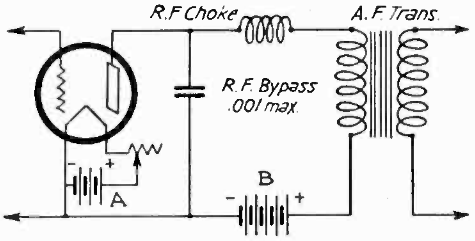


Fig. 1. Choke Coils in Last R. F. and First A. F. Stages of Ordinary Circuit.

If the same wire, with same number of turns, were applied in the ordinary layer wound manner, the value of the coil as a radio frequency choke would be very small, due to the distributed capacity effect of the layer winding.

Should the circuit require a coil with a higher value, put on 3,000 turns, 15 turns to the "pie." This would give a coil of about 125 millihenries. If 5,500 turns, 15 turns to the "pie," a value of 600 millihenries would be obtained. These coils are all of the air core type. If iron is introduced into them instead of the air, the values of the three coils respectively would be, one henry, three henries, and twelve henries. For average uses, the 85 millihenry coil will prove the most universally adaptable. Such coils can be bought ready-wound.

Some of the uses of r. f. chokes are shown herewith:

Fig. 1. Last r.f. and first a.f. stage in ordinary circuit. The choke keeps the r.f. current from getting into the primary of the first a.f. amplifier. This is to reduce instability and howling.

Fig. 2. Regenerative circuit. In this type of receiver it is usually necessary to by-pass the primary of the first a.f. transformer to obtain feed-back action. Here a by-pass condenser is used but in combination with a choke to keep the r.f. current out of the transformer.

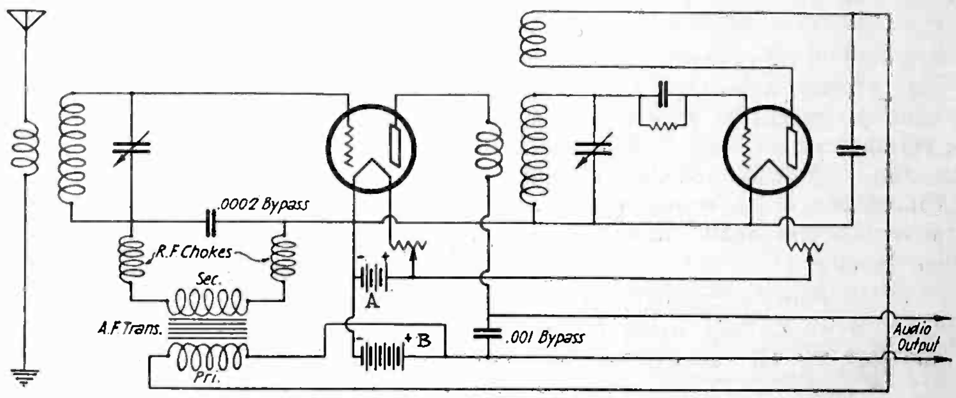


Fig. 4. Chokes in Regenerative Reflex Circuit.

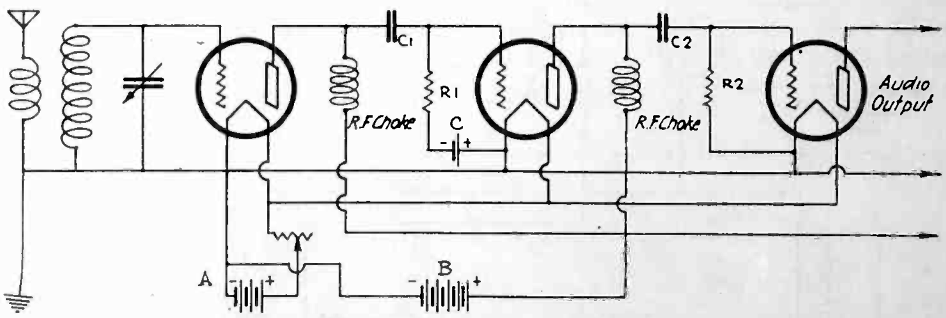


Fig. 5. Choke Coil Coupled Amplification.

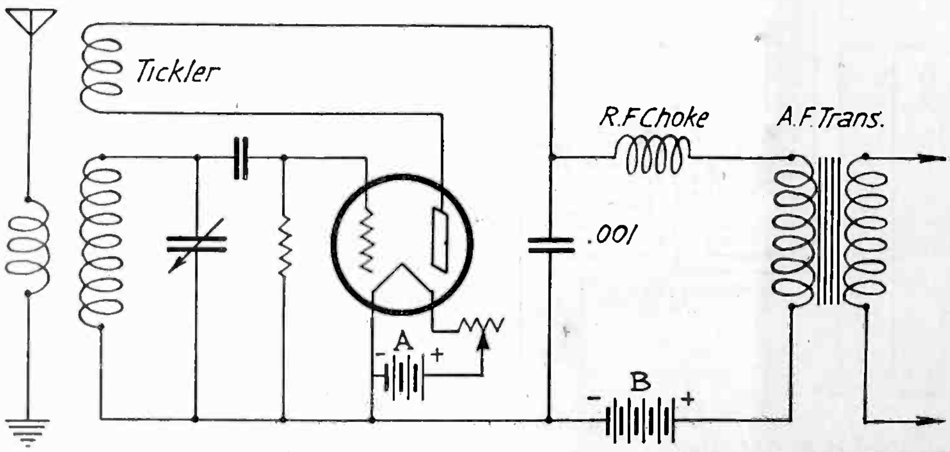


Fig. 2. Choke Coil Protector of First A. F. Transformer in Regenerative Circuit.

Fig. 3. Application of a choke in the *B* battery lead as r.f. currents are often built up by the internal resistance of the *B* battery. Here the choke furnishes a d.c. path to the battery but keeps back any r.f. currents which might originate in the *B* battery.

Fig. 4. A regenerative reflex circuit. This circuit has been unsatisfactory because of the howling and squealing due to instability. This instability has frequently been caused by r.f. currents in the a.f. circuits. Here two chokes are

(*Continued on Page* 53)

A Four-Stage Tuned R. F. Receiver With Single Dial Control

THE GENERAL trend of factory built receivers this year is towards single control, and great interest has been manifested by the average radio enthusiast as to the method of tuning two or more stages of r.f. amplification with a single control, and as to the possibility of duplicating the procedure with his own home-made radio set. Every day brings letters on the subject from readers, and requests are made for the details of the circuits, the method of assembling the r.f. amplifiers, and other interesting facts about the latest single control sets.

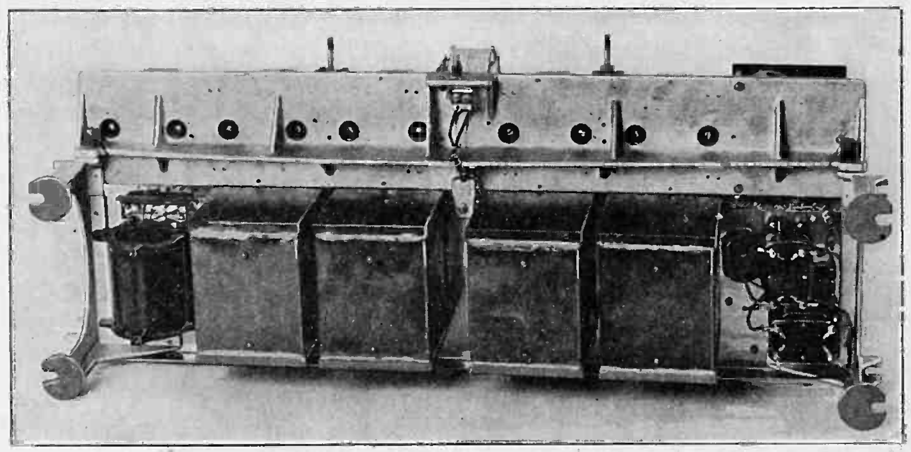


Fig. 2. Manner of Shielding Tuned Circuits on Under Part of Frame.

A typical set of this character is the Kellogg Type R-F-L 701. This receiver consists of four stages of tuned r.f. amplification, detector and two stages of transformer coupled audio amplification. Only two controls are mounted on the panel, one being the tuning adjustment and the other the volume control, thus reducing the necessary dials to a minimum.

The general appearance of the set without its cabinet is shown in Fig. 1, the volume control rheostat being on the left, the illuminated station indicator in the center, below which is the filament switch, and on the right is the station selector. The entire assembly is mounted on a cast aluminum frame of great strength, as can be easily seen in the lower view, Fig. 2.

The five tuning condensers are mounted on a common shaft, which is split between each condenser by means of an insulating bushing. The station indicator is a transparent sheet mounted on a cylindrical metal frame, and placed in the center of the condenser group. The shaft is turned by means of a worm drive shown between the right hand pair of air condensers. In back of the condensers are mounted the tube sockets, adjusting condensers and miscellaneous apparatus, while underneath the shelf are the four r.f. transformers and the antenna tuned circuit, which is the unshielded coil at the left, in Fig. 2. The filament rheostat and meter panel are mounted to the right of the condenser group, since the filament adjustment is seldom made, and it is not necessary to have the volt-meter on the panel for an operating indicator, as the dial is illuminated. On the left, at the rear, is the antenna series condenser, which is adjusted upon installation of the set to the point of greatest efficiency for that particular antenna system, and is then left alone.

The circuit diagram is shown in Fig. 3. Each of the four r.f. transformers are tuned with a .0005 mfd. variable condenser, each condenser being shielded by a metal can, not shown in the picture. The antenna coil secondary condenser is not shielded, being at the extreme left front of the assembly. From the diagram it can be seen that the grid return for three of the tuned circuits is through a one turn coil, which is coupled loosely with the primary of the next r.f. transformer and permits efficient neutralization of the amplifier. Each r.f. transformer consists of an 8 turns primary, wound on a 2⅜ in. form, and a 62¼ turn secondary wound on a 2¾ in. diameter, each coil being of the cylindrical, space wound type, with No. 20 enameled wire. The balancing coil, in the case of those transformers which are so equipped, is placed close to the primary, and both coils are at the low potential, or filament end of the secondary. The antenna coil consists of 45 turn primary and 51¼ turn secondary, both wound adjacent to each other on a 2¾ in. form, with No. 20 enameled wire. Copper cans enclose each r.f. transformer, and

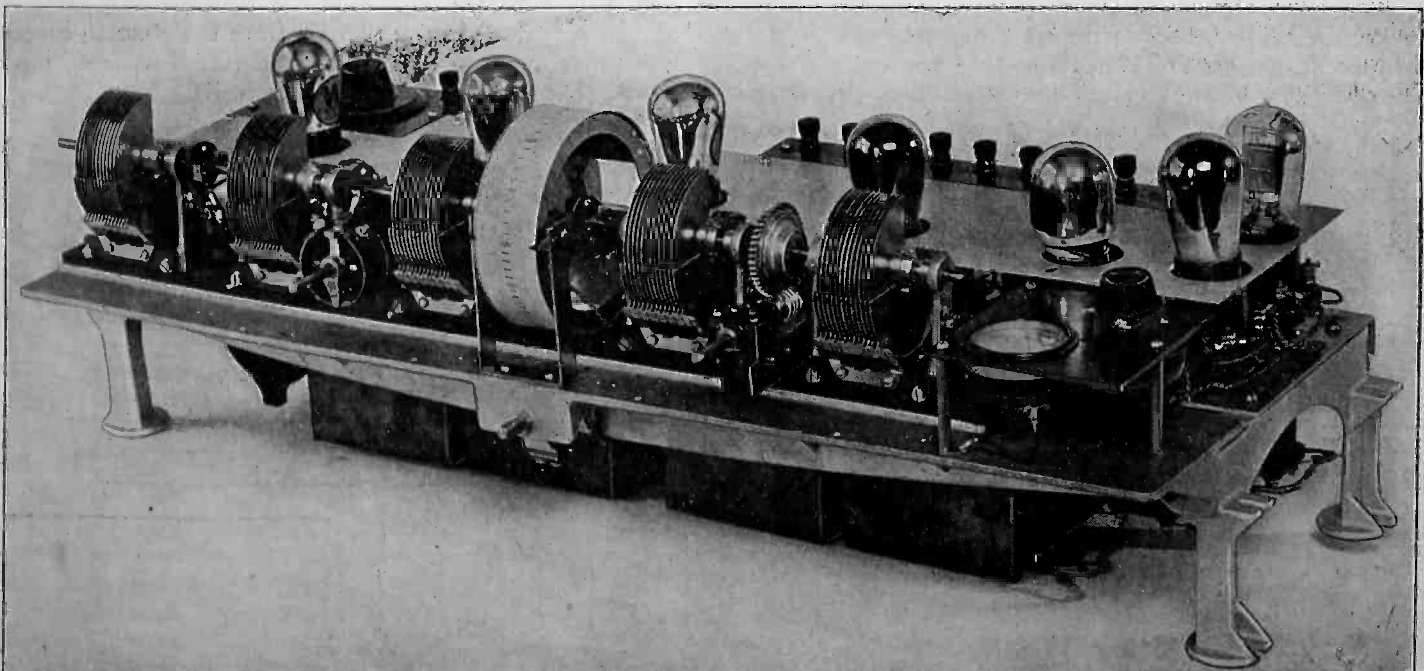


Fig. 1. Main Assembly of Kellogg Type R. F. L. Receiver, Showing Single Control Features.

the connecting leads from the transformers to the condensers and tube sockets are brought up through holes in the tops of the cans. This prevents coupling between tuned stages and is the reason for the sensitivity and selectivity of the set.

Each variable condenser is adjusted for minimum setting by means of set screws by which the rotor plate groups are attached to the shaft, and after all rotor plate groups are adjusted, the individual tuned circuits are brought to resonance by means of small shunt variable mica condensers, which are shown in the diagram in parallel with the variable air condensers. Additional shunt mica condensers are connected directly to the positive filament circuit from the grids of certain of the r.f. amplifiers, in order to stabilize the circuit.

Volume control is obtained by means of varying the filament current of the first r.f. amplifier tube, and placing a variable high resistance in the grid return of the second r.f. amplifier. The two variables are mounted on the same shaft, and are so adjusted that the set does not oscillate at any time, during the operation of the volume control dial. The positive *A* and negative *B* battery circuits are grounded to the frame and shields, so that the shielding becomes the actual conductor for the *A* and *B* current. This reduces the number of wires in the set, and simplifies testing. A voltmeter enables voltage control through a master rheostat, which is in the negative filament lead.

Like all modern receivers, the set is equipped for power tube operation. It is designed to use normally a Type UX-CX-112 tube, with 157½ volts plate and 10½ volts negative grid. The *C* battery, being connected to an external binding post, can be varied, however, to suit the particular *B* voltage available. The detector tube is of the High-Mu type, and hence has 67½ volts plate normally. All other tubes in the set are of the type *A*, and have 67½ volts plate.

The selectivity of this receiver is above the average, due primarily to the careful shielding and the space wound inductances. Having five sharply tuned circuits, it is capable of separating local or distant stations 20 kilocycles apart. It will separate stations of equal signal intensity 10 kilocycles apart, which permits installation of the set in any locality regardless of the congestion of radiocasting stations. In sensitivity, it is capable of working down well into the noise level on distant stations, so that with the average antenna, its range is very satisfactory.

SHIELDING TUNED RADIO FREQUENCY TRANSFORMERS

By H. A. Everest

This transformer consists of a solenoid coil of the desired size having a core and outer shell made of finely divided metal, preferably silicon iron, care being taken that the amount of iron introduced into the field is small enough to prevent broadening the tuning, and that the core and shell are far enough removed from the winding of the coil to prevent increasing the turn to turn capacity. The outer shell is in effect a shield which prevents losses due to stray magnetic field. Cutting down the stray magnetic field reduces interstage coupling and permits radio frequency sets to be operated with a higher oscillation control. This frequently results in increased volume on weak signals amounting to as much as 30 per cent. To test this type of shield for losses, one was made for a three circuit regenerative set working on 33 meters. With the shield a gain of 10 per cent in volume was registered, with increased stability and freedom from body capacity effects.

No radio frequency design has to date been able to utilize the full efficiency of its coils due to interstage coupling. Grounded shields prevent the interstage coupling but introduce losses due to hysteresis, eddy currents and distorted magnetic fields so that the actual gain per stage is small. The toroid coil reduces interstage coupling, but causes serious losses after the first stage of a multistage receiver, due to overloading the small air core. The permeability of air is assumed to be unity at low loads and low frequencies, but in this case the first condition is not true and the discrepancy increases with the number of stages.

Any one can make up a set of these shields and test their efficiency. The main points to observe are, to make the shield symmetrical with respect to the coil, keep it at least ½ in. from the coil, have the metal in a fine state of division and keep the shield less than ⅛ in. thick. The shield can be built up on paper or cardboard forms with shellac or glue. Coat the inside of the shield with shellac or glue and sprinkle on all the iron it will take up. Let it dry and repeat. Two or three coats should be sufficient. The core can be made on a small tube or on strips of paper like sandpaper.

The Silver-Marshall Six is an easy set to shield as all the coil connections are at the base and the shields can be lifted on and off to make comparisons.

The iron dust can be prepared by grinding up an old audio transformer core on an emery wheel, picking the iron up with a magnet and then screening through a piece of coarse cloth. Lacking the iron, a very good shield can be built up with either aluminum or copper paint using enough coats to get the effect.

Using magnetic shields permits the set to be housed in a shielded cabinet, this shielding being grounded. Individual coil pickup is then eliminated and the full efficiency of the set can be realized.

A series of broadcasting stations are to be erected thruout the Belgian Congo. Sites have been selected at Lisala, Albertville, Elizabethville and Coquilhatville.

Signals from the Russian broadcasting station at Nijni-Novgorod have been heard in Australia.

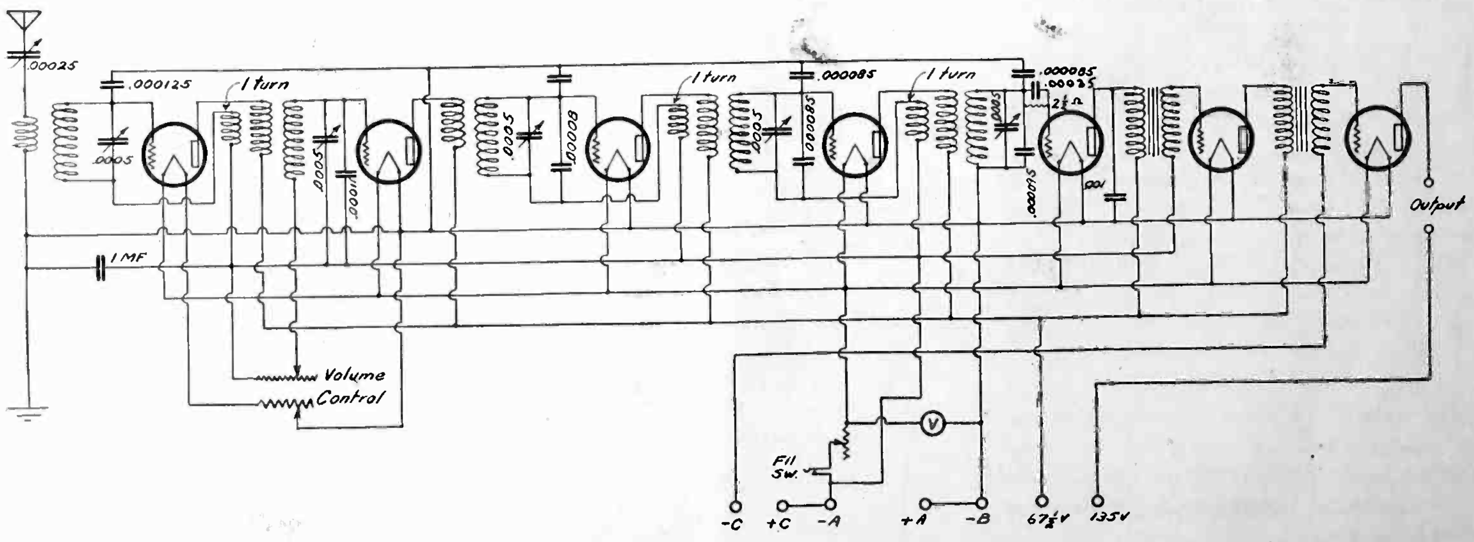


Fig. 3. Schematic Wiring Diagram of Kellogg R. F. L. Receiver.

Radio Construction Pointers

By Paul Oard

Ready Made Coils for Impedance Coupling

THE impedance coupled amplifier is enjoying widespread popularity at the present time, although this amplifying circuit is by no means a new one. The coils from the ringer movements of telephones make excellent auto- transformers for this purpose. There are two coils to each ringer, and the coils or ringer movement complete may be picked up cheaply from electrical houses that deal in this type of electrical equipment.

The cores of these coils are solid rods of soft iron, and theoretically, not as efficient as a coil made up with a core of soft iron wire. In actual practice, and making comparisons through ear alone, which is, incidentally, the final comparison anyway, they are fully as satisfactory as a more expensively built up coil. The writer finds that coils rated at 1200 ohms resistance (the resistance of each coil is stamped on the end of the coil) to be quite satisfactory. Fig. 4 shows a good circuit for the use of the bell ringer coils specified above. Three stages may be used without distortion.

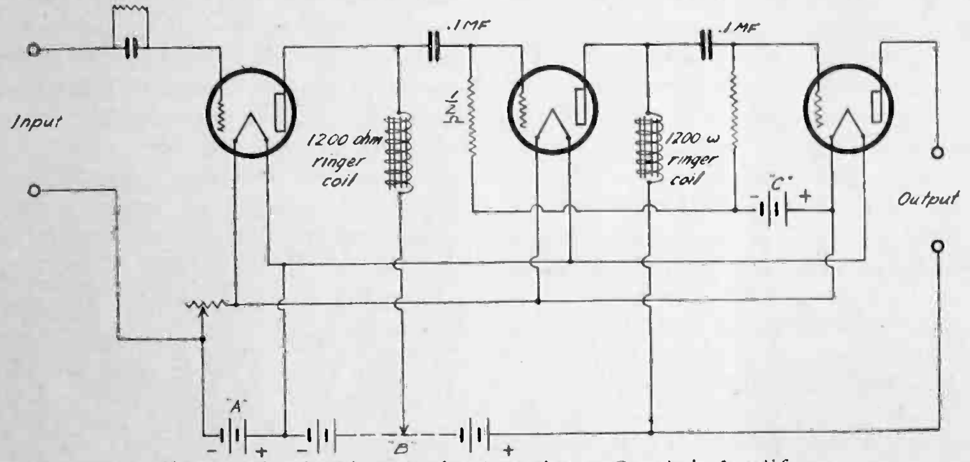


Fig. 4. Circuit Diagram for Impedance Coupled Amplifier.

Construction of Single and Gang Sockets

THE adoption of the new form of tube base, with its consequent standardization of terminals, will prove a boon to the constructor. In the so-called UX types of bases, the terminal connections to the prongs of the tubes are based upon the arrangement used in the UV-200, UV201 and UV201A types, so that the new adaptions of the 199 and WD11 and WD12 may be used interchangeably as well as the so called standard tube.

In Fig. 5 are given dimensions for a single socket and from these dimensions, the constructor can work out a gang socket arrangement with up to 8 tubes.

The material needed is as follows, for a single socket:

- 1 pieces Bakelite 2x2x⅛.
- 4 pieces brass, tapered as shown, 1⅜ in. long.
- 4 machine screws, 1 in. long, 8/32 thread.
- 4 machine nuts, 8/32 thread.
- 4 brass lugs, ¼ in. diameter by ½ in. long, tapped 8/32 thread.

Spot the center of the bakelite base with a punch, and draw a circle with a diameter of ⅝ in. Spot four points equi-distant around this circle, and drill through the two points on one side with a number 16 drill. This is the right size for the two large prongs on the new UX bases. Drill the two opposite holes with a number 26 drill. Bend the four springs as shown in the detail in Fig. 5 and mount as shown, ⅜ of an inch from each corner of the base. The heads of the machine screws are at the bottoms of the lugs.

Where economy is an important consideration, hardwood may be used in place of bakelite as a base, although it should not be used in circuits where it is intended to make use of high voltages, say over 45. Where a gang assembly of more than four tubes is made up, 3/16 or 1/4 in. bakelite should be substituted for the 1/8 in. stock. If one has some discarded sockets of the standard type, the springs of these may be used after being bent as shown. Spring material should be of good temper, and should be bent so that the grain runs lengthwise, particularly if phosphor bronze is used instead of brass.

The ingenious constructor will find little difficulty in adapting this form of socket to a shock proof mounting, and in gang arrangements, the tubes can be placed quite close together, with a consequent saving in space.

An Improved Storage Battery Connection

ONE of the most prolific sources of noise in the average radio receiver is to be found in the connections at the posts of the storage *A* battery. Due to the sulphuric acid solution used in the battery, corrosion sets up readily at the terminals, and this quickly eats into the clips which are generally used to make contact with the post. Constant attention and renewal of clips as required is a serious source of annoyance and is to be done away with.

The most satisfactory method of getting around this trouble, is to extend the length of the battery terminal to a point where the fumes of the acid will not strike directly against the junction between the wires leading to the set, and the battery. A convenient means of doing this is by soldering a foot length of ordinary wire solder to each post of the battery, and bending it over and away from the battery, fastening the battery leads to the set at the opposite end. It is not difficult in this way to keep a bright connection after each charging of the battery.

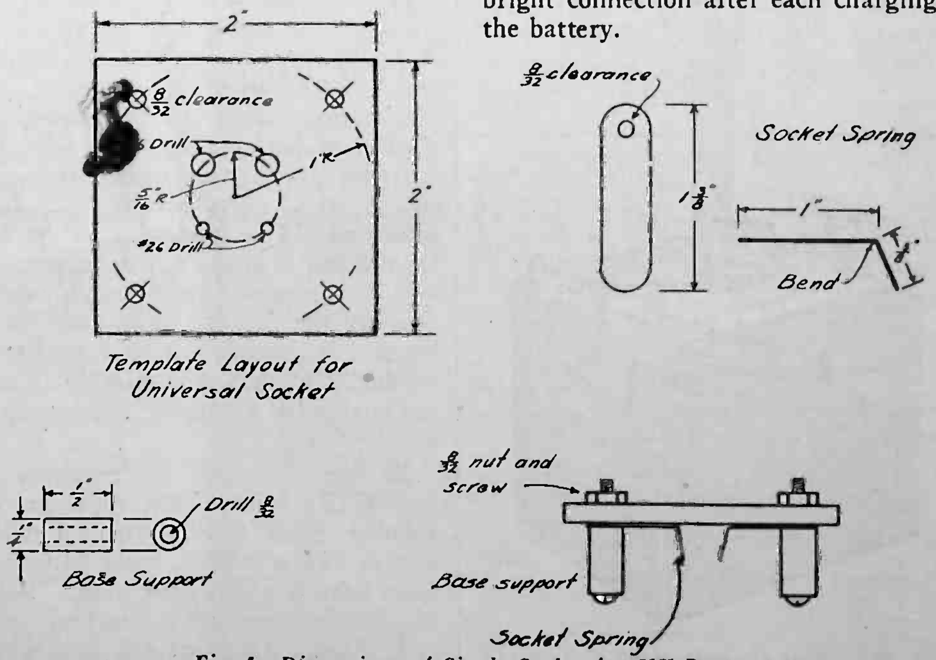


Fig. 5. Dimensions of Single Socket for UX-Base.

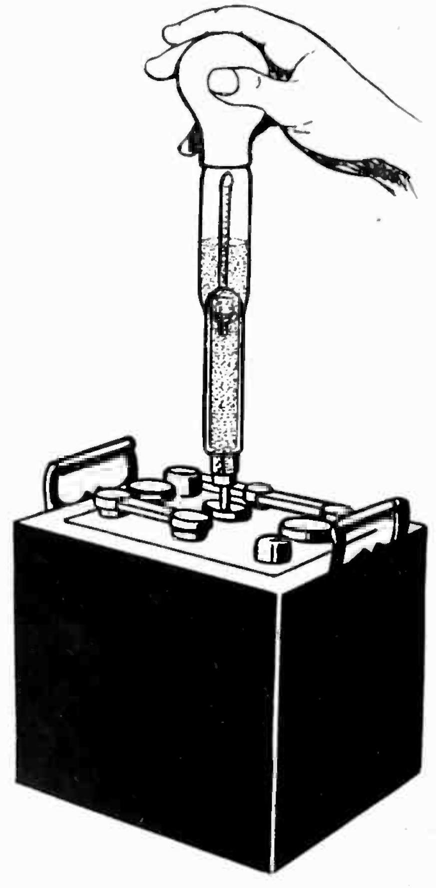
Storage Batteries

By John R. Loofbourow
The Crosley Radio Corporation

STORAGE batteries differ from dry cells in that after current has been drawn from them until they are "run down," or discharged, their original charge may be replaced by connecting them, through proper devices, to an electric light line, for a certain period of time. Thus, storage batteries may be charged and discharged over and over again, while dry cells which have deteriorated must be discarded and replaced by new ones.

The current development by dry cells is a consequence of certain chemical reactions that take place when plates of carbon and zinc are immersed in a solution of sal ammoniac and connected in a circuit. After the action has gone on long enough for the sal ammoniac to be completely decomposed, the dry cell will cease to deliver a current to the circuit.

In storage batteries, plates and solutions of such chemical substances are chosen that after the battery has been discharged, and the original chemical compounds almost entirely broken up, a current of electricity sent through the battery in the reverse direction will cause the chemicals to recombine, and be restored to their former state. Thus, the battery may be put through continuous cycles of charge and discharge until mechanical disintegration, or other factors, seriously decrease its value.



Use of Hydrometer.

The most common type of storage battery is the lead-acid type. It consists of a series of positive and negative lead plates immersed in a dilute solution of sulphuric acid. When the battery is charged, the surface of the negative plate is composed of pure lead in a spongy state, while that of the positive plate is composed of lead peroxide. As the battery is discharged, these surface layers change into lead sulphate. The sulphuric acid burns the active material of both plates into lead sulphate and thus transforms chemical energy into electrical energy. When it is desired to charge the battery, it is connected to a proper source of electric current, arranged to send current through it in the reverse direction, and during several hours of charge the plates are gradually restored to their original condition.

The solution, or electrolyte, of lead-acid batteries is made by mixing concentrated sulphuric acid with water. The proper strength of solution to use varies from one part of acid in two and one-half parts of distilled water, to one part of acid in four parts of water, according to the type of battery. As the battery is supplied to the consumer, it is filled with the proper mixture of electrolyte, and nothing but pure distilled water should be added to it unless considerable of the solution is accidentally spilled. While the water evaporates continually, the acid does not, and therefore water only should be added to the battery. Sufficient distilled water should be poured into the cells from time to time so that the plates are always covered. It is very important that this rule be followed. The battery should be inspected at frequent intervals, through the vent holes provided for that purpose on the tops of the cells, and water added when needed.

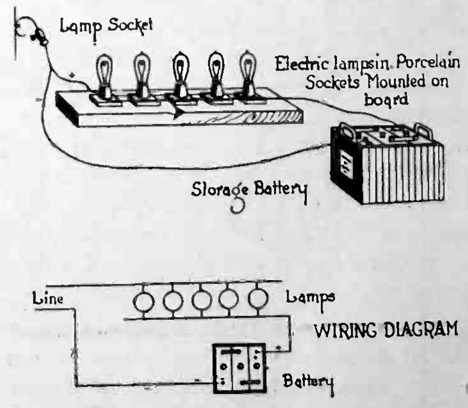
To insure most efficient operation of a storage battery, its state of charge must be carefully watched. To test the charge of storage battery, one of two means should be used. The most popular method is to use a hydrometer, a device which measures the concentration of acid in the battery solution. As the battery discharges, the solution becomes weaker, and thus it is possible to gauge the amount of charge by the strength of the solution.

Storage battery hydrometers are syringe-like instruments, consisting of a tubular glass body, provided with a nozzle and a rubber bulb. Inside the glass tube is a weighted float. The tip of the hydrometer is inserted into a cell, through the vent cap, and some of the solution is sucked up into the tube. The float will then sink to a certain level in the solution, depending upon the strength of concentration of the solution. A graduated scale on the float enables the level to which it sinks to be easily read. These graduations are usually in terms of "specific gravity" of the solution. A freshly-charged battery will ordinarily give readings from 1250 to 1300. If a battery gives a reading of from 1050 to 1100, it should be recharged. Each cell of the battery should be tested.

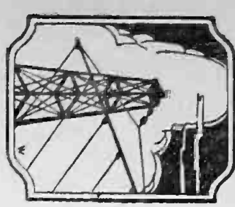
The other method of testing batteries is by means of a voltmeter. A small meter reading in tenths of volts should be used. The battery should be tested *while it is connected to a radio set and the tubes are turned on.* Many persons make the mistake of testing batteries while they are disconnected, and no load is being applied to them. When fully charged, a six volt battery should test six volts or slightly more. After the battery fails to test more than 5.4 or 5.5 volts it should be recharged.

For charging batteries in the home, one of three types of battery chargers is commonly used; the mechanical type, tube type, or chemical type. For those who are so fortunate as to have a direct current light supply in their home, it is merely necessary to connect several lamp bulbs in the line, with the battery. These bulbs should be connected together in parallel, and the whole bank of lamps should be connected in series with the battery and line, as shown in the accompanying illustration. The sockets may be mounted on a board and wired as shown. For charging the average radio battery five 40-watt bulbs or four 50-watt bulbs should be used. The positive side of the line must be connected to the battery terminal marked "+." In order to determine which side of the line is positive, insert the lead wire

(Continued on Page 52)



Method of Charging from Direct Current Line.



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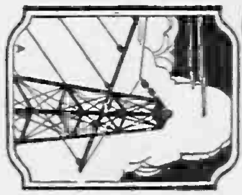


Useful Facts and Theory

Classified According to Dewey Decimal System.

Tear out page, cut along black lines, punch holes with pencil where indicated, and file numerically in standard notebook in accordance with Index Sheets Nos. 1 and 2.

R-230
SIMPLIFIED INDUCTANCE CALCULATIONS

By W. C. Eells

A direct solution for the problem of finding the specifications for a single layer solenoid coil to give the required inductance in microhenries, or conversely the inductance of a given coil, may easily be had by using equations (1) or (2) following:

$C = \frac{d^3 n^2}{L}$ ....(1) $L = \frac{d^3 n^2}{C}$ ....(2)

where L=inductance in microhenries.
d=diameter of coil in inches.
C=constant depending upon the ratio of d the diameter to l the length of the coil in inches as given in Table I.

For example how many turns of No. 26 D. S. C. wire wound on a 2-in. coil are necessary to give an inductance of 200 microhenries?

TABLE II. NUMBER OF TURNS PER INCH

B & S Gauge	*Enameled*	*S. C. C.*	*D. C. C.*	*S. S. C.*	*D. S. C*
14	....	12	11	14	13
16	....	14	13	16	15
18	....	23	21	24	25
20	29	25	23	27	26
22	36	31	28	34	32
24	45	37	33	42	39
25	51	41	36	47	43
26	56	45	39	52	46
27	64	49	42	57	52
28	71	54	45	63	56
29	79	58	48	70	62
30	88	64	52	77	67
32	112	75	60	93	78
34	140	87	68	112	91
36	173	101	78	130	104
38	225	115	89	151	117
40	288	130	102	178	129

From Table II the number of turns per inch is found to be 39 and by substitution in equation (1) $C=(2)^3(39)^2 \div 200=60.84$. From Table I, by interpolation, the value of d/l is found to be $C=(3)^3(30.3)^2 \div 160=27 \times 918 \div 160=155$.

From Table I, by interpolation, the value of d/l corresponding to 155 is found to be 2.029.
$[(155-151.8 \div 11.2\,(2.10-2.00)=.029).\ 2+.029=2.029]$.

Whence $l=3 \div 2.029=1.47$ in. and the required number of turns $nl=30.3 \times 1.47=44.5$ turns.

Conversely, what is the inductance of 44½ turns 1.47 in. long wound on a 3 in. coil?
$n=44.5 \div 1.47=30.3$. $d/l=3 \div 1.47=2.029$. C corresponding to 2.029 may be found to be 155. Substituting in equation (1) the inductance $=(3)^3(30.3)^2 \div 155=160$ microhenries.

Obviously any other values may be substituted in either equation and the desired answer secured more quickly and easily than by any other method known to the writer. The accuracy of the method is limited by the figure assumed as

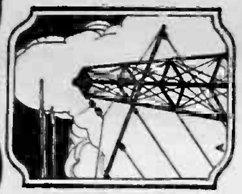
R-330
THE NEW ALKALI GAS DETECTOR TUBE

The familiar soft detector tube, known as the UX-200, CX-300 detector has been replaced with a new detector tube of the A type. Its characteristics as compared with those of the old tube are given in the following table:

Type	*Plate Volts*	*Plate Current*	*Plate Impedance*	*Fil. Volts*	*Fil. Current*	*Amplification Constant*
UX-200-A CX-300-A	45	1.5 M. A.	30,000 ohms	5	.25 amps.	20
UX-200 CX-300	18 to 22	.25 to 1.0 M. A.	10,000 ohms	5	1.0 amps.	6

The glass bulb contains gases of certain alkali metals, this together with the high amplification constant of 20, making the tube extraordinarily sensitive to weak signals. It is not critical as to filament or plate voltage, and may be operated without adjustments to the battery supply. The only change required in the circuits in which it is used, is to connect the grid return to the negative end of the filament instead of to the positive end, as heretofore considered as standard practise. If the grid return is connected to the positive end, the tube will be little if any more sensitive than the ordinary "A" tube, but with the negative filament-grid return, the sensitivity is greatly increased, and the tube will be operating at greatest efficiency. As the plate impedance of the tube is quite high, it will work best with audio frequency transformers having a high primary impedance, as is found in practically all the new, high grade transformers. If low impedance transformers are used, a large reflection loss will occur between the tube and the transformer, nullifying the advantage of the new tube.

When the filament is first lighted, a slight hissing sound will be heard, but this disappears in about ten seconds, and will not again occur until the set is turned off and the tube has had an opportunity to cool. In amateur short wave regenerative receivers, this tube will make a remarkable difference. It will be found that slightly greater capacity for any particular frequency setting will be required in the feedback condenser, and that the negative grid-filament return will be very important for proper regeneration, but otherwise no changes need be made in the circuit. The tube is non-microphonic, due to the rigid construction of the elements and the extra heavy supports, so that where a set is troubled with coupling between the detector tube and the loud speaker, due to improper cushioning of the detector socket, the new tube will greatly reduce the trouble.



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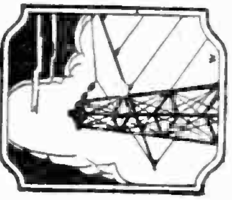


R-230

SIMPLIFIED INDUCTANCE CALCULATIONS

the number of turns per inch. The values given in Table II represent average practice.

For those interested in the mathematical derivation of the formula, that given on p. 252 B. of S. Circular No. 74, is taken as the basis. Converting from the metric to the English system this is expressed as $L = .02507d^2n^2lk$, d being the diameter of the wire in inches, n the number of turns per inch, l the length of the winding in inches and k a constant depending upon d/l, as given in published tables.

Multiplying and dividing by d, this becomes

$$L = \frac{.02507d^3n^2lk}{d} = \frac{d^2n^2}{d/l \div .02507k} = \frac{d^2n^2}{C}$$

The values of C in Table I are computed from this formula.

TABLE I. VALUES OF C

d/l	C	*Difference*	d/l	C	*Difference*
0.00	0.00	+2.04	2.00	151.8	+11.2
.05	2.04	2.12	2.10	163.0	11.6
.10	4.16	2.21	2.20	174.6	11.9
.15	6.37	2.30	2.30	186.5	12.3
.20	8.67	2.39	2.40	198.8	12.5
0.25	11.06	+2.48	2.50	211.3	+12.9
.30	13.54	2.57	2.60	224.2	13.2
.35	16.11	2.66	2.70	237.4	13.5
.40	18.77	2.76	2.80	250.9	13.8
.45	21.53	2.85	2.90	264.7	14.1
0.50	24.38	+2.94	3.00	278.8	+14.4
.55	27.32	3.03	3.10	293.2	14.7
.60	30.35	3.13	3.20	307.9	15.1
.65	33.48	3.21	3.30	323.0	15.4
.70	36.69	3.31	3.40	338.4	15.6
0.75	40.00	+3.41	3.50	354.0	+15.9
.80	43.41	3.50	3.60	369.9	16.2
.85	46.91	3.58	3.70	386.1	16.6
.90	50.49	3.68	3.80	402.7	16.8
.95	54.17	3.77	3.90	419.5	17.1
1.00	57.94	+3.86	4.00	436.6	+17.4
1.05	61.80	3.95	4.10	454.0	17.8
1.10	65.75	4.04	4.20	471.8	18.0
1.15	69.79	4.13	4.30	489.8	18.2
1.20	73.92	4.22	4.40	508.0	18.5
1.25	78.14	+4.30	4.50	526.5	+18.9
1.30	82.44	4.40	4.60	545.4	19.1
1.35	86.84	4.48	4.70	564.5	19.4
1.40	91.32	4.58	4.80	583.9	19.7
1.45	95.90	4.66	4.90	603.6	20.0
1.50	100.56	+4.75	5.00	623.6	+40.8
1.55	105.31	4.82	5.20	664.4	41.8
1.60	110.13	4.91	5.40	706.2	43.1
1.65	115.04	5.00	5.60	749.3	44.1
1.70	120.04	5.08	5.80	793.4	45.2
1.75	125.12	+5.16	6.00	838.6	+46.2
1.80	130.28	5.27	6.20	884.8	47.2
1.85	135.55	5.34	6.40	932.0	48.5
1.90	140.89	5.43	6.60	980.5	49.6
1.95	146.32	5.48	6.80	1030.1	

R-330

PRACTICAL USES FOR THE VOLTAGE REGULATOR TUBE

The type UX-874, CX-374 voltage regulator tube is a two electrode affair, whose bulb is filled with an inert gas such as neon or argon. Its purpose is to regulate the plate voltage supply from the output of a rectifier system obtaining its power from the lighting mains, and is used principally in certain factory built receivers operated from alternating current. It contains a cylindrical plate, called the cathode, and a metal point, called the anode, and when a direct current voltage of 125 or more is applied to the elements of the tube, with the positive terminal connected to the anode or point, the plate will glow with a bluish pink color, the intensity of the glow depending upon the voltage applied to the tube.

The tube is useful in limiting the voltage across its terminals to exactly 90 volts. In other words, it will consume current from the d.c. supply up to 50 milliamperes, and if the receiving set requires 25 milliamperes at 90 volts, the tube will permit the set to draw this much current, and will consume the rest. If the voltage rises above 90 volts, thereby increasing the current consumption of the receiving set tubes, the voltage regulator tube takes care of this additional load, and keeps the current drain of the receiving set at a constant level.

The tube is mounted in a standard X type base with four prongs like a standard vacuum tube, the grid prong being the anode, or positive terminal, and the positive filament prong being the negative terminal, the other two base prongs being connected together. The tube is particularly useful as a polarity indicator. If a source of direct current, the polarity of which is unknown, is to be measured, connect the voltage regulator tube directly across the line, and note which element of the tube has the main glow discharge. If the plate of the tube is covered with the glow, the grid terminal of the base is the positive of the d.c. line. If the metal point has the glow, and the plate is dark, then the positive filament prong of the base is the positive d.c. terminal of the unknown line. If the line voltage is a. c., both elements of the tube will glow in the same manner, no matter which way the line is connected.

THE C-377 PROTECTIVE TUBE

The C-377 protective tube is a non-inductive resistance in the form of a filament wire mounted between supports in a vacuum bulb similar to an automobile headlight lamp. It has a cold resistance of about 300 ohms, and is ordinarily connected in the *B* battery circuit of a receiver, between the first and second 45 volt *B* blocks. The wire is tapped in the center for the positive 45 volt *B* connection to the receiving set, the two end terminals of the wire going to the plus 45 volt *B* battery terminal and the negative terminal of the next 45 volt *B* block. In case of a short circuit in the receiving set, between the filament and plate circuits, the filament of the protective tube will burn out before the filaments of the tubes in the receiver, thus protecting the receiving set. The presence of the resistance in series with the *B* battery does not affect the operation of the receiver, provided that it is shunted with a 1 mfd. bypass condenser.

QUERIES *and* REPLIES

Questions of general interest are published in this department. Questions should be brief, typewritten, or in ink, written on one side of the paper, and should state whether the answer is to be published or personally acknowledged. Where personal answer is desired, a fee of 25c per question, including diagrams, should be sent. If questions require special work, or diagrams, particularly those of factory-built receivers, an extra charge will be made, and correspondents will be notified of the amount of this charge before answer is made.

Please publish an efficient circuit for an amplifier to be used in connection with a loud speaker and microphone in small public halls or churches.—F. V. L., Epe, Holland.

A satisfactory circuit for the purpose you describe is shown in Fig. 1. It consists of a microphone such as is used in broadcasting stations, and a three stage impedance coupled amplifier with the necessary input and output transformers. It is necessary to have an input transformer with a center-tapped primary in order that the microphone can be properly connected. This type of amplifier when used with a power tube will supply several horn type loud speakers with sufficient volume to fill a small hall. If it is used with a cone type loud speaker, care should be taken to separate the microphone from the speaker so as to prevent coupling and howling.

Would like to build a booster box for my superheterodyne and still retain the loop antenna. What is the best method of doing this?—W. A. K., Puente, Calif.

The antenna tuner shown in the article on the five tube superheterodyne in April RADIO is the most satisfactory antenna connection for your set. You can place the variable condenser and loading coil in series between the antenna and ground and bring the loop antenna near the coil, but the most satisfactory arrangement would be a primary and secondary circuit to be connected directly to the loop binding posts on the receiving set.

How is the current stepped up in the "B" eliminator described on Page 22 of March RADIO? If I use pint fruit jars instead of quart size as specified, how many jars will I need? Can 201-A tubes be used in the 50 watt transmitter described in March RADIO instead of the tubes specified? Is it possible to eliminate the auto-transformer?—W. R. F., San Leandro, Calif.

A complete description of how the voltage of the plate supply set output becomes twice the line voltage, is contained in the first column of the article. If the fruit jars are of the pint size it would be best to use four jars instead of the two recommended. If the proper filament and plate voltages are applied, the type *A* tube could be used in the transmitter described in March RADIO. You would require 5 volts filament and not over 150 volts plate. As the power would be low in any case you could omit the auto-transformer and the set would still operate satisfactorily.

I have a 2 circuit tuner which I wish to revise for use with honeycomb coils. Please publish this circuit together with constants of the condensers to be used.—G. P., Hamilton, Ohio.

The diagram you wish is shown in Fig. 2. The detector has been wired for the new CX-300-A, UX-200-A detector tube which has the grid return connected to the negative filament. A .0005 mfd. air-condenser should be placed in series with the antenna coil and another condenser of the same size should be used across the secondary. Care should be taken to prevent the set from oscillating, as it will radiate energy into the antenna and annoy your neighbor. For the broadcast band a 50 turn coil in the primary, 75 turn coil in the secondary and a 50 turn tickler coil will be the right sizes.

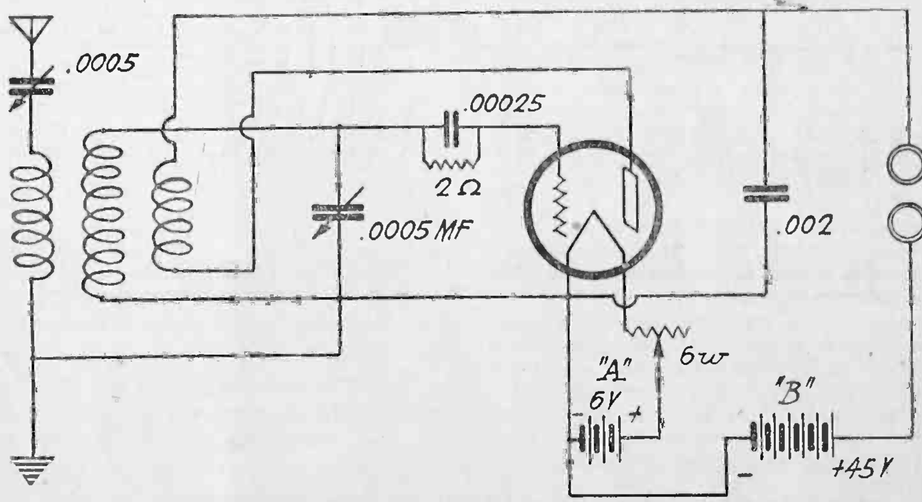


Fig. 2. Three Circuit Honeycomb Coil Tuner.

Have seen a great many ways of connecting a Harkness Reflex circuit and none of them appear alike. I notice that the by-pass condensers are not always in the same place and it seems to me that this circuit ought to be standardized by this time.—L. A. S., San Francisco, Calif.

A correct circuit diagram for the Harkness Reflex set appeared on Page 33 of February RADIO. All of the by-pass condensers are in their correct places and you will find the circuit standard in every detail.

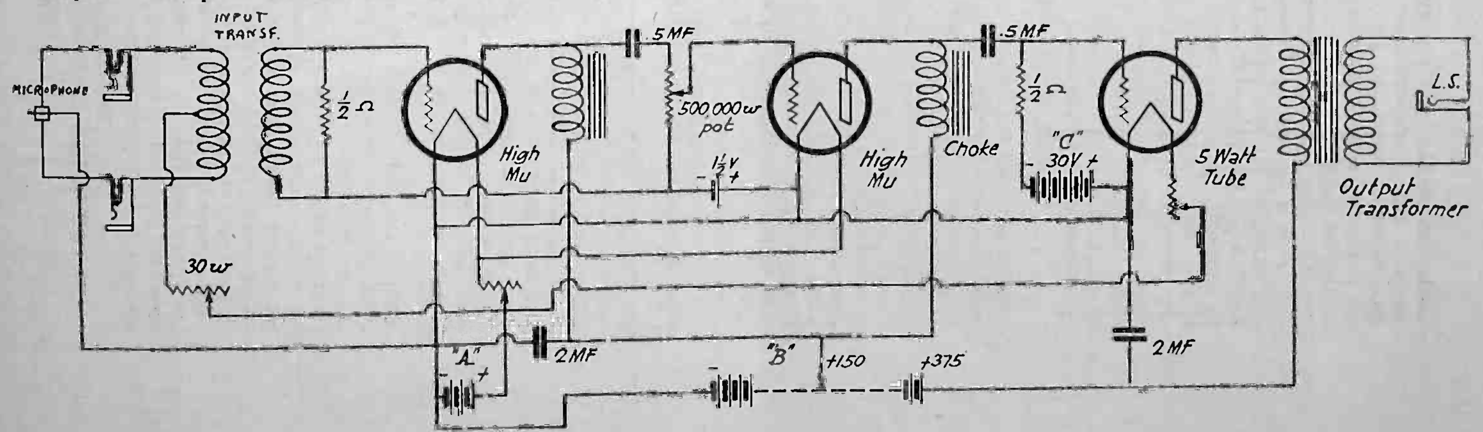


Fig. 1. Circuit for Microphone Amplifier.

What is the difference between a Silver-Marshall and a Browning-Drake 4 tube receiver? S. W. S., Berkeley, Calif.

The Browning-Drake has a stage of radio frequency amplification, regenerative detector, and two stages of audio frequency amplification. The S-C Circuit is practically the same except that it employs a fixed tickler coil in the detector circuit and uses different types of inductance coils.

Please publish a circuit for an A B C eliminator for use with 201-A tubes.—A. S. C., Los Alamos, Calif.

A circuit suitable for supplying .25 ampere tubes is shown in Fig. 3. You will require a step-up transformer having a 110 volt primary and 220 volt secondary with center tap. A 2 volt filament lighting secondary will be necessary to light the filament of the two 2 ampere Tungar bulbs. The filament winding must be capable of supplying 15 amperes so that it will have to be wound with very heavy wire. The choke coil should be wound with wire heavy enough to pass 250 milliamperes and yet have only a few ohms d.c. resistance. The fixed resistance in the output circuit for a 5 tube receiver should be about 350 ohms and should have a variable resistance capable of carrying 250 milliamperes, in series with it. All of the filaments in the receiving set must be wired in series, the circuits published in the December, 1925, issue of RADIO showing the proper connections. The *B* voltage supply is taken from the positive terminal of the filter through the variable resistances which may be adjusted to the proper values. Bear in mind that the maximum plate voltage obtainable from this outfit is about 100 volts and it would not be suitable for use with a receiving set having a power tube which requires 150 volts or more. It is unsafe to apply a voltage of more than 110 to the plate of the Tungar bulb so that it is not practicable to obtain higher voltages from the rectifier.

Aside from the difficulty of working are there any reasons for not using plate glass for the panel of a receiving set?—D. B. M., Berkeley, Calif.

Glass is a good insulator and there are no objections to its use as a radio panel, except the difficulty of working the material and the fact that many pieces of radio apparatus are designed to be "heard and not seen" and hence, will present a rather unsightly appearance when viewed through a transparent panel.

Have a five tube Neutrodyne with 150 ft. antenna. As the tuning is broad on locals could I use a shorter antenna, and would this cut down my distance. I. F., San Francisco, Calif.

Shortening the antenna to 75 ft. will undoubtedly improve the selectivity and ought not to reduce distance over which you can receive, unless you are in a poor location.

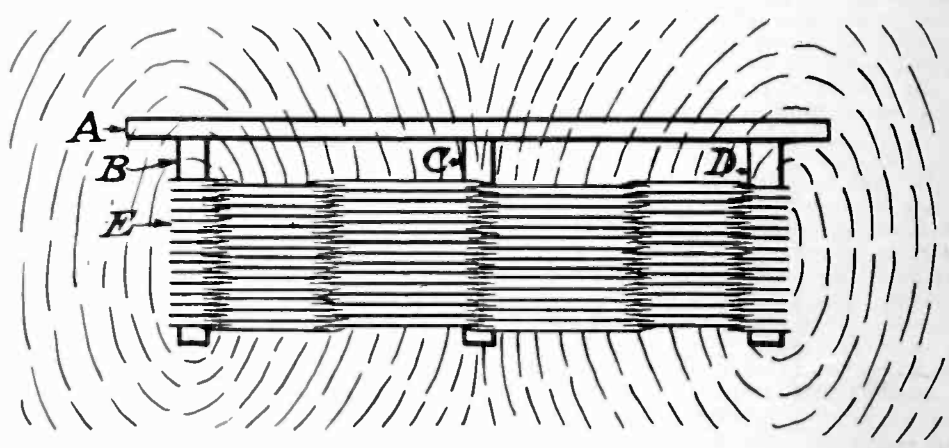
I have a factory built superheterodyne which does not tune below 220 meters. How can I change it so as to tune down to 200 meters?—H. Y. K., Guadalupe, Calif.

It will be necessary to remove several turns from the oscillator coil and in your particular set it would be necessary for you to be familiar with the constructional details before making such a change. I would advise your taking the set to a dealer who has an expert repair man so that the changes can be made without damaging the set. If the loop condenser does not tune to 200 meters it may be necessary to remove one turn from the loop.

STOPPING SQUEALS

By H. Melchior Bishop

OSCILLATIONS are stopped in many radio frequency sets employing basket weave coils by means of the eddy currents set up by the magnetic field of the coil in the metal end plate upon which the coil is mounted. As shown by the sketch, the field of the coil *E* in cutting across the end-plate *A* sets up a weak eddy current in the plate. These eddy currents are in direct opposition to the radio frequency current producing them, and, weak as they are, they are sufficient to stop oscillations in the radio frequency circuit. In fact if the coil is mounted too close to the condenser, thus strengthening the eddy current or increasing the radio frequency resistance of the circuit, the receiver may be insensitive or abnormally broad in tuning.



Field of Coil Through Condenser End Plate.

This gives a clue to one method of stopping the continuous, thin, high-pitched squeal which sometimes is heard from this type of set. First, try the simple expedient of tightening the screws which hold the coils to the condensers, and pressing the coils towards the condensers with the hand in an effort to bring the coils permanently closer to the end plates of the condensers.

If this does not suffice, dismount a coil, and file down the length of the coil supports, then remount the coil and try the set. If the squeal has not disappeared try the next coil, and if necessary, all three of them. Care should be taken when shortening the supports not to get them too short, as the set would then become, as before mentioned, insensitive and broad tuning. To insure against this it is best to remove only a little at a time, try the set, and then repeat the operation if necessary.

It might also profitably be mentioned here that a radio frequency squeal in this type of set may also be due to a fixed by-pass condenser (usually of 0.006 mfd.), which is defective or which has changed in capacity. This, of course, can be detected and also remedied by trying another fixed mica condenser of the proper capacity in its place. Care should be taken in soldering the new condenser in place not to heat it any more than necessary to obtain a good joint, otherwise it too, may change in capacity. Overheating is not likely to occur if the surfaces to be soldered are first scraped very bright, and then soldered with a very hot, well tinned copper, which will cause the solder to flow quickly before the heat gets much chance to spread through the metal.

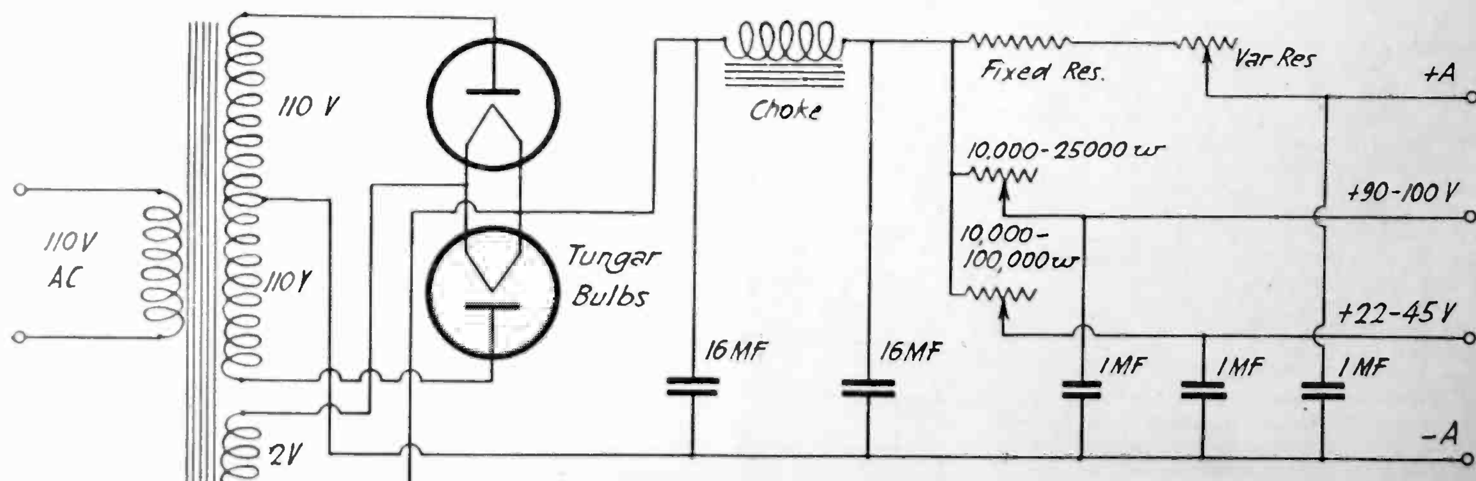
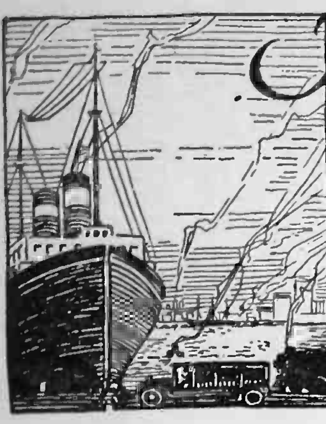
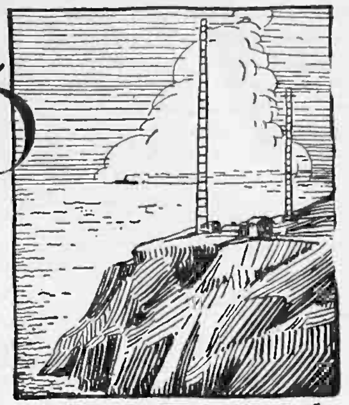


Fig. 3. A B C Eliminator Circuit for .25 Ampere Tubes.



The COMMERCIAL BRASSPOUNDER

A Department for the Operator at Sea and Ashore



Edited by P. S. Lucas

R. O. Koch, *Great Lakes Correspondent*

THE TRAFFIC PROBLEM

THERE are a few operators at sea and in the shore stations who never waste a high-frequency oscillation; who never press the key unless in the act of actually sending or receiving a message, TR, weather report or other communication necessary to commercial traffic, navigation or emergency. But the conservative, and therefore efficient operators constitute a very small minority among the hundreds of operators who are every day fighting for the congested ether. Or is it that the only one who makes an impression upon the listening critic is the ham who thinks his so-called SVC about the baseball game is more important than the paid message of his brother operator who may be having trouble clearing his hook? Perhaps this is more nearly the key to the situation than the former hypothesis, but if the thoughtless and wasteful operators are in the minority they certainly overcome their handicap in beautiful style.

In mentioning the "ham" in the above paragraph, it must be understood that it has two meanings. The term, as used by a certain group of operators of amateur rating who have built up for themselves a reputation of world-wide renown, is an honor, but when applied to a man who is supposed to be a commercial operator, is intended for a slur upon his operating ability.

I don't suppose there is much use of trying to convince the wilful disregarder of the law and of fair play that the air is too full of business for idle gossip. He hears it from all sides when he is interfering with someone, yet sometimes seems unbreakable. We'll admit that it is a temptation to break the monotony of the job by starting up the M. G. and chewing the rag with somebody, and that the fascination of holding up a two-way conversation over the air is alluring, to say the least. But it isn't business, and after all, the operation of a radio station is nothing more nor less than a business proposition. The operator is assigned to his post with a definite work to do; a job to perform; and he finds that this work has its limitations just as has every job in this crowded world. One of the limitations is that he must sacrifice some of the "fun" of the game in order to allow the industry as a whole to proceed uninterrupted, for here, as in no industry, is the value of cooperation appreciated.

There is another group of operators who contribute to the myriad of unnecessary signals that fills the air every day, and of this, more than nine-tenths of us are members in good standing. This group consists of operators who do not always make their transmission of messages, TRs, etc., as short and snappy as it is possible to do. This group is entirely innocent of any malicious or intentional interference, yet, due to the quantity of operators who aren't as careful as they might be, it is the cause of a large percentage of the unnecessary transmission we are talking about.

The difficulty seems to be in the fact that there is no standard form for handling traffic. Every man has his own system which he believes the best afloat; some operators shoot 'em in a different way every time; and as a result the shore station man has to readjust his brain and "mill" for every msg. Now there's no sense to this lack of system. Why can't we all learn a stereotyped form for messages, TRs and whatever we have to transmit? Answer: We can—but we're too lazy.

It seems foolish to fuss and fume about five or six letters, but when we count in all the time that is lost in calling, errors, acknowledgments, etc., and multiply it by a hundred or more for a day's work, we see that it does amount to something after all. It is quite a study to work out a system that is efficient enough to adopt as universal, but it is a well worth while one, and should be given a little thought by all who have the stabilization of this profession at heart. We have just received a little book by our well-known friend, Howard S. Pyle, entitled "Commercial Radio Traffic Manual for Marine Operators," which we have read with interest, for it takes up this very subject and advances a method of improving our sloppy handling of traffic. This is more than we are able to do by ourselves, so we shall be satisfied by referring to Mr. Pyle's manual.

Briefly, this booklet points out the general essentials of handling traffic, and suggests a definite system for clearing your hook in a minimum time. It is, of course limited to the ship within easy working distance of the shore station, because no rules will hold good for ships too far out to be easily copied, but it brings together all the good points of traffic handling and sets them down in such a way that all operators can incorporate them in their own methods and benefit greatly thereby in entering that enviable class of efficient operators.

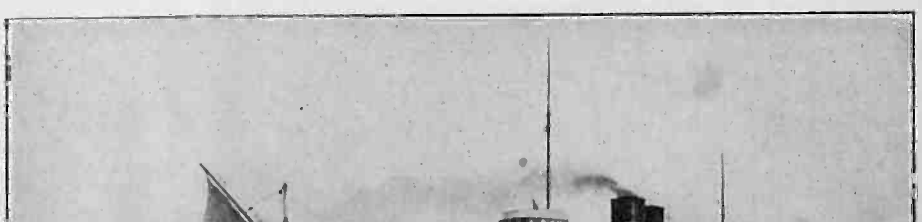
Mr. Pyle admits that his suggestions are probably far from the "last word" along these lines, but we are satisfied that they are a lot nearer the "last word" than these famous last words: "QTC? Nil. Sa OM did you get WWDO wx? QRM QRN." (Also asleep). So far, these problems have been left for the Government and the radio companies to solve. Why not give them a hand with some suggestions inspired by actual first hand information? Let's adopt a policy and see to it that it is enforced. Anyway, it is for our own good.

THE "LAKELAND" CASE

The decision in the second trial of the suit for $350,000 insurance on the *S. S. Lakeland,* which sunk on Dec. 3, 1924, is that the insurance must be paid unless it can be proved that the owners conspired in the sinking. Evidence was adduced to show that the vessel sank in Sturgeon Bay, Lake Michigan, as reported by the radio operator on the *Ann Arbor No. 6,* Elliott Jacobsen, who took the picture shown herewith just as she was settling down.

The accusation was made that the ship had been deliberately scuttled as no SOS or radio signals were sent out and as divers subsequently found the sea-cocks open. Consequently the insurance company refused payment of the policy on the vessel which was 37 years old.

The jury disagreed in the first trial at Cleveland in October, 1925, and the second trial was held in February, 1926. That the owners conspired in the sinking is difficult to prove. Loss of the vessel through negligence was one of the risks covered by the



The Sinking of the "Lakeland."

policy and it was largely on these grounds that the decision was based. If it can be proven that the ship was scuttled, the parties responsible may be punished but unless the owners were implicated, the policy is valid and full payment together with the accrued interest must be paid. This is one of the first Great Lakes scuttling cases to appear in the courts since the 70's. It is rumored that another trial is to be held in the U. S. Supreme Court at Washington, D. C.

ORIENTAL RADIO NOTES

This is the last installment of L. O. Doran's "Oriental Radio Notes" which have been running in RADIO for the past three issues. The other installments took up the North Pacific Schedules, Japanese Weather Reports and all the available press, time and weather schedules, codes, etc., that an operator will encounter on the Oriental Run. As announced before, Mickey Doran has gone to a lot of effort in gathering this data, so if you appreciate it drop him a line to this office.

INDIA METEOROLOGICAL DEPT. SHIPS' WEATHER CODE

Certain ships on regular runs in India waters send in daily weather report at 7 AM ship's time. The reports consist of four code groups, each group containing five figures. The arrangement of the groups and the translation tables follow:

	No. of Figs.
1st Group:	
Position of the ship. From map	3
Hour of the day. Table I	2
2nd Group:	
Day of week. Table II	1
Wind direction and force. Table III	2
State of the Sea. Table IV	1
Direction of swell. Table V	1
3rd Group:	
Barometer reading. Last three figures	3
Amount and kind of cloud. Table VI	1
General weather remarks. Table VII	1
4th Group:	
Barometer 3 hours previous. Last two figures	2
Wind 3 hours previous. Table III	2
Check figure. See note	1

TABLE I—HOUR

Midnight 00.	Noon 12.
1 A.M. 01.	1 P.M. 13.
2 A.M. 02.	2 P.M. 14.
etc.	etc.

TABLE II—DAY

Sunday	1	Thursday	5
Monday	2	Friday	6
Tuesday	3	Saturday	7
Wednesday	4		

TABLE IV—STATE OF SEA

		Code
Sea smooth or slight	Swell absent or slight	0
	Swell moderate	1
	Swell heavy	2
Sea moderate	Swell absent or slight	3
	Swell moderate	4
	Swell heavy	5
Sea rough	Swell inconspicuous	6
	Swell conspicuous	7
Sea very rough	Swell inconspicuous	8
	Swell conspicuous	9

TABLE V—DIRECTION OF SWELL

No swell	0	S	5
N	1	SW	6
NE	2	W	7
E	3	NW	8
SE	4	Confused	9

TABLE VI—AMOUNT AND KIND OF CLOUD

Number of Tenths of Sky Covered by Cloud	Low Clouds Code	Cirrus Clouds Code
0	0	0
1 or 2	1	6
3 or 4	2	7
5 or 6	3	8
7 or 8	4	9
9 or all	5	9

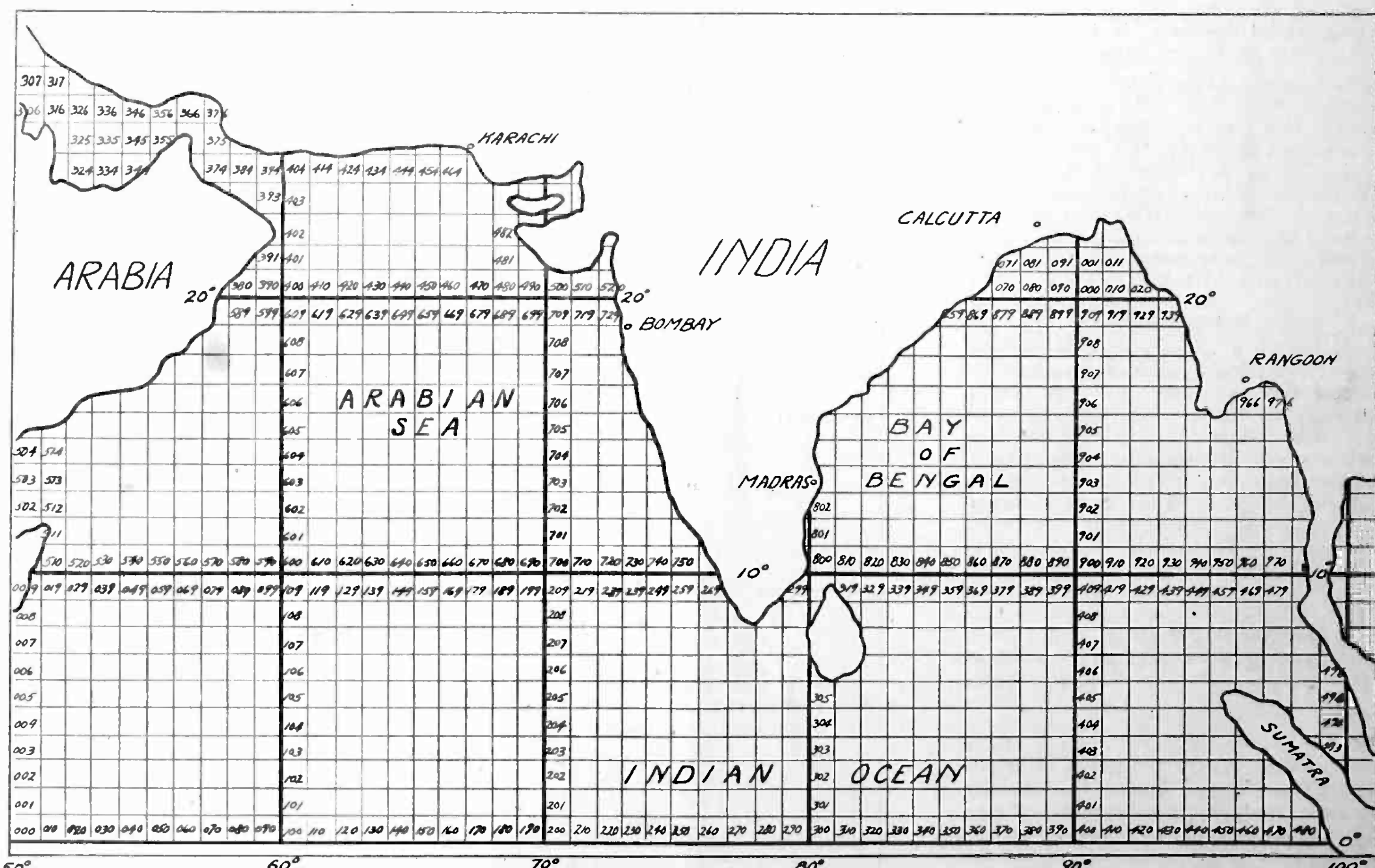
TABLE VII—GENERAL WEATHER REMARKS

Code
0 Appearances make it clear that a cyclonic storm has formed.
1 Appearances make it clear that a cyclonic storm is forming.
2 Weather squally.
3 Weather getting worse.
4 Weather getting better.
5 Heavy rain.
6 Rain.
7 Ordinary monsoon weather.
8 Suspicious weather.
9 Weather calls for no remarks.

The position of the ship is indicated by the number of the square on the map in which the ship is situated at 7 AM. Some of the numbers on the map are repeated so that the same number represents two positions. In every case these two points are so

TABLE III—WIND FORCE AND DIRECTION

Force Beaufort Scale	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
1, 2 or 3	01	07	13	19	25	31	37	43	49	55	61	67	73	79	85	91
4 or 5	02	08	14	20	26	32	38	44	50	56	62	68	74	80	86	92
6 or 7	03	09	15	21	27	33	39	45	51	57	63	69	75	81	87	93
8 or 9	04	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94
10 or 11	05	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95
12	06	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
Calm	00															



Map of East Indian Waters.

far apart that there will be no difficulty in deciding which ship is located.

The barometer reading in the third group is coded by omitting the first figure, thus 982 indicates 29.82 and 002 indicates 30.02, etc. In the fourth group, only the two figures after the decimal point are sent, thus 82 indicates 29.82 and 02 indicates 30.02, etc.

If for any cause it has been found impossible to take the observations three hours previously, the fourth group is left out and the message reduced to three groups.

The check figure in the last group is obtained by adding together all the digits used in the message and entering the last figure of the total obtained; thus, if the total is 95, the 5 is used as the check figure.

RATES

The rates below are given in centimes according to International practice. Five centimes equals one U. S. cent.

Station	Coast Charge Per Word	Coast Minimum Charge	Land Line Charge Per Word	Credit Other Line Charges to
Japan	60	Nil	10 to any point in Japan.	Japanese Govt.
XOF, XRT	50	Nil	50 to Tientsin.	Chinese Govt.
JDA	60	Nil	10 to Dairen.	Japanese Govt.
FFZ	50	Nil	Nil to Shanghai.	French Govt.
XSG	50	Nil	Nil to Shanghai.	Chinese Govt.
VPS	60	600	Nil to Hongkong.	British Govt.
Indo-China Stations	50	500	5 to any part Indo-China.	French Govt.
VPW	60	Nil	14½ to Singapore.	British Govt.
VPX	60	Nil	14½ to Penang or Singapore.	British Govt.
Dutch East Indies Stations	60	Nil	20 to nearby points.	Netherlands Govt.
India Stations	60	Nil	10 to points in India.	British India Govt.
VPB	60	Nil	5 to points in Ceylon.	British Ceylon Govt.
KZRC	50	Nil	Nil to Manila.	Radio Corpn. of Philippines
KZFR	60	Nil	Nil to Manila.	Far Eastern Radio Inc.
KPI, KPM, KIW	30	Nil	Nil for local delivery.	Bureau Posts Manila.

Rates change from time to time and the above may be found to differ from the rates given in the Berne List. The above, however, are absolutely correct up to July, 1925.

In the NORTH PACIFIC SCHEDULES, April "RADIO," the following changes should be made:

DELETE

GMT			
0000	NPL	9800	San Diego, Press to QST, Arc.
0915	NPG	4600	San Francisco, Press to QST, Arc.

ADD

GMT			
0000	GBR	18740	Rugby, British press, Arc.
0810	KPH	2200	San Francisco, Press to QST, ICW.
1200	GBR	18740	Rugby, Press.
1600	VPS	600	Hongkong, Weather, Spark.
2000	GBR	18740	Rugby, Press.

MISCELLANEOUS NOTES

MANILA. The commercial station KZFR has been discontinued and all Manila traffic is now handled by Station KZRC, Radio Corporation of the Philippines, 600 meters, ICW. Only one broadcasting station is now in operation, KZRQ, Manila Hotel, 380 meters, 500 watts.

JAPAN. Three broadcasting stations, all of 1500 watts are now operating. JOAK, Tokio, 375 meters. JOBK, Osaka, 385 meters. JOCK, Nagoya, 360 meters.

NORTH PACIFIC. NPQ, St. Paul, Alaska, while sending on 2250 meters puts out a strong harmonic on about 625 meters. Many operators mistake this harmonic for the 600 meter wave and quite uselessly call NPQ while he is busy on the longer wave.

—Mickey Doran.

WHO'S WHO AND WHERE

F. L. Dewey, Los Angeles District Manager for the Federal Telegraph Company, is visiting his folks in Northport, Washington, where, he says, the deer mingle with the cows and the trout jump out of the water to get a good looking hook.

* * *

Wayne Poole is on the *A. M. Byers* again this season.

* * *

G. M. Cozier, ex-WCZ, is now on the Ann Arbor carferry WDQ.

* * *

Geo. F. Hutchins, who took the *Washtenaw* to Ketchikan, Alaska and returned as a passenger, 1st. class on one of the Admiral liners, went out on the *Lio* vice D. Varney, who has broken into the motion picture game. What a comedown!

* * *

Karl Zint decided to come down off of his Big Bear Lake job and is now on his way to London via the Canal, New Orleans, and Liverpool.

* * *

J. M. Pearce has started this season on the *J. L. Reiss*.

* * *

Leo Shapiro left for Hamburg on the *La Brea*, after that ship had been running coastwise for a few weeks.

* * *

F. W. Everett, Geo. Morris, and E. A. Russell are now operating short wave commercial stations for the Western Air Express, under Mr. Harraden Pratt, chief radio engineer.

* * *

E. Pullman of Frankfort, Michigan, went to Detroit the other day and got a ticket. He is now on the *Ann Arbor No. 3*. Welcome, OM.

* * *

WSK is on the air again this year with the same hours as last season. The operator is Elmer Rose, who was also there last year.

* * *

Howell Paine is now on the *Bert E. Haney*, vice C. G. Batron, who came ashore for a spell.

* * *

"Spark Plug" Guersdorf has resumed his speedy sending over the F. T. Company's point-to-point arc since it has become too hot to do the Charleston.

* * *

Elliott Jacobsen, ex-WDQ, is now working at WFK, Frankfort, Mich.

* * *

C. F. Lahner has been transferred from the *Yosemite* to the *Munising*.

* * *

B. Baskin started the season on the *S.S. Block*.

R. O. Koch, of WMW, recently decided that the colorlessness of a perfectly good and gentlemanly 1st. Class ticket didn't jibe with his delicate sense of art, so he meandered down to Detroit and told the R. I. to crank up the old omnigraph and let 'er rip. Now WMW is adorned with a slip of paper of a most beautiful salmon-belly pink. Ain't that heck?

By the way, if any of the rest of you are in the market for pink tickets, here is the way the Government tries to discourage you: The applicants must have had at least eighteen months of satisfactory service during the two years previous to the filing of the application, on any first class license, and at any general public radio station. The applicant is not eligible if he has ever been penalized for violation of the radio laws and regulations. A code speed of 30 words per minute, Continental Morse, and 25 words per minute, American Morse, must be attained. The theoretical examination consists of three sets of regular questions; 80 or above constitutes a passing mark. These licenses are issued at Washington, D. C., by the Commissioner of Navigation, endorsed by the Secretary of Commerce, and delivered to the successful applicant through the examining officer. Such licenses may be renewed without examination, provided the service records properly certify to 12 months' satisfactory service in any general public radio station, at least six months of which must have been served during the last 12 months of the license period.

The first of the Ann Arbor ships to be equipped with a tube transmitter was the flagship No. 7. Her new set was put into operation April 28 and certainly is a wonderful improvement over the old QMS set. The new transmitter is an RCA affair and uses two fifty watters with 500 cycles on the plates. All other Ann Arbor vessels as well as the coast stations at Frankfort Michigan and Manistique, Michigan, will also be equipped with tube transmitters in the near future. Pretty nice, all right!

After reading the May number, a BCL asks if WMW means, "We Make Whisky." Hi.

The Pere Marquette Railway has signed contracts with the RCA for modern tube transmitters to be installed at all stations, both ship and shore. This means that both the Pere Marquette and Ann Arbor Lines will be using tube equipment in the near future. The Ann Arbor contracted for similar apparatus some time ago. The coming of the tube sets will mark the exit of four famous rotary spark land station transmitters and twelve QMS sets which were used on board the carferries. Turn over another leaf in the history of radio.

Member of ship's crew to **Passenger:** "What are the wild waves saying?"

Passenger: "Don't eat."

When it comes to an honest-to-goodness really pretty fist with either bug or straight key, we think that "FM" at WFK is hard to beat. F. B. OM!

A RADIO RHYMSTER

Dear Radio:

This letter is from Walter A. Peck,
I once owned a station, by heck,
At 40 Flatbush Ave., Hartford, Conn.
I lost lots of sleep so the air I could be on.
1ARH is the license I lawfully hold,
In December, 1925, my transmitter I sold.
My sig's around the world had madly tore,
Into 21 countries and maybe more.
The circuit used was drawn by old pop heart,
His monkey business gave me my start.
Many a message I toss across the ponds
To Marys, Annies, Joes and Johns.
From the far cold land around the pole,
To African jungles or wherever my sig's made a hole.
The A. C. was kept so tightly choked
That a P. D. C. note through the night I poked.
Then tired of cleaning the jar,
A raw A. C. note made the scar.
One night the A. C. sent the fifty west—
My heart popped out, then sank back in my vest.
I have chatted with over a thousand "hams,"
Some Qrz, others Qsb,
But they all came through my brandy cans.
I've dwindled down from a transmitter swell
To a receiver that perks extra well.
The B. C. L.'s no more mourn from my fist,
Their dials with pleasure I let them twist.
Their music that comes from far and near
I shall bother it not so they may hear.
I still love the radio game,
Its unseen listeners and its name.
The ether has always been my rave,
So long live the amateur upon the lower wave.

With the Amateur Operators

THE 7.5 WATTER AT 2AI

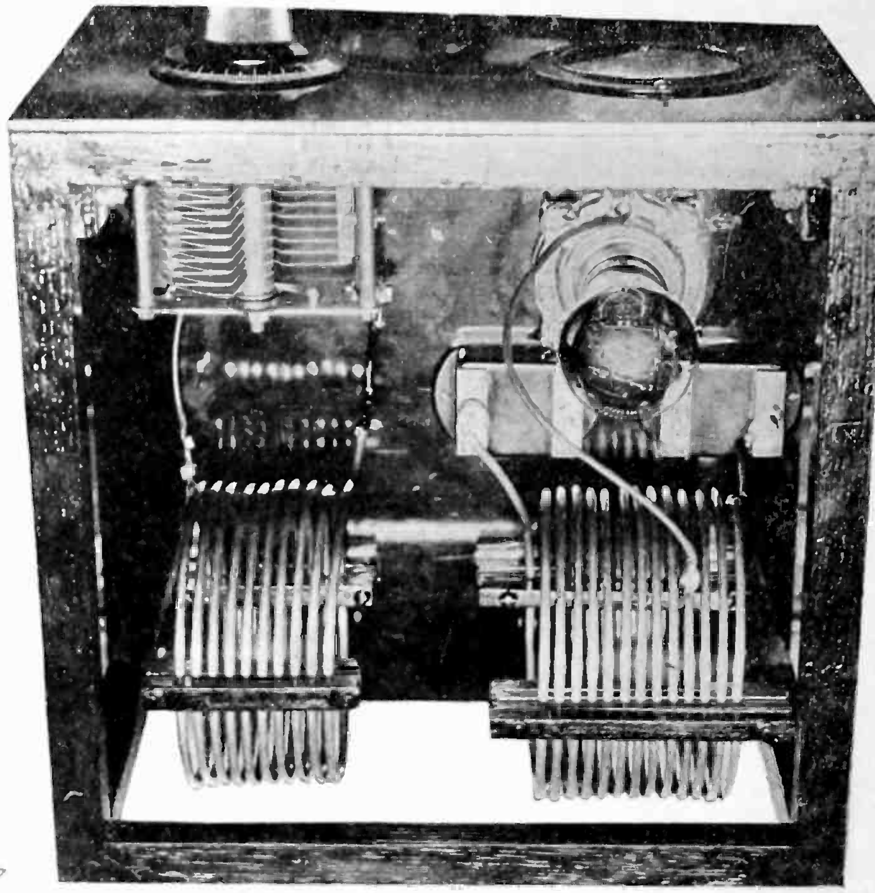
Many articles have been written about low power transmitters for use on the 40 meter wave band. Most of these tell of remarkable distances covered, but comparatively few writers have mentioned an all important item—design.

The transmitter shown in the accompanying pictures is in use at 2AI, operated by Paul H. Nisley. It presents, we believe, somewhat of a design standard which might well be followed by many "hams." The general tendency seems to be to assemble the component parts of the average transmitter on a work bench and then leave them there in disordered array.

2AI is neatly assembled on a bakelite panel 12 in. wide by 15 in. high. A hardwood frame is used behind the panel to hold it and the necessary shelving for apparatus. The extreme depth of this 7.5 watter is only 12 in., making it a very compact job. The base panel is made of kiln dried threeply veneer. On this base are mounted the filament and plate transformers, chokes, filter condensers, tube socket and rectifier tube. A CX-313, UX-213 tube is used for rectification, the plates of this tube being connected together, thus increasing the rectified output of the tube. The choke shown in the photographs is suspended from the upper shelf and at the extreme back center of the base is mounted the 110 volt input connection.

The upper shelf, strongly supported by *L* shaped bakelite brackets screwed to the wooden frame, holds the transmitting tube and socket, filament, by-pass condensers, plate blocking and grid condensers and inductance coils. The grid leak is suspended by a small bracket almost directly under the tube socket.

On the front panel are mounted a .00025 Cardwell condenser for tuning the antenna. The closed circuit, being the standard Hartley hook-up, is tuned by the use of adjustable clips. The r.f. ammeter, filament voltmeter and plate milliammeter are mounted as shown in the pictures. The rheostat controlling the transmitting tube is centered on the front panel. The key is connected to the transmitter by means of the two binding posts shown in the bottom center of the panel. 2AI puts .3 amperes into the antenna with 400 volts on the plate of the tube and was awarded first prize in its class at the 6th Annual Radio Show of the 2nd District, recently held at the Pennsylvania Hotel in New York.



Top View, Showing Construction of Inductances.

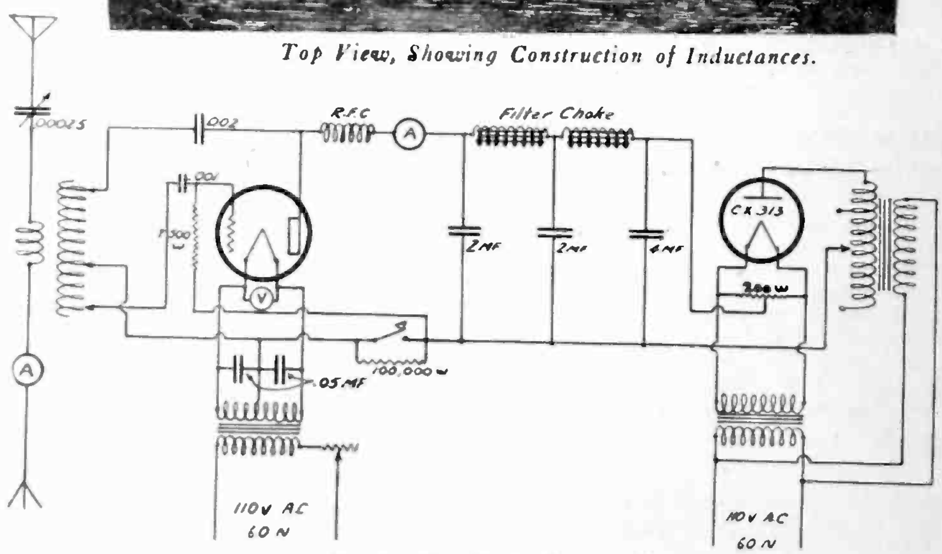
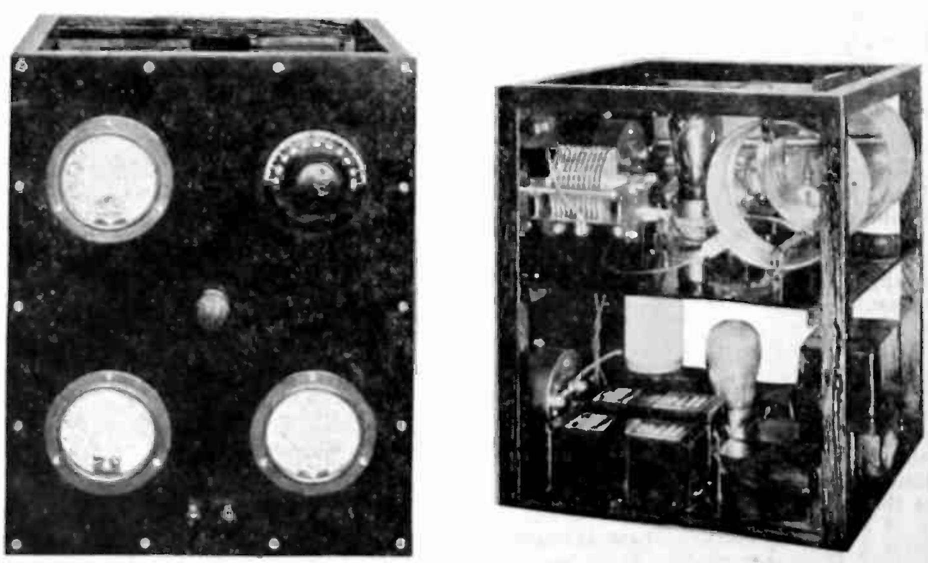


Fig. 1. Circuit Used at 2-AI.



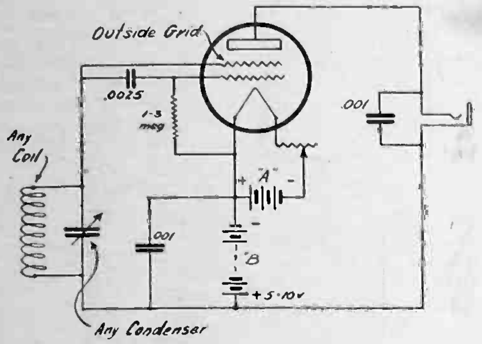
Panel and Side View of 2-AI Transmitter.

LIST OF PARTS

- 1 Bakelite panel 12x15 in.
- 1 Cardwell .00025 transmitting condenser.
- 1 Jewell Ammeter 0-1 a.
- 1 Jewell Voltmeter 0-10 v.
- 1 Jewell Milliammeter 0-100 m. a.
- 1 Oscillator Inductance—13T No. 12 on 4 in. dia.
- 1 Antenna Inductance—10T No. 12 on 3½ in. dia.
- 2 Dubilier Type 577 condensers, .001 and .002 mfd.
- 1 Dubilier type 580 condensers with center tap .05-.05 mfd.
- 2 Dubilier type 769 filter condensers 2 mfd. each.
- 1 Dubilier type 770 filter condenser 4 mfd. each.
- 2 30-50 henry choke coils.
- 1 Filament transformer.
- 1 Plate transformer with secondaries connected in series.
- 2 Ward-Leonard 15,000 ohm resistances connected in parallel for grid leak.
- 1 100,000 ohm resistor.
- 1 Rheostat, suitable for transformer use.
- 1 r. f. choke—120 turns No. 22 D.S.C. wire on 1½ in tube.

THE NEUMANN OSCILLATOR

Mr. C. R. Russell, of Christchurch, New Zealand, sends some interesting information regarding experiments with the four electrode tube as an oscillator. This circuit, which is commonly called the Neumann oscillator, employs a Phillips 4 electrode tube manufactured in Holland, and is particularly useful in heterodyne wavemeters or in the oscillator circuit of a superheterodyne. The great advantage of the circuit is that the frequency is practically independent of the operating conditions of the tube, and it is therefore ideal for an oscillating wavemeter.



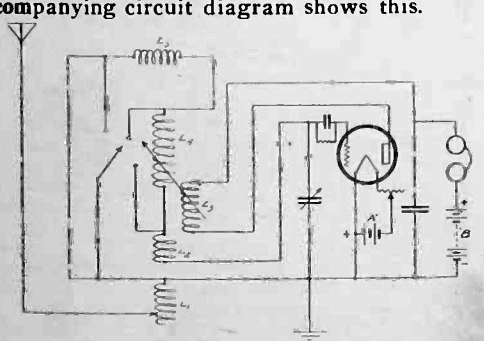
Four Electrode Oscillator Circuit.

Successful experments were made using a Phillips tube, with .06 amperes at 1.1 volts filament, and a 7 volt *B* battery. With a 2 turn coil the tube will oscillate down to 10 meters, and with a 2000 turn coil, and without any readjustment, the tube oscillates on 20,000 meters. At no time was it necessary to increase the *B* voltage above 7, so that the radiated energy was small, and interference with neighboring receivers while making the tests was negligible. It is to be hoped that tubes of this description will be available for American experimenters, as they would be useful in short wave work.

MINIMIZING LOSSES IN A MULTI-WAVE TUNER

By C. H. STARR, *C-3KA*

Most of the dead-end losses in a tapped coil can be overcome by arranging the coil so that there is no magnetic coupling between its used and unused portions, and so that the dead ends are short-circuited and kept on the filament side of the secondary. The accompanying circuit diagram shows this.



Circuit Diagram for Tuner Covering Range From 50 to 625 Meters.

L_1, L_2 and L_4 are made up of No. 18 d. c. c. wire wound on the same 3 in. diameter corrugated paper tube with ½ in. spacing between L_1 and L_2 and 1¼ in. spacing between L_2 and L_4. L_1 consists of 12 turns tapped at the 1st, 2nd, 4th and 8th turn. With 9 turns L_2 covers from 50 to 110 meters and with the 20 turns of L_4 in series with L_2 it will cover from 100 to 245 meters.

The tickler L_3, placed between L_2 and L_4 consists of 11 turns of No. 25 d. c. c. wire jumble-wound on a tube 2 in. in diameter, and tapped at the 3rd and 6th turn. The unused turns are best left open.

L_4 consists of 90 turns of No. 18 d. c. c. wire wound on a 3 in. tube. When in series with L_2 and L_4 it covers from 245 to 625 meters.

C_1 has a maximum capacity of 250 m.m.f.

By U-3OP-AJJ, Edwin Laker, Jr., 3908 Park Heights Ave., Baltimore, Md.

U. S. A.: 6aaf, 6aak, 6aau, 6ael, 6afh, 6ajm, 6ake, 6amm, (6anc), 6ase, (6asv), 6atu, 6awt, (6azv), (6azz), 6bad, 6bav, (6bcn), 6bek, (6bjv), 6bm, (6bol), 6bq, 6bur, 6buj, 6bvq, 6bvy, 6cae, 6cbj, 6cco, 6cdl, 6cev, (6cgk), 6chl, 6cnd, 6cns, (6cof), 6csa, 6css, 6csw, 6cto, 6ct, 6cvk, 6dag, 6dah, 6dax, 6dn, 6eb, 6ec, 6gk, 6hv, 6ih, 6ji, 6kd, (6mb), 6oi, 6qi, 6rw, 6sb, 6uf, 6vc, 6vr, (6vz), 6wt, 7afo, 7aij, (7dd), 7fb, 7gs, (7nh), (7nl), 7nx, 7or, (7pu), 7sl, (7wu), 7ya. Canada: 4bt, (4dw), 4gt, (5as), 5bh, (5go), 5hp. Porto Rico: 4ja, (4kt), 4rl, 4sa. England: 2nm, 2sz, 2od, 2wj, 2xa, 2xy, (5hs), 5lf, 6lj, 6rm, 6ry. Mexico: 1aa, 1b, 1x, 9a, jh. Cuba: 2jt, 2lc, 8kt. Bermuda: ber. Italy: 1ay. Switzerland: 9ad. Belgium: 4yz. Argentina: af1. Brazil: (2ab), 3af, 1ak, 1ag, 5ah, 1ab. Australia: 2cm, 2jw, 2yi. New Zealand: 1ao, 2ac, 3ao, 4ag. France: (8uin), 8ja, 8yor. Hawaii: (6bdl), fx1. Naval: nem, nisr, (nitc), (nitz), (nivd). Miscellaneous: kfuh, utm, xda, wiz, sgc, wbc, fw. Qrk? my fifty watter on forty meters. Will answer all reports and qsls.—3op.

By 6RO, 284 4th St., San Francisco, California.
(40 meters)

1cmf, 2nz, 2sq, 3bwt, 3lw, 3te, 4ak, 4ct, 4fl, 4ft, 4jn, 4kn, 5aay, 5ac, (5agp), 5ald, 5aij, 5ain, 5akt, 5aky, 5amk, 5amw, 5apm, 5arh, 5asz, 5att, 5atf, 5atv, 5atw, (5aqs), 5cr, (5fc), 5ef, 5go, 5kk, 5oq, 5qk, 5ux, 5vm, 5vu, 5xau, 5yb, 5xax, (6bcm), 6bty, (6rv), hu, (6axw), 6bdl, (6buc), (6bdl), 7aab, (7ajq), 7ay, 7bb, 7dd, 7ek, 7en, 7ip, (7jf), 7ki, 7ne, (7pj), 7pi, 7sf, 7tk, (7wb), (7wu), 8aay, 8blb, 8ccm, 8cgz, (8cwr), 8dka, 8fj, 8rh, 8sz, 8bzt, 9aab, 9aon, 9amb, 9aot, (9alt), 9axx, 9bhp, 9bjp, (9bjn), 9bmt, (9bwo), 9cej, 9elr, 9cvc, 9cvn, 9cwn, 9cwf, 9daw, 9daq, 9dhw), 9dmz, 9dyz, 9dxr, 9ecl, 9egs, 9eky, 9elt, 9fj, 9hb, (9hp), 9pn, 9zd, wyh, npa, (npg).

By 6DDN, Willis L. Nye, 1344 Bernal Ave., Burlingame, Calif.
(40 meter band)

1ao, 1adm, 1akz, 1bfr, 1bq, 1ga, 1ku, 1ts, 2aa, 2aai, 2ah, 2ai, 2amj, 2atl, 2aut, 2awq, 2bun, 2bur, 2buy, 2by, 2cqo, 2cql, 2cqz, 2cxl, 2fm, 2fr, 2ha, 2lr, 2kg, 2ld, 2nf, 2px, 2qz, 2wc, 3by, 3ea, 3ni, 3nf, 3ll, 3wf, 4al, 4am, 4bk, 4cc, 4fa, 4fr, 4fx, 4hr, 4pu, 4pf, 4tz, 4za, 5aab, 5adx, 5ald, 5aij, 5ajj, 5am, 5amc, 5anj, 5amn, 5apm, 5atq, 5atv, 5ase, 5asv, 5bn, 5dd, 5dl, 5dq, 5ea, 5eb, 5fl, 5gw, 5ha, 5hl, 5iz, 5jr, 5kk, 5kx, 5ld, 5nm, 5nq, 5qa, 5qx, 5rg, 5uh, 5ur, 5uk, 5vm, 5yb, 5yd, 5za, (7aab), (7aek), 7alk, 7apg, 7dd, 7do, (7df), 7dx, 7fi, 7fq, 7ge, 7ha, 7hl, 7lk, 7kk, (7kl), (7lq), 7mp, 7nc, 7nh, 7ob, (7os), 7pu, 7px, 7sa, 7ut, 7vr, (7wu), 7ya, 7zx, 8adh, 8ajn, 8alf, 8aly, 8ary, 8cli, 8cnt, 8cny, 8cor, 8dpz, 8kv, 8pl, 8rh, 8yl, 9s too numerous. Australia: 2aj, 3ea, ch-9tc, c-9el, m-jh, m-1j, m-9a.

By 9APY, 3337 Oak Park Ave., Berwyn, Ill.
(On 40 and 80 meters)

1ag, 1amd, (1aye), 1azd, 1bkq, 1chl, 1it, 1yb, 2abt, 2aef, 2ahk, 2ahm, 2apv, 2arm, 2axp, 2bnz, 2caz, 2cxl, 2ev, 2ha, 2im, 2oc, 2px, 2qf, 2sk, 2xac, 2xaf, 2xk, 2bjt, (3cnn), 3cpa, 3mk, 3ur, 3vj, 4aar, 4bw, 4cu, 4du, 4fj, 4fx, 4lt, (4mm), 4na, 4oy, 4sl, 4wg, 4wi, 5aab, 5aaq, 5aav, 5ado, (5agj), 5ain, 5ajj, 5akg, 5am, 5amg, (5anl) (5apl), 5apm, 5aqf, 5aub, 5cu, 5ha, 5ls, 5qj, 5sl, 5uk, 5va, 5ww, 5zal, 6aaf, 6afs, 6aon, 6bgv, 6bhz, 6bmw, 6bxc, 6bxd, 6qa, 6cto, 6dag, 6dax, 6kb, 6rm, 6um, 6xl, 7aib, 7dd, 7ok, 7tj, 8ahm, (8alw), 8bqk, 8bsm, 8cgt, 8cvo, 8cuv, 8don, (8hm), 8kw. Canadian: c-4ah. Mexican: 9a.

By PI3AA, F. Johnson Elser, Baguio, P. I.
(On 40 meters)

5za, 5zal, (6abg), (6ahp), (6akm), 6aks, (6alt), (6amm), 6aps, 6awt, 6bcl, (6bjd), 6bjx, 6bmw, 6bq, 6bwi, 6chl, (6clx), 6clz, 6cmg, 6cqa, 6dag, 6fz, 6rw, 6xl, 7vh, a2yx, (a3bd), a3bq, a3ef, a3hl, a6kx, (a7hl), bz1an, c5go, f8jc, fc8ag, fc8gg, fc8xx, (fi8qq), hu6asr, (hu6axw), (hu6bdl), hu-6buc, hu6dcf i1mt, j1aa, (j1sk), (j1kk), j1ts, j2ld, (j3aa), (j4ww), (oa3b), x2bg, andir, bm, glub, kel, ls, npg, npu, nqv, actj, wghm, (wuq), wux.

By n6WU, R. E. Calhoun, 1443 California Street, Berkeley, California, U. S. A. 40 meters—Month of April, 1926

Australia: a2ar, a2bb, a2cg, a2cs, a2ij, a2im, a2mh, a2rc, a2ss, a2tm, a3ad, a3bd, a3bh, a3en, a3kb, a3lp, a3ot, a3tm, a3xo, a4cm, a4rb, a5ay, a5da, a5kn, a6kx, a7cs, a7cw, a7dx, a7hl. Chile: ch2ah, ch2ar, ch2ld, ch3an, ch3ij, ch9tc. French Indo-China: fi8qq. Hawaii: hu6aff, hu6asr, hu6axw, hu6buc, hu6clj, huc3n. Japan: j1kk, fc8flo. Java: anf, andir. Mexico: m-1j, m-1n, m-9a, m-jh. Africa: o-1sr, o-a3e. Philippines: pi-1at, pi-1hr, pi-3aa, pi-cd8, najd. Porto Rico: pr-4je. Cuba: q-2mk, q-8kp. Argentine: r-aa9, r-bal, r-bd2, r-fa3. Singapore: ss-2se. India: x-2rb. Uruguay: y-JCP. New Zealand: z1aa, z1af, z2ab, z2ac, z2ae, z2ak, z2ga, z2xa, z3af, z3ai, z3aj, z3ak, z4ac, z4am, z4av, kfuh. Miscellaneous: pt5, c5g, bxw, wxp.

By PI3AA, F. Johnson Elser, Baguio, P. I. During March, 1926

A-5kn, 2bk, 2bb, 3bd, 2yi, 2jm, (6kx), 3my, b-(4yz), bz-snm, ch-(3ij), 1tm, f-(8jn), fc-(8em), 1ego, fi-8lbt, g-2it, (5nj), 6yo, (5lf), hu-6dcf, fx1, (6buc), wyq, (6bdl), 6dbl, J-1aa, 1kk, (3az), 1ts, N-(stb), O-(a6n), (a3z), a4l, PI-(1hr), (1au), 1ar, 1at, cd8, (1dl), (1xa), S-(2ns), U-(6ahp), 6kb, 6csd, 6hm, (6nx), 6btm, 6ann, 6csx, 6xl, 6ctd, 6bjx, (6dag), (6chl), (6amm), 6bbv, (7ay), (6alt), (6bq), 6sb, (6hv), (6ccl), 7tm, 6avj, 6akm, 9ax, (6ajm), 6ea), 6awt, (6cmg), 6if, 6cgw, 6abg, 6kb, 6jn, (7hb), (7tm), (6bmw), 6sv, 6bgo, 6cqn, (7wu), 6bwi, 7ho. Navy: ngy, npo, a6w, nqt, c9m, npn, (npp), dp7, nupd, c5g. Others: bam, joc, (glub), (geft), ot, (andir), fw, anf, ffz, bg, rrp.

By 6cqw, Bx261, Heber, Calif.

U—1awe, 1cal, 2amj, 2arm, 2aky, 2bur, 4fl, 5gl, hu6aff, 6dbl, u7alk, 7aaj, 7ne, 7pu, 7do, 8aul, 8alf, 8wy, 8bau, 9aiz, 9cfy, 9caa, 9dkx, 9drz, 9ck. Pi.—1hr, c4cc, c4ag, c3jw, 19al. Nz.—2ac, z3af, z4am, z2ae, ch3ij, o2ar, ?8i, ?agb.

By 6DN, L. W. Bristol, 528 So. Garnsey St., Santa Ana, Calif.

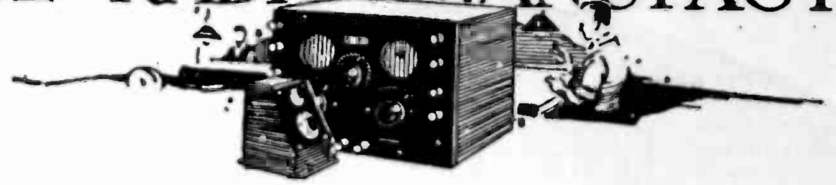
1au, 1xb, 1axa, 1cmp, 1ahm, 1apz, 1axg, 1id, 1ak, 1apm, 1abt, 1awe, 2bkr, 2alm, 2gp, 2fj, 2anm, 2rm, 2aoc, 2kg, 2kf, 2cty, 3dh, 3bqd, 3kg, 4sl, 4av, 4jn, 4bu, 4cu, 4fl, 4rz, 4aar, 4rz. Foreign: a-2cm, a-2yi, a-3ad, a-3bd, a-3ef, a-5ka, a-7gt, be-ber, c-4ac, c-4fv, c-4ks, c-4ea, c-5go, hu-6aff, hu-fx1, hu-wyi, hu-6tq, j-1aa, m-5c, pi-1hr, r-db2, r-dh5. Samoa: 6zac, z-1ao, z-2xa, z-2ae, z-2ac, npm, npo, npl, npu, npg, nar, neqq, nkf, wvc, wzt.

By u2AHK, 554 South Clinton St., East Orange, N. J., U. S. A.

5acf, 5acl, 5acy, 5ada, 5add, 5aev, 5afb, 5afu, 5agn, 5ahr, 5ahk, 5ajj, 5akl, 5akp, 5akz, 5aij, 5am, 5ame, 5amw, 5anl, 5aqn, 5aou, 5aqw, 5asb, 5asv, 5atf, 5atp, 5atx, 5auh, 5ax, 5cc, 5ce, 5eh, 5gq, 5jd, 5jf, 5kw, 5ls, 5nj, 5nq, 5ov, 5ox, 5pb, 5pi, 5qj, 5qk, 5rj, 5rg, 5sd, 5se, 5tn, 5uk, 5ux, 5ww, 5za, 5zal, 6aak, 6abg, 6adt, 6aff, 6afh, 6afs, 6ahg, 6ahp, 6aiv, 6aji, 6ajm, 6akm, 6aks, 6akw, 6akx, 6akz, 6al, 6alt, 6amm, 6ano, 6anw, 6aoy, 6api, 6apl, 6apy, 6apk, 6app, 6apw, 6aqg, 6aqp, 6asd, 6ase, 6auf, 6avj, 6aws, 6awt, 6bad, 6bau, 6bav, 6bbv, 6bcs, 6bfe, 6bgc, 6bgo, 6bgv, 6bha, 6bhz, 6bis, 6biz, 6bjd, 6bjv, 6bjx, 6ble, 6bls, 6bmw, 6bol, 6bon, 6bpg, 6bpn, 6btj, 6btm, 6bts, 6buc, 6vi, 6bvo, 6bvs, 6bwi, 6cae, 6cah, 6cba, 6cbg, 6cby, 6cck, 6ccl, 6cco, 6cct, 6ccv, 6cda, 6cdp, 6cfj, 6cgf, 6cgw, 6chk, 6chl, 6cht, 6clp, 6clt, 6cmq, 6cnd, 6cof, 6cpf, 6cpg, 6cqa 6crb, 6crp, 6crs, 6crz, 6csa, 6csw, 6csx, 6ct, 6ctd, 6cte, 6cto, 6cuk, 6cur, 6cuw, 6cva, 6cvp, 6cvv, 6cww, 6daa, 6dac, 6dag, 6dah, 6dal, 6dan, 6dam, 6das, 6dat, 6dax, 6db, 6dbe, 6dbl, 6dh, 6dl, 6dn, 6eb, 6ec, 6ew, 6fz, 6hm, 6ih, 6jl, 6jn, 6jp, 6js, 6kb, 6ia, 6la, 6ml, 6nh, 6nw, 6nx, 6ol, 6qg, 6qu, 6rh, 6rj, 6rm, 6rn, 6sb, 6sz, 6ts, 6tx, 6ue, 6uf, 6uy, 6vr, 6vz, 6wt, 6xaf, 6xao, 6zac, g2lz, g2nm, g2sz, g2kf, g2xy, g2aj, g2nb, g2od, g2fm, g2wd, g2qb, g2blm, g2bz, g2cc, g5nn, g5sz, g5ma, g5ls, g5qv, g5ma, g5hg, g5rz, g5nj, g5xn, g6td, g6lj, g6yd, g6nf, g6kk, g6yu, g6nf, g6tm, g6al, g6ox, f8yor, f8dp, f8tok, f8dd, f8nn, f8gpv, f8rz, f8go, f8wx, f8gi, f8rh, f8aix, f8al, f8ip, f8xp, f8dk, f8jn, f8bf, f8cs, f8fn, f8zo, f8rbp, f8gra, f3ca, focng, i1as, i1mt, i1rm, i1gw, i1ay, i1aq, i1bw, 1ntt, npcjj, npb3, nonl, npc2, npb7, b4yz, bb2, bwl, bo8, bj2, p3gb, plae, ssdkv, ssmzs, ssrd, ssgc, q2jt, q2mk, q2by, m1af, m1aa, m9a, mbx, m1j, m5g, m1g, ear2, ear9c, ear21, ear22x, ear24, 19k, 11jw, pr4rl, pr4sa, pr4kt, pr4je, pr4bj, pr4ur, hu6db, hu6dbl, hu6buc, hu6aff, huwyq, bz1ab, bz1ac, bz1af, bz1ib, bz5ab, a2rj, a2jw, a2yi, a3af, a3ad, a3bd, a5da, a2ds, a3kb, a2lo, a3wm, a3yn, a3xo, z1fm, z1ao, z2ac, z2xa, z4ar, z4as, 1dn? u7aaj, 7adf, 7alk, 7bb, 7dd, 7df, 7do, 7ek, 7g, 7gv, 7hv, 7he, 7hc, 7jf, 7oz, 7uj, 7uz, 7vr, 7wu.

Pse qrk u2AHK on 20 es 40 meters??

FROM THE RADIO MANUFACTURERS



The All-American Constant-B plate power set is a compactly built outfit occupying less space than two standard 45-volt batteries. It is completely shielded and housed in a neat case on the panel of which are terminals marked for 135, 90, 67 and 48 volts. It employs a Raytheon tube to give full wave rectification

and is equipped with cord and socket for direct attachment to the 110 volt 60 cycle a.c. supply. A rheostat adjusts the voltage for the detector tube. The parts entering into its construction are also sold separately for home assembling.

Electrad metallic grid leaks and resistors are made up of resistance elements fused to the inside of a glass tube. They contain no paper, carbon, fiber or varnish

and are claimed to be constant in all weather, temperatures and working conditions, being paraffined under vacuum so as to be non-hydroscopic. They are noiseless and non-inductive and are made in sizes from 5000 ohms to 10 megohms.

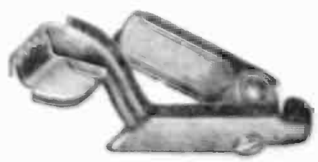
The Majestic Super B current supply set is designed to supply direct current from a 110 volt 60 cycle source to the plate of as many as 12 tubes. It uses a Raytheon tube to give full wave rectification. With the "high" switch on it delivers from 5 milliamperes at 226 volts

to 60 milliamperes at 94 volts; with the "low" switch from 5 milliamperes at 194 volts to 60 milliamperes at 38 volts. Adjustable resistances on the detector and intermediate frequency amplifier terminals enable careful regulation of voltage supply.

The new Crosley portable is a four-tube set with one stage of tuned radio frequency amplification, Crescendon control detector and two stages of audio frequency amplification. Ample room is

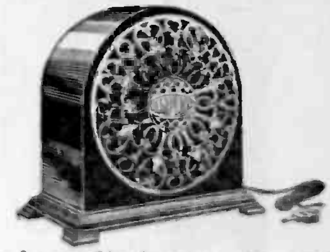
provided in the leatherette-covered carrying case for large dry-cell batteries. It is intended for use with an improvised aerial and ground so that the complete self-contained outfit, except for the loudspeaker, may be used to bring in radio entertainment anywhere.

The Valley battery clip is made of tough steel with ribs and channel shape to give great strength and a positive grip.



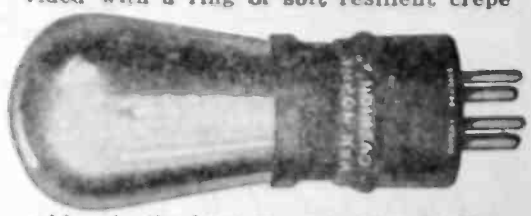
It is electro-plated with an acid-resisting metal which minimizes the possibility of corrosion. The jaws provide an opening that will admit round battery posts up to ¾ in. diameter. The rated carrying capacity is 25 amperes.

The Amplion Radiolux is a cabinet speaker resembling an English bracket clock in shape, standard 16 in. in height. The speaker element is of the electromagnetic type with a laminated permanent magnet having high flux density and



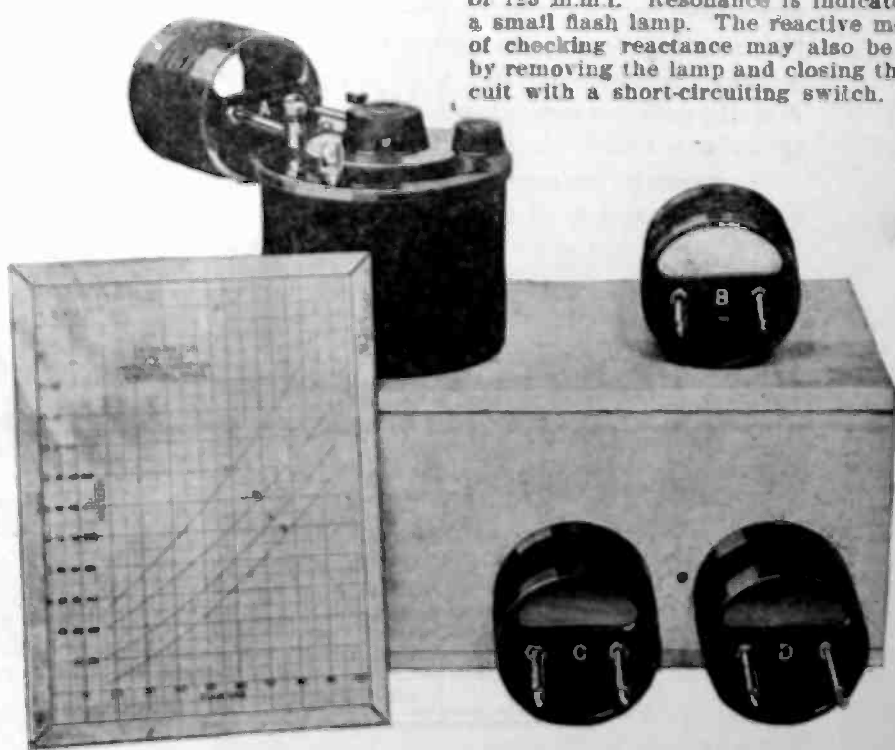
with a large diaphragm. The volume is adjustable. The acoustic system consists of a long tapered duct and a hyperbolic reflector. This is exceedingly sensitive and gives clear, loud and realistic tone reproduction free from distortion and resonance.

The Van Horne cushion tube is provided with a ring of soft resilient crepe



rubber in the base so as to absorb vibration and eliminate microphonic noises. It has an X-type base to fit any socket.

The General Radio Type 358 wavemeter covers a range from 14 to 240 meters by means of four plug-in coils for each of which a calibration chart is provided. The condenser has a maximum capacity of 125 m.m.f. Resonance is indicated by a small flash lamp. The reactive method of checking reactance may also be used by removing the lamp and closing the circuit with a short-circuiting switch.



Constant-B

ALL-AMERICAN
TRADE MARK
PERMANENT PLATE POWER

Steady "B" power without batteries

Pure full tone is possible only with "B" voltage kept constantly *up to standard;* All-American "Constant-B" *gives it to you*

YOU'VE had your "B" battery troubles; everybody has. Here's a permanent end to them—install an All-American "Constant-B," attach it to a light socket, and turn on the switch. You get a dependable, permanent supply of uniform, constant plate current; insuring full, pure tone.

There's no acid to ruin things; no annoying hum. And all inside units are permanently sealed against atmospheric conditions.

"Constant-B" has taps for 135, 90 and 67½ volts; and a 10 to 60 volt tap varied in output by a "Detector" control.

PRICE $45
Complete with Raytheon Tube

The "High-low" switch insures uniform voltage, regardless of the number of tubes used; "Low" for 2 to 5 tube sets, "High" for sets with 6 tubes or more.

"Constant-B," after passing the highest laboratory tests, carries the seal of approval of the Popular Science Institute of Standards and other testing laboratories. It measures up in every way to All-American's high standards of painstaking workmanship and satisfying performance.

Descriptive folder and interesting booklet showing how to build a "B" Power Supply similar to "Constant-B" sent free on request. Specify bulletin B-82.

ALL-AMERICAN RADIO CORPORATION
4215 BELMONT AVE., CHICAGO, U. S. A.

Station WENR—266 *Meters—is owned and operated by the All-American Radio Corporation*

Tune them out and KEEP *them out with* Filtrola STATION ELIMINATOR

This attractive compact unit, complete in itself, makes it a simple matter to tune out interfering stations you don't want—even the most powerful. No tubes, batteries or other units to install. A typical All-American product in its precision and quality of workmanship.

Price $15

ALL-WAVE DUPLEX RECEIVER

(Continued from Page 29)

calibration due to dampness or other causes can be compensated for with the antenna series condenser, with which the whole scale can be shifted a fraction of a meter up or down as desired.

Fig. 8 shows the medium and long wave circuit which was adopted because a minimum of apparatus was required. Throwing the 4PDT switch connects to either the medium or to the long wave coils. Such a single circuit receiver is useless if to be used within three miles of a broadcasting station or near neighbors who will be annoyed by its radiation.

The medium wave tuning coil and tickler consists of an ordinary 180 degree variometer with 70 turns of No. 28 d.c.c on the rotor.

The stator consists of 40 turns, single layer wound with taps at 20, 30 and 40 turns, then a 1/8 inch space and 10 more turns and a tap at 50. After this the coil is bank wound on top of the 50 turn layer, 25 turns to a bank until 325 turns in all were wound. Taps every 25 turns after the 50 turn tap. A 15 point Carter inductance tap switch, back panel type is used.

Match sticks are set in holes in the coupler stator to hold the banked turns until completion of the winding after which the turns are stiffened into place with coil cement. With the 15 taps the range is 400 to 5000 meters with a good overlap between taps.

Five taps were used on the long wave honeycomb coil, giving a range of 4000 to approximately 19,000 meters, also with a good overlap between taps.

HANDY HINTS

By D. B. McGowan

If a *C* battery is needed in a hurry, a spare tray of 6 volt storage batteries may help out, or several may be connected in series if more than 6 volts is needed.

Thin brass or copper strip metal is very handy around the radio constructor's table; it serves to connect small bearings, when bent into "pigtail" form, for shim material, for short connectors, and the like.

When brass nuts are screwed down fast on terminals, which are required to remain solid, a center punch mark on the side of the screw, between the nut and screw often will lock the affair securely enough to prevent loosening.

Glass tubing insulation is very handy when placing a box or cabinet around a storage battery. Small lengths can be forced through holes in the wood, and extremely good insulation will result.

Common "liquid glue," used sparingly, and well dried in a warm oven will make a fairly satisfactory substance for holding wire on a form or tube. Care should be taken to keep it dry or it will soften and lose its strength and insulation if it is dampened.

One of the best solders for hard soldering is silver, with borax as a flux. In an emergency a dime may be used with good success.

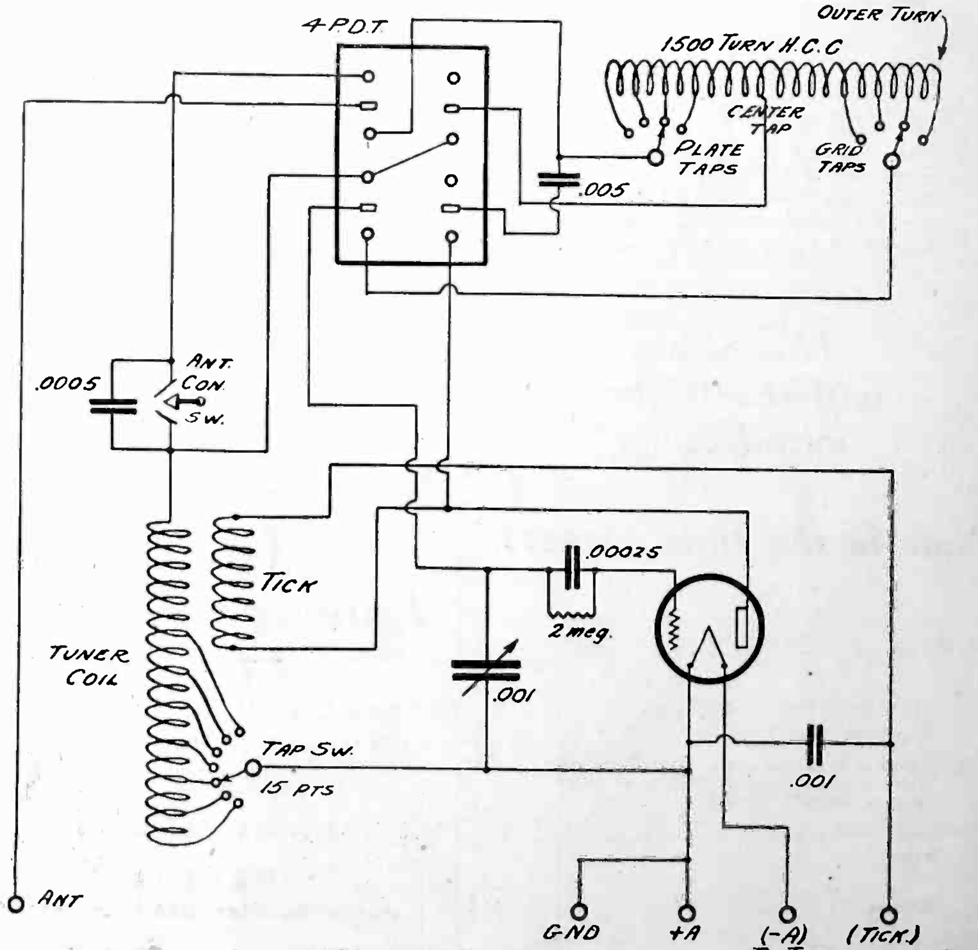


Fig. 8. Medium Long Wave Circuit.

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.

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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.

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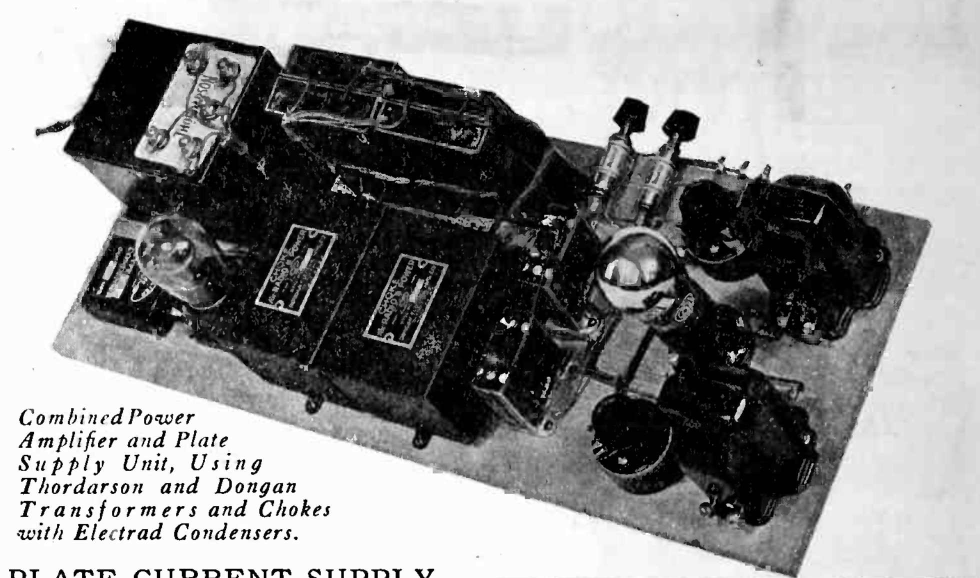


Combined Power Amplifier and Plate Supply Unit, Using Thordarson and Dongan Transformers and Chokes with Electrad Condensers.

PLATE CURRENT SUPPLY SETS

(Continued from Page 16)

The filament rheostat is necessary in order to reduce the filament voltage from 7½ to 5 volts, at ½ ampere, and as this unbalances the transformer secondary circuit, a 200 ohm potentiometer for the grid and negative *B* returns is necessary as is shown in the diagram. As the plate current of the 371 type tube is from 15 to 20 milliamperes, with the *B* and *C* voltages mentioned, an output transformer is necessary, as the plate current might burn out the loud-speaker windings. The output of the tube can be impedance coupled to the loud speaker if desired, but the transformer is equally as good, and requires less apparatus. The entire amplifier can be turned on and off from the 110 volt a.c. main switch, which also controls the input to the plate current supply unit.

If the power transformer has no 7½ volt filament winding, a 6 volt bell-ringing transformer may be used and the filament rheostat omitted.

If a type UX-210, CX-310 power tube is to be used in the power amplifier, the circuit shown in Fig. 9 will have to be employed, if the Raytheon tube is used. One extra transformer and Raytheon tube should be installed, with the outputs of the two tubes in series as indicated in the diagram. This arrangement will give an output of 400 volts d.c., and variable resistors of 100,000 ohms or more will be required for any lower voltages required by the receiving set. The filter condensers in this case must be capable of withstanding 500 volts d.c. under continuous service, and all connections, as well as the terminals, should be thoroughly insulated.

LIST OF PARTS FOR POWER AMPLIFIER

- 1 General Radio Type 285 Input Transformer.
- 1 General Radio Type 367 Output Transformer.
- 1 6 ohm filament rheostat.
- 1 200 ohm potentiometer.
- 1 UX base socket.
- 1 30 volt "C" battery.

In the experimental power amplifier-rectifier shown in the picture, the insulated, cabled wiring was used throughout, except the grid and plate leads of the power amplifier, with the wiring laced together with waxed twine or other strong cord. The *C* battery is connected externally, as it is quite bulky, and it does not matter if the connecting wires are long, as it is at a low voltage part of the circuit. If the type UX-CX-112 tube is used instead of the 371, the effective *B* voltage will be near 175 volts, and hence the *C* voltage should be adjusted to 12 volts.

In order to supply sufficient power to take care of the new Raytheon 85 milliampere type BH tube, which will be on the market soon after this article is published, the equipment shown in Fig. 10 has been developed and merits a special description. The new BH Raytheon tube has a larger current output than its predecessor, and while it can be used interchangeably with the present Raytheon, with no difference in the results, it

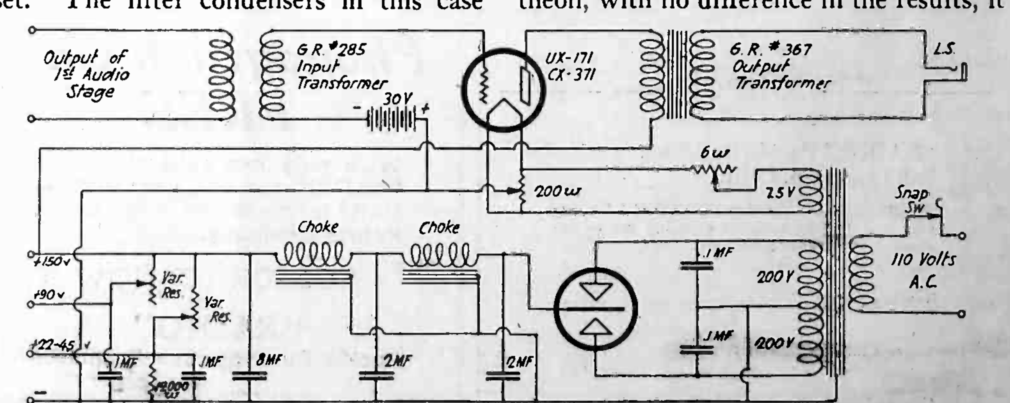
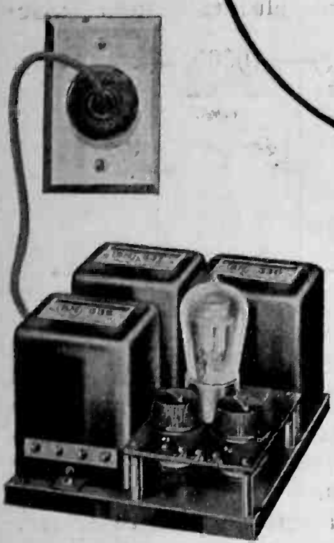


Fig. 8. Wiring Diagram of Power Amplifier with Built-in Rectifier.

"Plug-In B"



"Plug-In B"

The Silver-Marshall type 650-B gives the highest power, the best regulation (constant output) regardless of number of tubes used, and greatest freedom from hum of any power supply you can buy. It will supply from 25 milliamperes at 300 volts to 90 milliamperes at 190 volts—more than enough for the largest set. In it is incorporated the S-M 331 Unichoke—probably the greatest single advance made in "B" eliminator design since the Raytheon tube.

The S-M "Plug-In B" will operate any type of set, no matter what it is. It will handle the largest power tubes (especially the new UX171 soon due), and it will supply "A" and "C" power for audio amplifier tubes, too.

The "Plug-In B" never runs down, never is noisy—and will give constant, ample power long after you've spent three or four times its cost for dry cells. It is completely assembled, and requires the connection of a few wires, using only a screw-driver, to put it in operation.

Price, with genuine guaranteed Raytheon tube, $35.00.

The 220 and 221 Audio Transformers

The 220 and 221

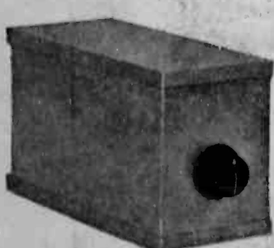
A Silver-Marshall audio transformer with a guarantee!—nothing less than a promise that it's better than anything you've ever heard—bar nothing.

The 220 audio, and 221 output transformers, are designed for the new power tubes as well as present day tubes.

Big, husky, solid—they usher in a new principle in audio equipment—the falling high frequency characteristic that means no hiss or noise—and quality such as you've simply never heard.

A pair of 220's and a 221 put into your present set will convince you of what radio reception can be. And remember, these transformers are unconditionally guaranteed to give better quality than any audio amplifier you've ever heard—resistance, impedance, any type at all. $6.00.

Shielded Stages



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The new Silver-Marshall No. 631 shielded stage unit incorporates all necessary parts for an R.F. amplifier or detector stage for any wavelength. The 631 unit is supplied with pierced aluminum shield, 316A condenser, 515 coil socket, 511 tube socket and ½ mfd. condenser. May be used as detector, R.F. stage, oscillator, wave trap—almost anything. Price, $7.75.

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is capable of handling an a.c. input of 300 volts to each plate of the tube, permitting a current drain up to 85 milliamperes without heating or damaging the tube, whereas the old tube is limited to 60 milliamperes.

By means of an electrostatic shield, which is inserted between the primary

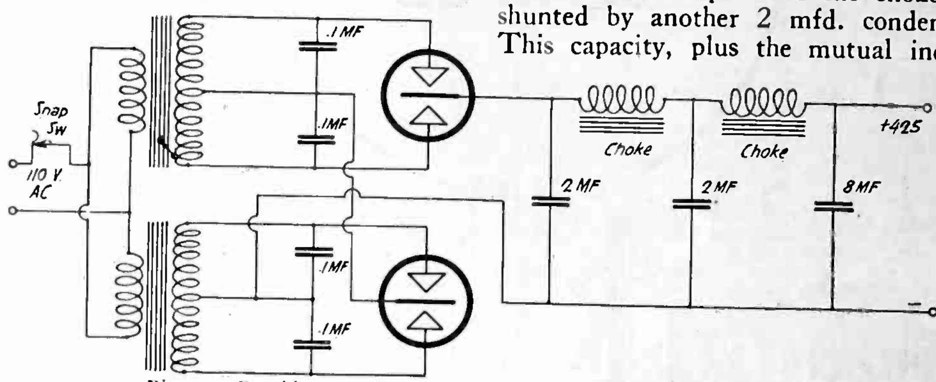

Fig. 9. Double Raytheon Rectifier for High Voltage Supply.

and secondary windings, any noise emanating from the power line is eliminated, and stray radio signals, clicks and pops originating in electrical equipment are prevented from reaching the radio set via the rectifier and filter system. Due to care in design, the voltage regulation of the transformer is unusually good, and the secondary voltage will remain constant regardless of the current drain of the receiving set, up to the maximum output of the rectifier tube.

The filter is the most unusual part of the Silver-Marshall rectifier, employing the Clough invention, which, rather than depending upon brute-force action to eliminate the 120 cycle fundamental hum which is very strong at the rectifier output, uses a selective section, plus brute force action, to eliminate this frequency. For the weaker 240, 480 and 960 cycle harmonics it depends upon brute-force action. The filter is made up of a special unichoke and condenser bank, in identical steel cases. The choke coil consists of two windings, one large and one small, wound in opposition upon a common core. The input of the filter is shunted by a 2 mfd. condenser as in Fig. 1, and the mid point of the chokes is shunted by another 2 mfd. condenser. This capacity, plus the mutual inductance of the opposed coils, provides a resonant circuit of extremely low resistance which effectively eliminates the 120 cycle hum.

The actual resonance curve is sufficiently broad to take care of line variations, yet the resistance is so low that the filtering action is unusually good. The brute-force section of the filter consists of the remaining choke, which is of very high inductance, with a 4 mfd. condenser shunted across the output of the filter, where it is connected to the receiving set. In this filter, the connections differ slightly from Fig. 1 in that 4 mfd. is used instead of 8 mfd. ordinarily specified.

The complete set of parts is mounted on a small metal base 6½x7½ in., the base serving as the negative or ground connection for the supply unit, and simplifying the wiring.

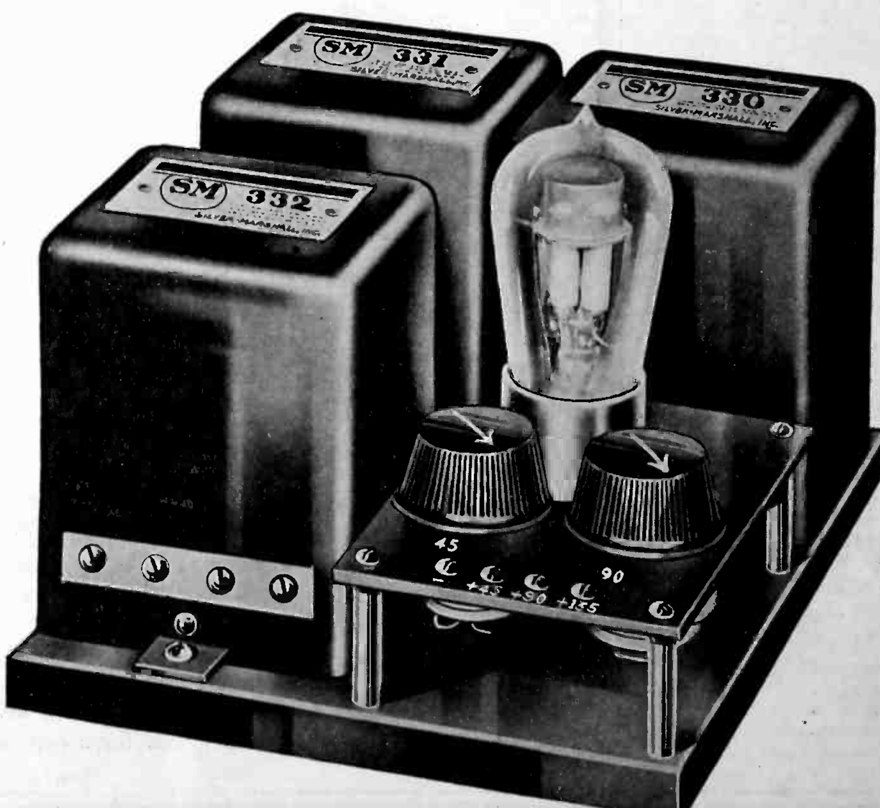

Fig. 10. Plate Supply Unit for B-H Raytheon Tube Using Silver-Marshall Parts.

WEEKLY CALL BOOK

and Station Program

AT LAST a Call Book corrected weekly, to take care of the many weekly changes made by broadcasters in wavelength, location and operating hours. Only a weekly book can keep you fully posted on the many changes. It also gives you a list of new stations as they "come on the air." As many as fifty changes a week are made in this new book to keep up-to-date station listings and as many as 300 changes in schedules are made every week. As a radio listener, you know what this means to you. The book is published by the publishers of "RADIO." It is known as "RADIOCAST WEEKLY."

IMPORTANT INFORMATION Every week in this 64-page book you get the "AROUND THE DIAL" station log, distance chart, spaces for dial recordings, wavelength, power, location and owner of station.

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10c

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Ten Radio Points for 10c

1—The list of important radio stations of the U. S.—corrected weekly and kept up-to-date. This is a "CALL BOOK" in itself.

2—The location of stations, their power and wavelength. This tells you, at a glance, just what reception you may expect.

3—The distance of important stations from various important centers along the Pacific Coast. This tells you how far you are receiving.

4—The operating hours of the stations within audible radius of Coast listeners. A speedy and accurate method for "what's on the air."

5—The listing of stations by wavelength, starting with the minimum operating wave and ending with the maximum. Use this for dial settings.

6—Logging spaces for "stations heard." Space is provided for three dial readings, enabling you to quickly locate a station when you want to.

7—Listing of Canadian and Mexican stations. This is worth a lot to the listener who can "reach out." These listings are up-to-date.

8—VERY IMPORTANT is the weekly correction feature of the above high lights. Accuracy and reliability are responsible for the success of this magazine.

9—The listing of station programs by the day. Large headings in black type enable you to quickly locate the station you are after.

10—And — last of all — you get this data every week in "Radiocast Weekly," the reliable guide to WHAT'S ON THE AIR. The simplest form of schedules and the handiest reference book of its kind on the market. It costs 10 cents.

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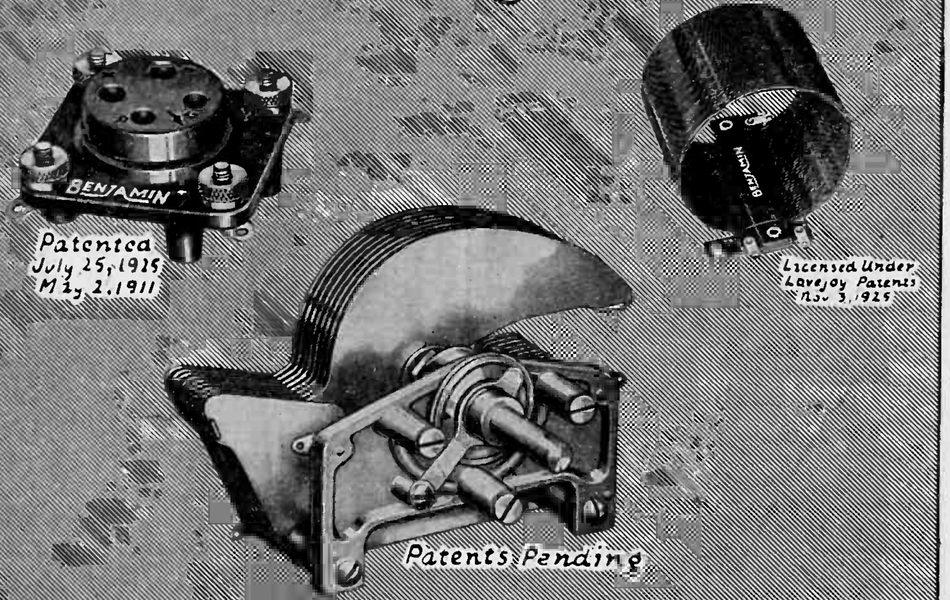

Radio sets of today are very simple when compared to those of yesterday. This simplification has only been achieved by the finer, more delicate and more efficient *parts* that go into the makeup of the set.

Benjamin Radio Products have set up such high standards that many of the country's greatest radio authorities have continually advised and used Benjamin Radio Parts in their newest and best radio creations. They are essential to better radio sets, being built for the years to come.

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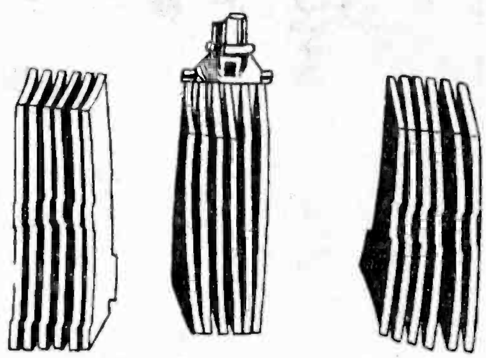
BENJAMIN

TRADE MARK

STORAGE BATTERIES

(*Continued from Page 34*)

which is to be run from the bank of the lamps to the battery and the lead wire from the line in a tumbler of water containing a slight amount of salt. Be careful not to touch the wires together, and be sure that the lamp bulbs are connected in the line. Bubbles will form about the parts of the wires immersed in the water. The wire from which the greater number of bubbles comes is the negative one.



Buckled Plates Resulting from "Run-Down" Battery.

The mechanical type of charger is reliable, and perhaps somewhat more efficient on the average than the tube type, but it is noisy, and does not deliver so steady a charging current. Some difficulty is also encountered from the contact points on the vibrating switches used in such chargers becoming burned, or worn. The tube type of charger is in many instances more expensive than the mechanical charger, but is free from the noise and interference effects because of which the mechanical charger is objected to.

"Trickle chargers, (small chemical chargers which are used to continually charge batteries when the radio sets are not in use), have become quite popular recently. They are desirable from the standpoint of convenience, inasmuch as they may be left connected to the battery indefinitely without danger of injuring it, and, without attention, they keep the battery constantly in a state of full charge. Periodic testing of the battery, and periodic charging is eliminated.

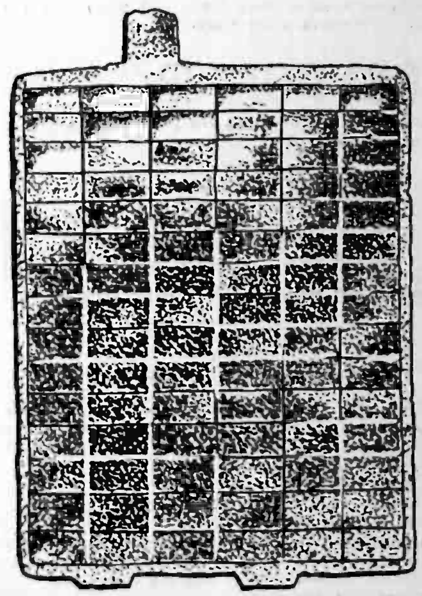
Battery manufacturers customarily supply complete charging instructions with their batteries. In general, the charge should be continued until the hydrometer reading is that which the manufacturer states as representing full charge for his battery; or until all cells of the battery are gassing uniformly, and successive readings taken with a voltmeter across the battery terminals (while it is on charge) are the same when repeated at fifteen-minute or half-hour intervals.

There are certain rules which should be observed in the care of any acid storage battery, and if the owner carefully abides by these, he may be sure of obtaining maximum length of service from his battery. The following are the most important requirements:

(1) Do not allow the battery to become over-discharged. As soon as its hydrometer reading or voltage test reading, (as described in the paragraphs above) becomes low enough to indicate that re-charging is advisable, the battery should be immediately placed on charge.

(2) Do not over-charge the battery. Stop the charge as soon as the battery comes up to full charge. A small overcharge at times is advisable in order to keep many batteries in the best of condition, but the battery should not be habitually over-charged for extended periods of time.

(3) Replace evaporated electrolyte by pure distilled water. Nothing but distilled water should be used. This may be obtained at a battery service station or a drugstore. Do not allow the solution to become so low that it does not cover the tops of the battery plates. Examine the battery frequency through the vent holes, and add distilled water whenever required.



Too Low a Level of Electrolyte Causes Top of Plate to Become Sulphated.

(4) Never add acid to the battery solution. If some of the electrolyte is spilled, take the battery to a service station, as the amount of acid that should be added depends on the state of charge of the battery and several other factors, and it is best to have fresh solution added by someone familiar with storage battery care and operation.

(5) Do not bring flames near the vent caps of the cells. The gases which bubble off are explosive, and may be ignited if flames are brought near.

(6) If one of the battery cells heats up abnormally, take the battery to a service station, so that it may be examined for a possible internal short circuit.

(7) If the battery is over-discharged (through an accidental short circuit of the battery leads, or a short circuit inside the set) it will be best to have it examined by a battery expert before putting it into service again.

Another type of battery much used in services which require extreme ruggedness and ability to withstand rough treatment, is the alkaline storage battery. These batteries are considerably lighter than those of the lead-acid type, but have a potential voltage of but 1.75 per cell, as compared to 2.0 in the acid type of battery. As alkaline cells are but little used by radio set owners at the present time (they are gradually acquiring greater popularity, however), it is hardly worth while to describe them in detail here. Complete directions for their care and operation are supplied by the manufacturers.

ARRESTING STRAY R. F. CURRENTS

(*Continued from Page* 30)

used in such a way that a.f. oscillations only are permitted to return to the first amplifying tube.

Fig. 5. Choke coil coupled amplification. This can be accomplished if chokes with very low distributed capacity are used. Coupling condenser C should have a capacity of .005 mfd. C_2 .0005 mfd., while R_1 is .3 megohm and R_2 1 megohm. This type of amplification has one marked advantage over the conventional type of resistance coupled amplification. With choke coil coupled amplification, standard tubes at economical B battery potentials can be used and at the same time achieve a high quality of reproduction.

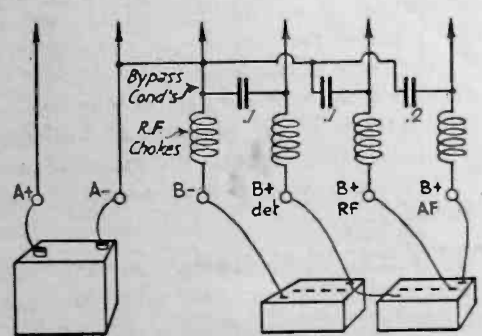


Fig. 6. Chokes in all "B" Battery Leads.

Fig. 6. B battery leads with chokes in all leads. As pointed out above defective B batteries tend to build up r.f. oscillations. If these are prevented from going where they are not wanted, the operating characteristics of the set and the quality of reproduction will be improved.

The indications are that next season will see a large movement toward the introduction of r.f. chokes in receiving circuits.

When you are troubled with noises in a receiving set, be sure that you have checked over the insulation of the battery cases of the B batteries, especially if they are of the storage type, as the wooden cases may absorb moisture and acid, and become partial conductors, which will be noisy and cause sounds that are hard to locate and eliminate.

RADIO, PAST, PRESENT AND FUTURE

(*Continued from Page* 10)

The radio receiver, too, was at first a crude device containing a hundredth of the number of parts used today—an aerial, a piece of galena under a wire, and an old telephone receiver—now we have inductances, condensers, tubes, power-amplifiers, and battery-eliminators —and more coming. Development from crude and simple to complex, efficient, beautiful, graceful, and harmonious forms is an absolutely fundamental law governing the progressive (not the retrogressive) evolution of everything that exists.

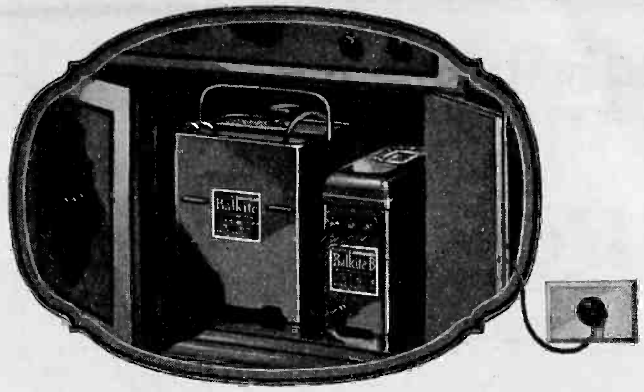
Now a few words as to the comparative advantages of buying a factory-built set and assembling one at home. The merits of the factory-built broadcast receiver are that it is ready to run, that it is usually attractive in appearance both inside and out, and that it is as a rule covered by some sort of guarantee. Yet I should personally rather prefer to build my own set; because I can then get what I want in the way of a circuit and in the way of parts—but I, who have made a sort of specialty of radio for so many years, should be a foolish crank were I to try to urge every novice to buy an armful of radio parts and essay to build his own outfit. The radio fan who desires a super-heterodyne, other than the single factory-built make now on the market, will have to build it himself, or have some one assemble it for him. One advantage of assembling a large set is that a better receiver can be put together for the same outlay of money, if the constructor knows how to select good parts —and there is the pleasure of building something that appeals to many of us. This subject would bear some further discussion.

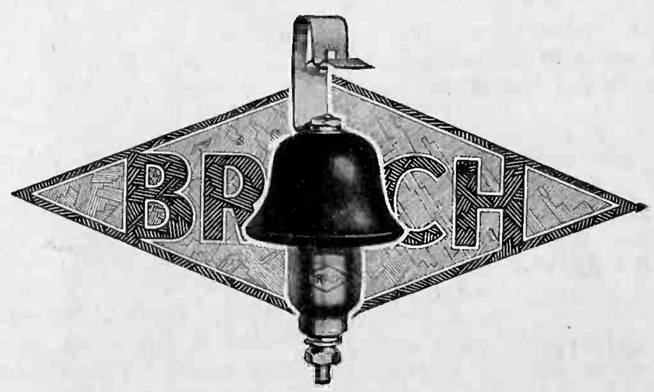
TO RAISE the curtain on the field of radio twenty-five years hence is at best a highly speculative proceeding; because any one of a number of unforseen things may suddenly develop at any time in a science or industry that will entirely alter or vastly accelerate its progress. This is becoming more and more the case today, for a simply dazzling correlation is rapidly developing among all the higher sciences, even among those that are at first glance as far separated as electricity and astronomy and medicine. Advances in electrical science are uncovering long-hidden mysteries in chemistry; the study of electrons bids fair to throw a powerful light on evolution, on the science of psycho-analysis, on the very mysteries of life itself. We are getting on the threshold of a period wherein invention is no longer a result of haphazard experiment, but a deliberate process of using powerful mathematical calculations which are in turn based upon the precious treasures of scientific knowledge so far accumulated and organized. Advances of olden centuries are today excelled by those of fleeting months; it is probable that the progress of a year at present will one day be a matter of a week's work.

One may easily go astray, therefore, in attempting to predict what radio will be twenty-five years hence. I think that by then radiophotography will be a highly perfected and practical art; it may be that even radiocinematography and radio-vision will have arrived; that we shall have the beautiful and engaging artists who sing over the radio present before our eyes in a small artistically-arranged "silver sheet" above the broadcast receiver. This would mean bringing both the music and the pictures of the movie palace into the home—with the possibility of being able to frame-in any one of several pictures running simultaneously "on the air." Twenty-five years seems almost too short a time in which to encompass all this, but, as I have remarked, the rate of scientific progress is daily growing swifter.

The design of radio apparatus may, by that time, be fundamentally altered; possibly we shall be speaking of wavelengths in millimeters or microns, or, again, we may be still employing some of the wavelengths of the present day. Engineers see no chance of radio replacing our present commercial wire telephone systems. Auxiliary "radio links," however, will easily within twenty-five years, have brought all the world, from Canton to Buenos Aires, as near you as your telephone; and it is entirely probable that a speaker in any great city on the earth will be able to address, through telephone, radio link, and radio broadcast systems, not merely his own nation, but *the entire globe!*

But, whatever radio marvels the future holds in store for us, you can just about bet your oranges that a good late-model neutrodyne, tuned-frequency, or superheterodyne receiver bought ready-made or assembled from high-grade parts will certainly have delivered full value in the way of enjoyable entertainment long before it becomes obsolete.





SHORT WAVE RECEIVER

(*Continued from Page* 18)

thing. This coil is inserted in series with the primary of the audio transformer and the tickler coil.

It is not necessary to wind special coils for the feedback circuit, for the coupling coil of the Reinartz becomes the tickler coil of the capacitative feedback circuit. The small one can be used for the 20 and 40 meter band, and the large one for the 80 meter range.

Now a few words as to the operation of the receiver. The aerial chosen is a single wire, preferably vertically situated, and 40 ft. long. This is particularly important for the reception of the very short waves. For wavelengths above 20 meters, almost any type of aerial can be used successfully. In fact, it is suggested that a large antenna tuned to some multiple of the wavelength to be received might have proved exceptionally efficient.

The proper size antenna coil should be used for the wavelength range to be received, and applies to the combination secondary and tickler coil units. Once the tubes are turned on, and the phones inserted in the jack, there is nothing much to the operation of the receiver other than proper tuning.

Turn the oscillation, or right-hand dial until the familiar "rushing sound," denoting regeneration, is heard. While the set is oscillating, turn the wavelength tuning condenser until a station's signals are heard. Here, a small wavemeter will come in handy, if you are after a special station.

Then, gradually reset the oscillation control to the point just before oscillations cease. The loudest signals will then be heard. In the case of radiocast reception, it is of course undesirable to have the receiver in an oscillating condition. The method outlined above, however, can be used to tune in the carrier wave, or "whistle," as it is known among the novices. Then, by turning the oscillation control until the voice or music clears, distortion due to regeneration will be considerably reduced. If the same dial is now gradually brought back to the point just previous to oscillation, the strongest signals will be had.

It is of course possible to connect any type of audio amplifier to the output of the set. The author has used with interesting results a resistance coupled audio amplifier which was plugged in instead of the phones. A second audio transformer could be used as well.

It should be noted that detector voltages are fairly critical. Therefore provide yourself with a battery having variable taps. While the regenerative control will move upward on the scale with an increase in wavelengths, it will never cover as wide a range as the wavelength control. This permits the operator to give more attention to the tuning dial, at the same time obtaining good efficiency from the oscillation control.

In originally trying out this receiver, no less than several dozen grid leaks were tested. Grid leaks and condensers play an important part in the efficiency of short-wave receivers, and should be chosen with care. A value between 5 and 10 megohms can be used, the best resistance being determined by test only.

There may be a "spot" in the wavelength adjustment when the set may fail to oscillate. That is because the natural period of the antenna system is the same as that of the tuned circuit of the receiver. The best way to get around this situation is to reduce the coupling between the primary and secondary coils, or to insert a small loading coil in the antenna circuit.

COILS TABLE

Wavelengths Range (Meters)	Antenna Coil Turns	Secondary Coil Turns	Tickler Coil Turns	Total Turns Secondary and Tickler
10-32	4	4	5	9
30-51	6	7	8	15
49-84	8	12	8	20
77-128	8	20	10	30

As the coils have been designed to cover a certain wave range with the condensers used, there is of necessity an overlap between each set of coils. It is largely a matter of using the right coil for the given range. When signals are received over either extremities, change to a higher or lower coil to receive them efficiently.

The lead from colored pencils can be used to mark the ends of soft cotton sleeving, by heating the colored lead, (which is only wax colored) with a hot iron, and letting the color flow into the sleeving.

A few pieces of resin core wire solder, with a couple of matches make a good hurry-up soldering outfit for small wire jobs.

In fitting screws and nuts onto manufactured sets, be sure that they are of the proper threads. Many sets sold have odd threads which will not fit the standard screw products. If the latter are forced onto the screws they may be damaged.

In tapping or drilling moulded bakelite, be sure to avoid all strains as the material is brittle and liable to crack and chip, which is much less the case with the sheet material, such as is used for panels, etc.

Sealing wax can be used as a binder, to "solder" non-metallic, or similar parts together, or even to fasten metal to bakelite, etc., by heating one or both parts, applying the wax, and screwing the two together while hot.

Common sheet tin, such as can be obtained from any plumber or hardware store is an effective shielding material, and much cheaper than copper or brass.

HANDS ACROSS THE AIR

(Continued from Page 22)

the sign language and partly to his unwillingness to believe, he learned that in Acapulco there was no railroad, no telegraph or telephone and very decidedly that there was no radio, neither ham nor commercial. Another Mexican Line ship would call in perhaps a week or so but in the meantime he found that for all practical purposes he might just as well be on Robinson Crusoe's well-known desert island.

He returned dejectedly to his room and, his head still throbbing at almost audio frequency, strove to evolve some means of communicating with San Francisco and apprising Mr. Bellis of the now evident and deplorable rascality of Senor Malagua and his precious syndicate.

"What I can't get, though," he mused "is why that gang should put up a wad of money like ten thousand plunks and then try a stunt like this."

Then he remembered that their offer to Mr. Bellis had been for any device that would eliminate static, and that there was some hint that another whom they were financing was on the point of perfecting a similar invention.

"That's the idea," O'Dwyer grinned in spite of his splitting headache. "They're going to take my little bambino and dress it up in a fancy cabinet, and when Manuel reports to the Mammoth that my invention is just a lot of applesauce, those babies are going to draw down that ten thousand and use the Static Stopper to make demonstrations in floating some stock-selling swindle. Bet that's those boy's specialty —promoting fake stock companies and here's their chance for a quick clean-up."

O'Dwyer's speculations as to the plans of Malagua and his gang were absolutely correct and Manuel's selection of Acapulco as the spot to maroon the inventor was about the cleverest stroke in the plot. Three hundred miles to the north was Manzanillo, three hundred to the south was Salina Cruz and in between lay nothing but bare rugged mountains with no means of transportation except the occasional pack trains of slow-moving little burros that wound leisurely over the rocky trails. Travel in either direction was out of the question, and O'Dwyer racked his brains to evolve some method of getting a message to Mr. Bellis before Malagua and his gang should have time to put their plans into effect. He knew that Manuel would lose no time in reporting to the Mammoth that the test was a complete failure and to his Central American Syndicate that he had secured possession of the Static Stopper and had left its rightful owner in a position where he could cause them no immediate anxiety.

Then he recollected that the *City of Alameda* would not be in range of the

California coast stations until after dark and that the operator on there would not try to forward any messages which Malagua might hand in until later in the evening, so with the idea of at least hearing Manuel's message to San Francisco he connected one of the commercial regenerative sets to the aerial and tuned in on 600 meters. Static was beginning to rumble and grumble, so O'Dwyer removed the large unopened case from beneath the pile of empty ones in the corner, and prying off the lid, he dug down among the contents and drew out the duplicate Stopper which he had fortunately included with the other spare parts.

He placed the Stopper beside the receiver in operation, pressed the switch and the grinding and clattering ceased abruptly. He re-tuned the set and the room was filled with the shrill piping of two Mexican land stations working with each other in that peculiar choppy style of sending so oddly characteristic of all Mexican, Japanese and Filipino operators.

"Can't hear much else," O'Dwyer muttered irritably, "until those caballeros decide to call it a day," and turning off the filaments he went back to the "junk pile."

Rummaging through the mess he came across the parts of a short-wave adaptor designed by him some time previously for this particular type of receiver he had just been using. He connected it in the aerial circuit and bringing its movable coil close to the primary of the receiver adjusted the rheostats and slowly rotated the calibrated dials which indicated directly in meters the wavelength being received.

At almost every degree on the dial he picked up the faint but readable chirpings of dozens of amateurs scattered over every district and was impressed anew with the almost incredible distances that could be covered with such very low power on those recently available waves.

While making his experiments with the touch transmitting apparatus in San Francisco he had been allotted the special call of 6ZXY and permission to work on a narrow band around 50 meters, and he now rather idly swung the dial to cover that wavelength.

"You never can tell," he said to himself as he fitted the earphones closer, "I might pick up Joe fooling around with artificial paw."

"Joe" was his partner whom he had left in charge of the laboratory and whose interest in their odd experiments hardly allowed him time to eat and sleep.

At first there seemed to be a complete and profound silence but a moment later O'Dwyer's trained hearing picked up a faint almost inaudible sound. Carefully he adjusted the controls to obtain maximum sensitivity and sharp on 50 meters the signals were unmistakable. Rapid groups of dashes, not the Morse code, were being repeated at varying intervals.

"That's Joe," exclaimed O'Dwyer delightedly, "He's playing with the iron mitt! If there was only some way to ——."

He broke off suddenly and jumping up ran to the "junk pile" and turning the big box upside down spilled its contents on the floor. For two hours he worked feverishly, pausing now and then to clap on the phones and listen intently for a moment. The signals were still being irregularly repeated and O'Dwyer, with an energy entirely foreign to his usual leisurely manner, gradually evolved a weird-looking but workable short-wave transmitter that he fervently hoped might bridge the eighteen hundred miles between himself and the city by the Golden Gate.

He had hooked up four of the 201 A tubes in parallel, using the McGown loose coupled method which avoided the necessity of having a specially tuned aerial, and with a plate supply of 500 volts obtained from a dozen 45 volt *B* batteries, he inserted the key and a small thermo-ammeter in the ground lead.

Perspiration, induced by excitement as much as by the tropical heat, ran unheeded down his face as he cautiously adjusted the two variable condensers and slowly moved the clips on the grid and plate coils. With the key held down and the phones tightly clamped to his ears he made minute changes of capacity and inductance and he almost shouted in triumph when the oscillations of the transmitter crossed those of the receiver producing the familiar beat note that showed that both were in almost absolute resonance, and consequently that he was emitting a wave within a fraction of the desired 50 meters.

For another half hour he alternately sent his groups of supersonic signals and then listened with straining ears. He held his breath when the incoming dashes changed to a series of dots and then into the dots and dashes of the Morse code spelling out the well-known CQ or general call, followed by the international abbreviation QRA? meaning "who are you?"

Controlling a powerful impulse to toss something into the air, O'Dwyer began to send slowly and distinctly, repeating his name and location and adding a word in the special code which he and his partner used.

"O.K. om.," came back the welcome answer. "Your signals very weak and wavering badly but can read. Go ahead slowly. What's the big idea?"

Again O'Dwyer sent steadily and without wasting words conveyed to his partner the exact condition of affairs.

"Inform Mr. Bellis who will take necessary action," he concluded, "power supply here giving out. Can't send any more. QSU, om. gn."

The overworked "*A*" tubes gave up

the ghost, and O'Dwyer relaxed from his strained tensity with a grin of satisfaction, as his partner signalled:

"Everything received O. K. See you later."

In the laboratory a twin grin of satisfaction overspread the features of Joe Knapp as he read over again the astonishing message he had just copied.

"A good thing Manuel didn't know it," he chuckled, "but the only thing that could keep O'Dwyer down for any length of time would be about six feet of well-packed earth with daisies growing on top."

Next morning Joe was admitted into Mr. Bellis' private office as that gentleman was frowning over a radiogram which he had just opened. Without a word he handed the sheet to Joe and the latter after a glance at the signature—Malagua—handed to Mr. Bellis the message which he had received the night before from O'Dwyer.

"How did you get this?" demanded that puzzled gentleman.

Joe seated himself and in a few simple, convincing sentences related the manner in which the message had been delivered.

"I was fiddling around as usual," he said, "with that hand-shaker contraption and was trying various adjustments of the transmitting mechanism and watching the effect on the receiving outfit across the room. I stopped to light a cigarette and was amazed to see the forefinger of the receiving hand continue to make an occasional jerky motion. As I sat there flabbergasted the doggone finger kept up that jumpy movement at regular intervals. In spite of an uncanny feeling at its unexpected antics I realized that it must be partner who was sending the proper key-group to operate the forefinger, as he and I are the only ones who knew the combination. I plugged in a pair of headphones instead of the hand attachment and then had little trouble communicating with O'Dwyer until his batteries gave out. I told him, though, before signing off that I'd call him tonight at the same hour and give him the latest dope."

"You can tell him from me," replied Mr. Bellis, "that the necessary action he refers to will be taken very willingly."

The action included a free ride in a fast automobile for the members of the Central American Radio Syndicate, but their enjoyment was somewhat marred by the persistent, unpleasing clang of the gong beneath the good right foot of their chauffeur in the blue uniform with the large brass buttons. They had "gone west" as far as nature permitted, and although sundry states on the less sunny side of the Rockies clamored to extend to them a permanent abode, they are still the cherished guests of the state where the lemon is joyfully tendered by the native son to the undesirable stranger.

The action further contemplated a like thoughtful care for Mr. Malagua, but the slippery Manuel had listened in on a broadcast account of his friends' visit to San Quentin for an indefinite stay and he had unobtrusively abandoned the ship at Los Angeles. He has not since been heard from though he is quite possibly ranging the great wide spaces within the city limits there, perhaps trying to sell the Stopper to some horseshoe-pitching champion of Iowa.

O'Dwyer returned two weeks later, having been informed of passing events by listening for Joe's nightly bulletins. He was not at all disturbed by the possibility of Manuel's extracting the secret of the invention from the model which he had stolen, as it was so constructed that any attempt to open it by an uninitiated person would cause the little *B* battery inside to send a spark through a tiny capsule of black powder. A small explosion would result, sufficiently to destroy effectively the more delicate parts of the arrangement, and discourage further investigation.

From Mount Olympus Jupiter is casting malignant and suspicious glances in the direction of San Francisco, and quite likely some of this terrible weather we have been enjoying lately is just an evidence of the old monarch's peevish worriment at the prospect of losing his most effective weapon for goading a patient people to unwonted profanity.

But there's many a slip 'tween the hip and the lip, and maybe he doesn't need to worry much—yet.

VOLTAGE VERSUS POWER AMPLIFICATION

(*Continued from Page 26*)

at 1006 cycles per second. After this maximum the curve falls rapidly, crossing *A* at 1500 cycles. At 8,192 it has dropped to 2.1 from the maximum of 3.16 times. This curve also is typical of many transformers which are not so good. The rise of *B* above *A* up to the maximum peak is due to parallel resonance of the condenser and the inductance, which increases the primary voltage. The rapid fall of *B* above the maximum is due to the by-pass effect of the condenser.

Now the value of the condenser chosen is that which is usually recommended for by-passing the radio frequency current across the primary. Sometimes smaller condensers are used, sometimes larger. The rapid fall of the curve above the maximum shows the importance of using the smallest by-pass condenser possible. If the circuit will oscillate or regenerate without any by-pass condenser at all, then it should by all means be omitted.

Before concluding it may be well to call attention to some of the peculiarities of the curves in Fig. 2, and to what use the properties of these curves may be put. First take Curve *F*. This is nearly a straight line from middle *C* to C^{111}, with a negative slope. Likewise Curve *A* is very nearly a straight line between $\text{Log}\ _2f=2$ and $\text{Log}\ _2f=4$, but its slope is positive. It is possible by the proper choice of resistances, capacities, and inductances to make the middle of the straight portion of one curve coincide with the middle of the straight portion of the other. For instance the *A* curve may be moved over so that the point now at $\text{Log}\ _2f=3$ and .69 will fall on $\text{Log}\ _2f=9.5$ and .505. One curve will then attenuate the high frequencies as much as the other will attenuate the low, and the result will be that all the frequencies within a certain range will be attenuated to the same degree. This double attenuation will of course require additional amplification by means of a non-distorting amplifier.

A telephone line such as is used for transmitting programs from one station to another, or from a pick-up station to the central studio, is electrically a series resistance with a shunt capacity, with an almost negligible amount of inductance. Its transmission characteristic will be somewhat like Curve *F*. Of course, this would so distort the signal as to render it unsuitable for re-transmission. It is necessary to compensate for the unequal attenuation, and this is done by means of inductance and resistance, and capacity if required, in the manner indicated above. This compensation may be made to any required degree of accuracy, over any desired frequency range. The electrical device required for accomplishing the compensation is called an equalizer, and a line in which the attenuation has been levelled by means of such a device is said to be equalized. In practice the equalization is held within such narrow limits that any residual intensity difference within the essential frequency range are quite inappreciable to the keenest ear.